

$$x^2 + y^2 = r^2$$

$$x + y = r$$

$$\frac{x}{a} + \frac{y}{b} = c$$

Expts. : → test tube expt. →

test tube with height marks

Ellen : test tubes → (test tubes & r there) (Apoon)

Creek Cray : variations in the expts. →

Surfactant	wt%			
	0.0125	0.025	0.05	0.1
2.5 mg/ml	0	0	0	0
0.75	0	0	0	0
1.5	0	0	0	0
3 mg/ml	0	0	0	0

photos immediately after shaking & foam height measurement

Antifoaming agent Lefax

Surfactant	0	0.025	0.05	0.1
Particles	0	0	0	0
0.75	0	0	0	0
1.5	0	0	0	0
3	0	0	0	0

Diffusivity equation

Transient, Steady-state & semi-steady state

$$r \cdot \frac{\partial P}{\partial r} = \frac{-\log B_0}{k}$$

$$r_e \rightarrow \infty$$

$$\frac{\partial P}{\partial r} \neq 0$$

Steady

ξ zeta

$$\frac{\partial P}{\partial r} = \frac{\partial \xi}{\partial t}$$

Van Everdingen skin

DIMENSIONAL ANALYSIS

$$\int e^x \cdot dx =$$

Laplace transform studies

Fourier series \rightarrow inverse Laplace transformation

$$\frac{1}{\infty} = 0 \quad \frac{1}{0} = \infty$$

Fourier
Laplace
Bessel Functions

Laplace transformation of radial ~~flow~~ diffusivity equation

Steh Fert

Surfactant / Particles

~~1~~ 1 ltr 1 ltr ~~2.56~~ 997.44

To prepare 0.1 wt% active soln

0.1 : \longrightarrow 100 g
1 : \longrightarrow 1000 gms

But 1 gm is for 100% conc. soln and we have 39.1% active soln so we need

1 — 100
2 — 39.1
(2.5575 gms)

2.5 gm
A
997.5 gm of mine soln
1000 gms
3% NaCl
1000 gm of water
970 gm of water
+ 30 gm of NaCl

After complex calculations, we added

2.5 + 997.5 water + 30.8 gm of NaCl

46

100
30

5/5/20

To prepare the diluted versions of soln. →

1000 ml of 0.3% AES

Take ~~out~~ out 500 ml & add 500 ml of ~~500 ml~~ (normal water + 0.3% Brine)

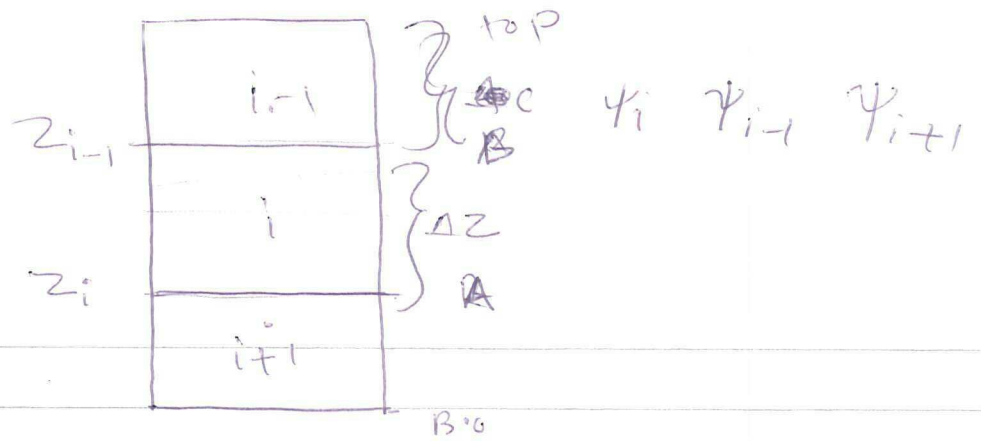
② We will get 1000 ml of 1.5% AES

Take out 500 ml of & add 500 ml of (normal water + 0.3% Brine)

1
We will get 1000 ml of 0.75% AES

~~So we~~ We need 1000 ml of (normal water + 0.3% Brine)

② AES %	Quantity
0.3%	500
0.15	500
0.075	1000



$$q_{i-1} = q_{i+1}$$

$$-\frac{\phi}{K_{i-1}} \frac{\mu}{\bar{s}} \frac{\Delta \phi_{i-1}}{\Delta z_{i-1}} = -\frac{\phi}{K_{i+1}} \frac{\mu}{\bar{s}} \frac{\Delta \phi_{i+1}}{\Delta z_{i+1}}$$

$$\Delta z = z_{i-1} + \frac{z_{i+1}}{2}$$

$$\phi_i (K_{avg, i-1 \rightarrow i} - K_{avg, i \rightarrow i+1})$$

$$A = \begin{bmatrix} \gamma & & & \\ & \phi & \phi & \phi \\ & & & \end{bmatrix} \quad \psi_{i+1} = A_{i+1} + B_{i+1} z_{i+1}$$

$$\psi_{i+1} = \psi_i (K_{i-1 \rightarrow i} + K_{i \rightarrow i+1})$$

$$K_{i \rightarrow i+1}$$

$$- \psi_{i-1} \left(\frac{K_{i-1 \rightarrow i}}{K_{i \rightarrow i+1}} \right)$$

$$i=0$$

$$\psi_i = \psi_0 \frac{(K_{-1 \rightarrow 0} + K_{0 \rightarrow 1})}{K_0 - K_{-1}} - \psi_{-1} \left(\frac{K_{-1 \rightarrow 0}}{K_0 - K_{-1}} \right)$$

$$\begin{bmatrix} k_{avg} \xrightarrow{k_i} k_{i+1} \\ k_{i+1} & k_{i+2} & k_{i+3} \end{bmatrix} \cdot \begin{bmatrix} \phi_{i-1} \\ \phi_i \\ \phi_{i+1} \end{bmatrix} = \begin{bmatrix} c_1 \end{bmatrix}$$

$i=1$

$$k_{11} = \frac{k_i + k_{i+1}}{2} = k_i$$

$$k_{12} = \frac{k_i + k_{i+1}}{2}$$

$$k_{avg, i-1} = \frac{k_{i-1} + k_{i-2}}{2} =$$

$$\begin{aligned} & i=1 \\ & k_{11} = k_{avg} \\ & = \frac{k_{i-1} + k_i}{2} \\ & = \frac{k_1}{2} = k \end{aligned}$$

$$K\phi = c$$

$$\begin{bmatrix} 3 \times 3 \end{bmatrix} \begin{bmatrix} 3 \times 1 \end{bmatrix} = \begin{bmatrix} 3 \times 1 \end{bmatrix}$$

$$\begin{bmatrix} k_{11} & k_{12} \\ k_{21} & k_{22} \end{bmatrix}$$

Q9

Kavg

~~Kavg~~

Kavg

$$\frac{1}{K_1} + \frac{1}{K_2}$$

$$K_{avg} = \frac{K_1 + K_2}{2}$$

$$\begin{matrix} i=1 \\ i=2 \\ i=3 \end{matrix} \left[\begin{matrix} K_1 \\ K_2 \\ K_3 \end{matrix} \right]$$

K_{12}

~~Kavg~~

ϕ_i
 ϕ_{i+1}
 ϕ_{i+2}

$$K_{avg} = \frac{1}{\frac{1}{K_1} + \frac{1}{K_2}}$$

$$\frac{K_1(i-1)}{K_1(i)} \downarrow K_2(i+1) K_2$$

$$\begin{matrix} 1 & K_{i-1} \\ 2 & K_i \\ 3 & K_{i+1} \end{matrix}$$

$$i=5 \quad K = K_{avg} = \frac{K_1 + K_2}{2}$$

$$K_{i-1}$$

K_1

~~Q9~~

K_2

$i=10$
to 10

Q9

$$2(K_{(1,29)}) + \frac{1}{2K(1,30)}$$

$$K_{avg} = \frac{1}{\frac{1}{K_{15}} + \frac{1}{K_{16}}}$$

$$\frac{1}{\frac{1}{1} + \frac{1}{90}}$$

$$K_{avg} = \frac{90}{91}$$

22 8 Oct. 2010

Martijn Gijzen

WI4012a Mathematics, Special Subjects (2010-2011 Q2)

↑

intended holidays 17 Dec 21 am

second period 4 hrs?

3ml of soln → initial height = 39.5 mm

Tubes of int. diameter = 9.5 mm

Experiment with solns

	min 10	height	min 20	height schuim	min 10	Heights
0		39.5	10	39.5		
0.075		55		15.5 56		
0.15		53		56 93		
0.3		51		15.5	56	
0.5		66		26	65	

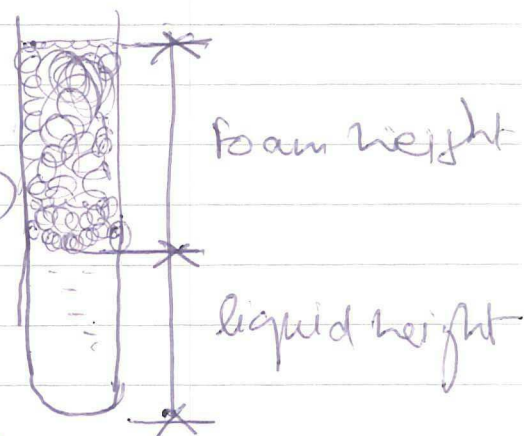
10 min

Foam height is measured from

①

(fix the problem of vibration)

(3 ml of soln)



1 April 2011

~~to gm~~ ~~0.1%~~ 0.1%

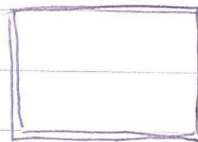
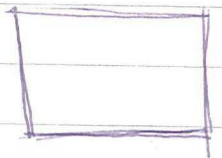
$$K = \frac{1}{\frac{1}{K_1} + \frac{1}{K_2}}$$

$$L_i = \frac{1}{\frac{1}{L_1} + \frac{1}{L_2}}$$

Discussion with Hans

multiphase flows : →

Water + oil
~~Water~~ + Air



nuclear magnetic resonance : →

Effect of force < force at distance
 force in contact

997 → 3
994 → 2.95

997 → 3
994 → 2.95

1000 ml of ~~332.3~~ 0.3 % NaCl

¹³³
332.3

~~Determine~~ mix it with ^{0.3}
~~0.3~~ % Nanoparticles

997
332.3

$$\frac{994}{332} = \frac{497}{160} = \frac{71}{251} = \frac{0.15}{0.075}$$

$$\frac{1000}{997} \rightarrow 0.075$$

$$994 \rightarrow 8$$

$$\frac{994 \times 0.075}{997} = x$$

1000 ml of 0.3 % Nanoparticles

Take out 500 ml & add 500 ml Brine water
You will get 1000 ml of 0.15% conc.

Now take ~~100~~ 500 ml out & add
500 ml Brine

You will get 1000 ml of ~~0.15~~ 0.075% soln

2000 ml of 0.3 % Nanoparticles

Take out 1000 ml out & add in 1000 ml

2000 ml of 0.15 %

Take out 1000 ml & add 1000 ml

so that

Wt of beaker 274.6 gm

1272.50

274.50

1268.27 g

1271.50

276.00

274.50

992.21 g

997.00

997 → 39

992.21 → 2.95 g

1500 → 4.5 gm

1000 → 3 gm

$$\phi_i (K_{i-1 \rightarrow i} + K_{i \rightarrow i+1}) - \phi_{i-1}^* (K_{i-1 \rightarrow i}) - \phi_{i+1}^* (K_{i \rightarrow i+1}) = 0$$

$$\begin{bmatrix} K_{i-1 \rightarrow i} & K_{i \rightarrow i+1} & 0 \\ 0 & K_{i \rightarrow i+1} & 0 \\ 0 & 0 & K_{i \rightarrow i+1} \end{bmatrix} \begin{bmatrix} \phi_i \\ \phi_{i-1} \\ \phi_{i+1} \end{bmatrix}$$

$$K_{i-1 \rightarrow i} \phi_i + K_{i \rightarrow i+1} \phi_i - K_{i-1 \rightarrow i} \phi_{i-1} - K_{i \rightarrow i+1} \phi_{i+1} = 0$$

$$(K_{i-1 \rightarrow i} + K_{i \rightarrow i+1}) \phi_i + (-K_{i-1 \rightarrow i} - K_{i \rightarrow i+1}) \phi_{i+1} = 0$$

$$\begin{bmatrix} -K_{i-1 \rightarrow i} & (K_{i-1 \rightarrow i} + K_{i \rightarrow i+1}) & 0 \\ 0 & K_{i \rightarrow i+1} & 0 \\ 0 & 0 & K_{i \rightarrow i+1} \end{bmatrix} \begin{bmatrix} \phi_{i-1} \\ \phi_i \\ \phi_{i+1} \end{bmatrix} = 0$$

$$\text{If } i=2$$

$$\begin{bmatrix} -K_{1 \rightarrow 2} & K_{1 \rightarrow 2} + K_{2 \rightarrow 3} & -K_{2 \rightarrow 3} \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} \phi_1 \\ \phi_2 \\ \phi_3 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}$$

3×3 3×1 1×1

① why the ~~analytical~~ numeric soln is approaching analytical one?

② why the boundary conditions are required to incorporate in the matrix?

$$\begin{array}{l}
 i=0 \\
 i=1 \\
 i=2 \\
 i=3
 \end{array}
 \begin{bmatrix}
 -K_{-1 \rightarrow 0} & K_{-1 \rightarrow 0} + K_{0 \rightarrow 1} & -K_{0 \rightarrow 1} & 0 \\
 -K_{1 \rightarrow 2} & (K_{1 \rightarrow 2} + K_{2 \rightarrow 3}) & -K_{2 \rightarrow 3} & 0 \\
 0 & 0 & 0 & 0 \\
 0 & 0 & 0 & 0
 \end{bmatrix}
 \begin{bmatrix}
 \phi_0 \\
 \phi_1 \\
 \phi_2 \\
 \phi_3 \\
 \phi_4
 \end{bmatrix}
 =
 \begin{bmatrix}
 0 \\
 0 \\
 0 \\
 0
 \end{bmatrix}$$

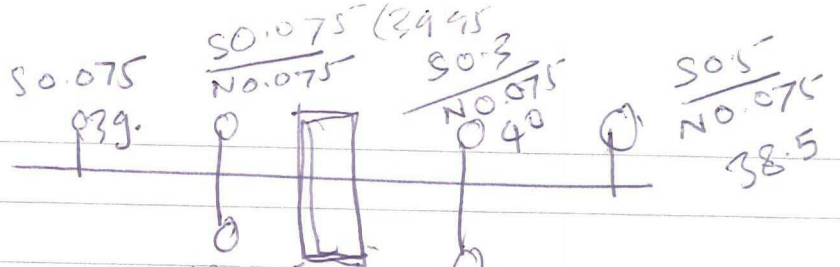
for 0 conditions $K_{-1 \rightarrow 0}$

Numerical computation is not working for
The equations do not work for $i=0$

Experiments: \rightarrow

		1	2	3	4
		0.075	0.15	0.3	0.5
1	0.075	E_{11}	E_{12}	E_{13}	E_{14}
2	0.15	E_{21}	E_{22}	E_{23}	E_{24}
3	0.3	E_{31}	E_{32}	E_{33}	E_{34}

1st expt.



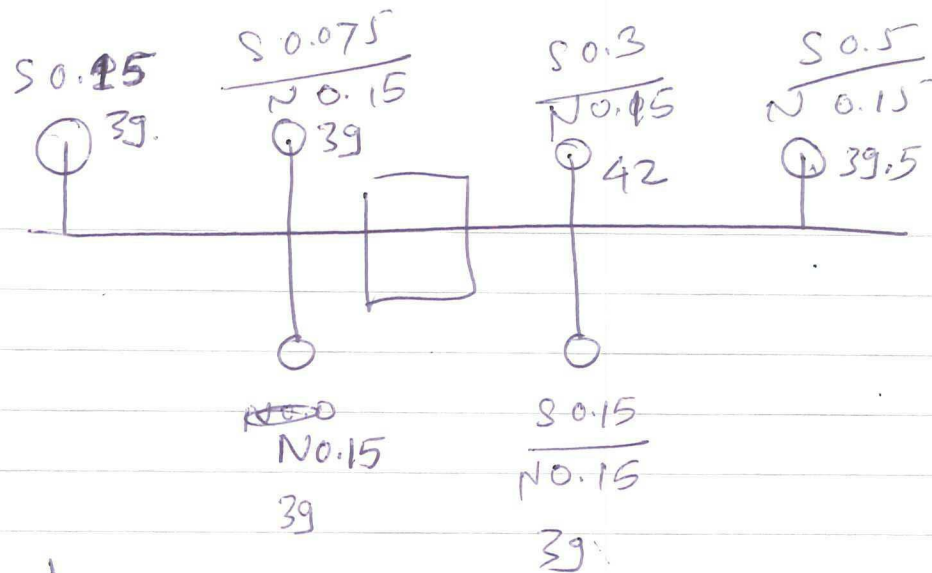
16:15 After 10 min shaking 16:25 NO.075 39.35

	After 1 min		10 min	20 min	40 min	80 min
	L	F				
50.075 / 0.075	37	55				
NO.075	38.5	0				
50.075 / 0.075	37	55				
50.15 / 0.075	39	21				
50.3 / 0.075	38	55				
0.5 / 0.075	37	16				

next photos taken after 40 min

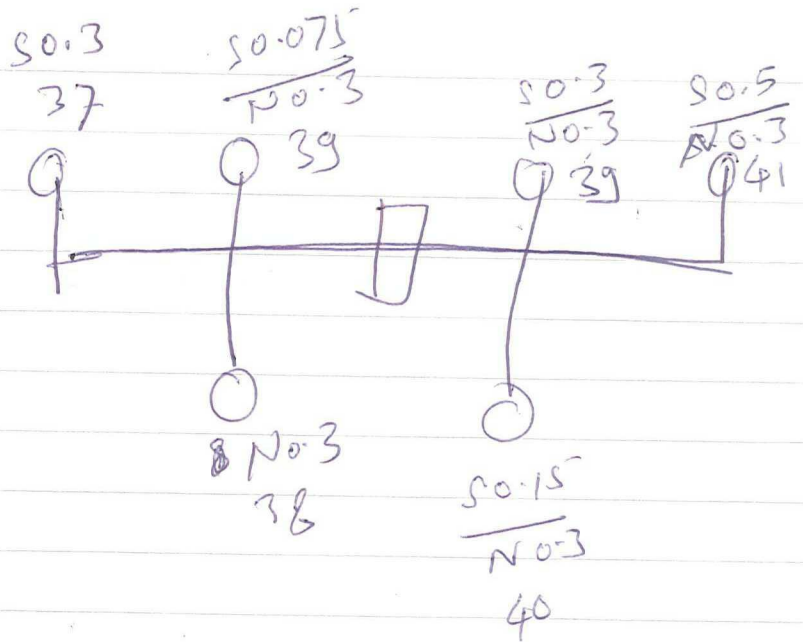
2nd expt.

2nd expt.



	36	55
No. 15	39	0
S 0.075 No. 15	36	55
S 0.15 No. 15	37	14
S 0.3 No. 15	39	52
S 0.5 No. 15	37	54

rotas taken after 40 min



	L	F
50.3	35	57
100.3	38	0
$\frac{50.075}{N 0.3}$	37	55
$\frac{50.15}{N 0.3}$	39	13
$\frac{50.3}{N 0.3}$	36	55
$\frac{50.5}{N 0.3}$	38	57

conductivity

$$\frac{10.34}{28.26} = \textcircled{K} \cdot \frac{10}{4} ; \quad \frac{4 \times 10.34}{10 \times 28.26} = K$$

$$\frac{41.379}{282.6} = K$$

$$\boxed{K = 0.146 \text{ cm}^2}$$

②

$$\frac{10.34}{28.26} = K \cdot \frac{17.5}{7} \quad K = \frac{10.34 \times 7}{17.5 \times 28.26}$$

$$= \frac{72.38}{494.55}$$

$$K = 0.146 \text{ cm}^2$$

③

$$\frac{10.34}{28.26} = K \cdot \frac{13.5}{6} \quad K = \frac{10.34 \times 6}{28.26 \times 13.5}$$

$$= \frac{62.04}{381.51}$$

$$K = 0.162 \text{ cm}^2$$

④

$$\frac{10.34}{28.26} = K \cdot \frac{4.1}{8} \quad K = \frac{10.34 \times 8}{28.26}$$

$$K = 0.731 \text{ cm}^2$$

⑤

$$\frac{10.34}{28.26} = K = \frac{2.5}{8} \quad K = \frac{10.34 \times 8}{28.26 \times 2.5}$$

④

$$\frac{6.057}{26.28} = k \cdot \frac{2.3}{8} = \frac{26.28}{8}$$

$$\frac{6.057 \times 8}{2.3 \times 26.28} = \frac{48.456}{60.44} = 0.8 \text{ cm}^2$$

$$= 0.170 \text{ cm}^2$$

③

$$\frac{6.057}{26.28} = k \cdot \frac{6}{8.1} = \frac{26.28 \times 8.1}{6}$$

$$\frac{6.057 \times 6}{26.28 \times 8.1} = \frac{36.34}{212.868} = 0.150 \text{ cm}^2$$

②

$$\frac{6.057}{26.28} = k \cdot \frac{10.1}{7} = \frac{26.28 \times 10.1}{7}$$

$$\frac{6.057 \times 7}{26.28 \times 10.1} = \frac{42.4}{265.428} = 0.167 \text{ cm}^2$$

$$= 0.167 \text{ cm}^2$$

$$\frac{144.54}{24.22} =$$

①

$$\frac{6.057}{26.28} = k \cdot \frac{5.5}{4} = \frac{26.28 \times 5.5}{4}$$

$$k = \frac{5.5}{4} \times \frac{26.28}{6.0577}$$

$$F \cdot Q = n \cdot \frac{\Delta h}{\Delta z}$$

$$F \cdot Q = n \cdot \frac{\Delta h}{\Delta z} = k' \cdot f =$$

$$Q = n \cdot \frac{\Delta h}{\Delta z}$$

$$Q \propto \Delta h$$

$$F \uparrow$$

$$\frac{14.50}{24.77} = \frac{1.70}{26.28}$$

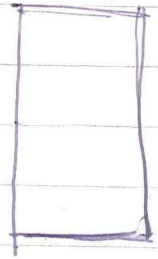
$$\frac{152}{24.77} = \frac{6.0577}{26.28}$$

$$\textcircled{5} \quad \frac{6.057}{26.28} = K \cdot \frac{1.5}{8} = \frac{6.057 \times 8}{21.5 \times 26.28} = \frac{48.456}{39.42} = 1.23 \text{ cm}^2$$

$$\boxed{S = \frac{m}{V} =}$$

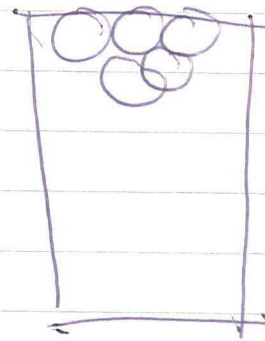
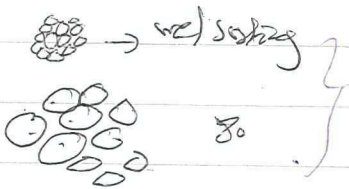
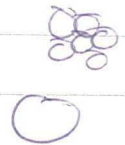
$$V = \frac{\pi}{4} d^2 h =$$

Fine sand $V =$



$$\rho = 2.6 \text{ g/cc} = S$$

$$V = \frac{\pi}{4} \times 6^2 \times h_1$$



∅ Fine sand

$$V_F = \frac{\pi}{4} \times 6^2 \times 15 = 423.9 \text{ cm}^3$$

$$\square \quad m_F = S \cdot V = 2.6 \times 423.9 = 1102.14 \text{ gms}$$

(Coarse sand)

$$V_C = \frac{\pi}{4} \times 6^2 \times 16.5 = 466.29 \text{ cm}^3$$

$$\square \quad m_T = S \cdot V = 2.6 \times 466.29 = 1212.357 \text{ g}$$

$$m_{F_T} = 1102.14 \text{ g}$$

$$m_{F_A} = 586 \text{ g}$$

$$m_{C_T} = 1212.35 \text{ g}$$

$$m_{C_A} = 781 \text{ g}$$

$$1102.14 \text{ g} \longrightarrow 423.9$$

$$586 \text{ g} \longrightarrow x \quad V_{F_A}$$

$$x = \frac{586 \times 423.9}{1102.14} = \frac{248405.4}{1102.14}$$

$$V_{F_A} = 225.384 \text{ cm}^3$$

$$\text{Porosity} = V_{F_T} - V_{F_A} = 1 - \frac{423.9 - 225.384}{423.9}$$

fine sand

$$= 1 - \frac{198.51}{423.9} = 1 - \boxed{0.468\%}$$

$$= 0.532 \approx 53.2\%$$

coarse sand: \rightarrow

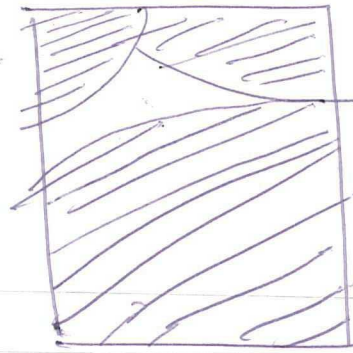
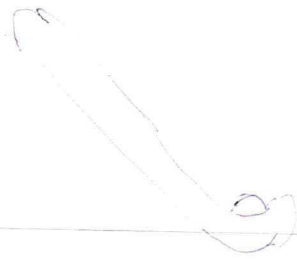
$$1212.35 \longrightarrow 466.29$$

$$781 \longrightarrow x$$

$$x = \frac{781 \times 466.29}{1212.35} = 300.385 \text{ cm}^3$$

$$\text{Porosity} = \frac{466.29 - 300.385}{466.29} = 1 - 35.57\%$$

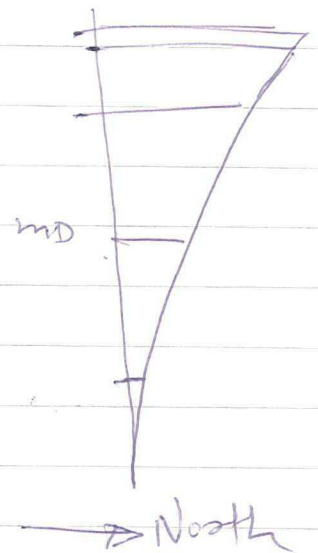
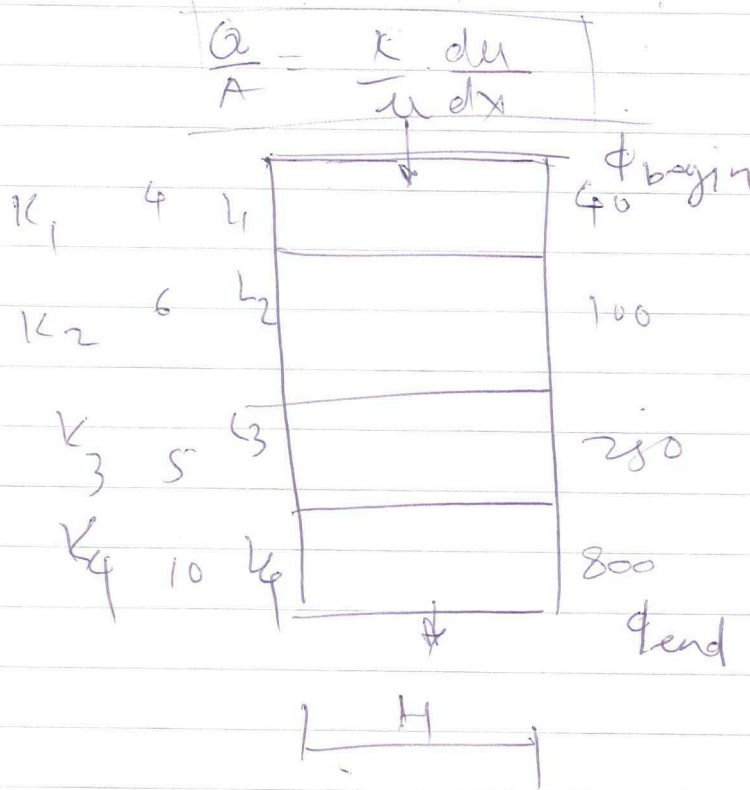
$$= 64.43\%$$



Theory of Physical hydrodynamics



lecture by
Susanne Rudolph



$$Q_{tot} = \frac{-\kappa_{avg}}{\mu} \cdot \frac{\Delta\phi}{L_{tot}}$$

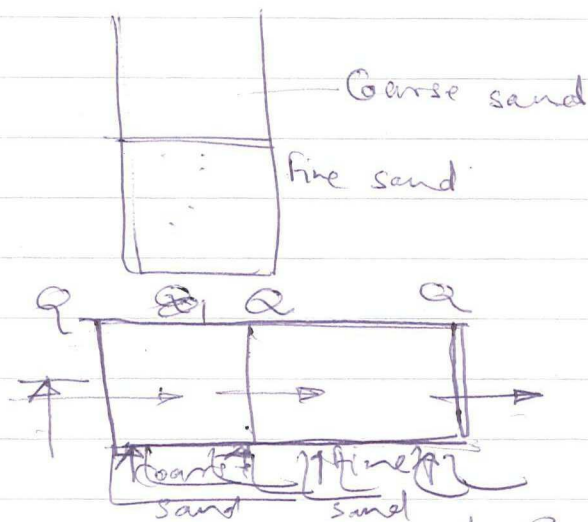
$$\Delta\phi_1 = q_1 \times L_2 \times \mu \quad \Delta\phi_2 = q_2 \times L_2 \times \mu$$

$$q_{avg} \frac{L_{avg}}{K_{avg}} = \left(q_1 \cdot \frac{L_1}{K_1} + q_2 \cdot \frac{L_2}{K_2} + q_3 \cdot \frac{L_3}{K_3} \right) h$$

$$q = q_{avg} = q_1 = q_2 = q_3$$

$$\frac{L_{total}}{K_{avg}} = \frac{L_1}{K_1} + \frac{L_2}{K_2} + \frac{L_3}{K_3}$$

$$K_{avg} = \frac{L_{total}}{\frac{L_1}{K_1} + \frac{L_2}{K_2} + \frac{L_3}{K_3}} \quad \text{Harmonic}$$



$$\psi_1 = p_1 + \rho g h$$

$$\psi_2 = p_2 + \rho g h$$

$$\psi_3 = p_3 + \rho g h$$

$\rho = 1000 \text{ kg/m}^3$ or m^2

(liquid in the layer between two solid particles covering bubble.

$$\frac{V}{4R_p^2} = 4 \frac{R_1}{R_p} \sin(\phi) \cdot \cos(\phi + \theta) - 2 \left(\frac{R_1}{R_p} \right)^2 \left(\left(\frac{\pi}{2} - (\phi - \theta) \right) \right.$$

$$\left. - \frac{\sin(2(\phi + \theta))}{2} \right) - 2 \left(\phi - \frac{\sin(2\phi)}{2} \right)$$

Ref (8)

Sussang Rudolph Course Rock Fluid Interaction

Boundary conditions during radial diffusivity equations
Laplace transform Bessel function

Difference between ~~numerical~~ ^{Analytical} solution & ~~Steepest~~ solution



wetting phase - nonwetting phase change

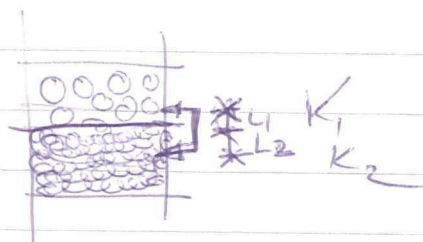
No question on Carman-Kozeny equation

Gedanken experiment thought experiment

Avg permeability derivation

Superposition theorem

multiphase flow capillary pressure



$$\phi \quad q = \frac{K}{\mu} \frac{d\phi}{dz} \quad \left| \quad Q = \frac{K}{\mu} \frac{d\phi}{dz} \right|$$

Water $\mu = 8.9 \times 10^{-4} \text{ Pa}\cdot\text{s}$

$= 8.9 \times 10^{-3} \text{ dyn}\cdot\text{s/cm}^2$

8.5

$$\frac{K}{\mu} = 0.167$$

$$K = 0.167 \times 8.9 \times 10^{-3}$$

$$8.5 \times 8.5 = \text{---} \rightarrow$$

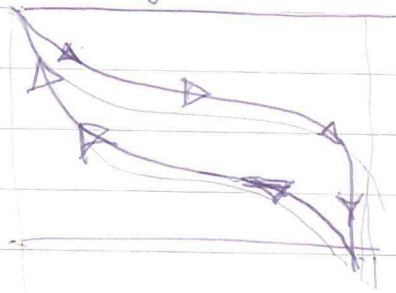
$$\left| \frac{Q}{A} = \frac{K}{\mu} \frac{\Delta h}{\Delta z} \right|$$

~~Q~~ $K = \frac{Q}{A} \cdot \mu \cdot \left(\frac{\Delta z}{\Delta h} \right)$

=

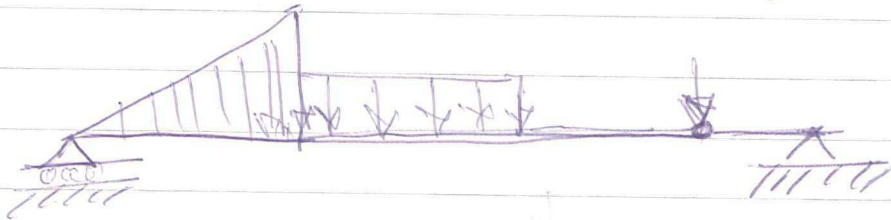
←: Rock fluid interaction :→

Mathematical modelling of fluidflow in porous media :A



Darcy's law

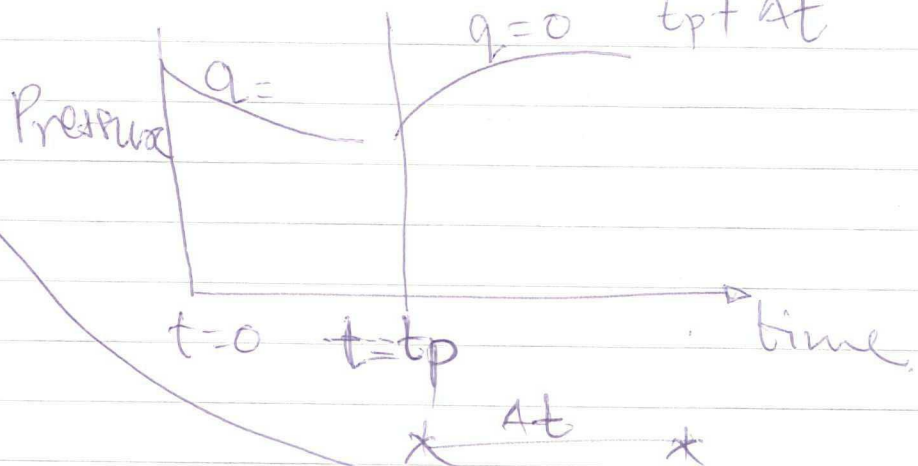
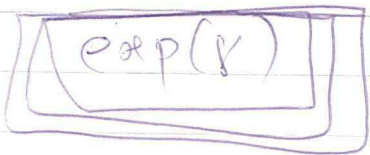
Capillary forces — wettability.



linear wave equation

$$P_D^s = P_D(t_{pD} + \Delta t_D) - P_D(\Delta t_D)$$

$$P_D(r_D = 1, t_D)$$



$$P_D = \frac{(P - P_i) 2\pi K h}{q \cdot B_o \cdot \mu}$$

$$t = \frac{K \cdot t}{\mu \cdot \gamma}$$

$$\frac{2\pi K h}{\mu} (P_1 - P_2) = q_1 (P_D (t_{Dn} - 0) + S) + (q_2 - q_1) (P_D (t_{Dn} - t_{D1}) + S)$$

\uparrow
 t_p

$$\frac{2\pi K h}{\mu} (P_1 - P_2) = \sum_{i=2}^n (q_2 - q_1) P_D (t_D - t_p) + q_2 S$$

At $t=0$ $P(r,0) = P_{ini}$

At $t=t_p$ $P(r,t_p) = - \frac{\pi K h}{q_1 B_o \mu} \left[\right.$

$$\left. \ln \left(4 \left(\frac{t_p \cdot K}{\phi \cdot C_{eff} \mu r_w^2} \right) \right) - \gamma \right] + P_{ini}$$

At $t = t_p + \Delta t$

$$\frac{2\pi K h}{\mu} (P_i - P_o)$$

$$P(r, t_p + \Delta t) = \frac{-\pi K h}{q_1 B_o \mu} \left[\ln \left(4 \frac{(t_p + \Delta t) \cdot K}{\phi \cdot c_{eff} \cdot \mu \cdot r_w^2} \right) - \gamma \right] + P_{ini}$$

$$\ln 0 = \gamma$$

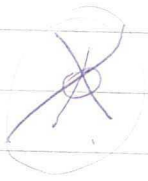
$$\frac{2\pi K h}{\mu} (P_{ini} - \frac{-\pi K h}{q_1 B_o \mu} \left[A \right] - \gamma) + P_{ini}$$

$$= q_1 P_D (t_D - 0) + S$$

Two phase flow with
(meetings)



Have Draining (one of the

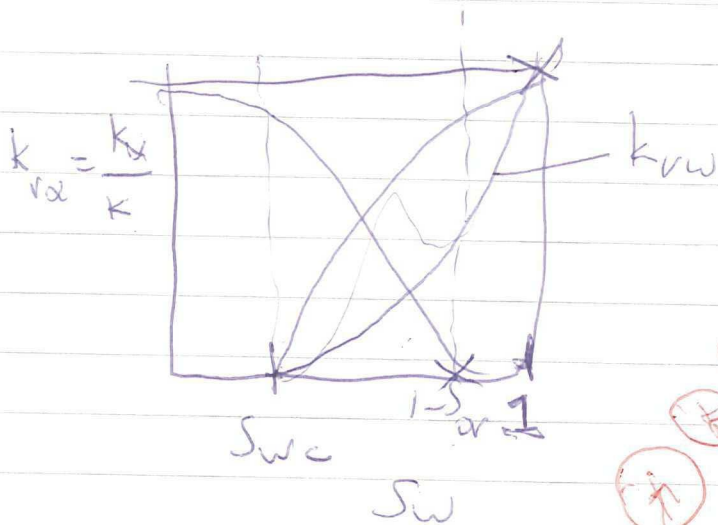
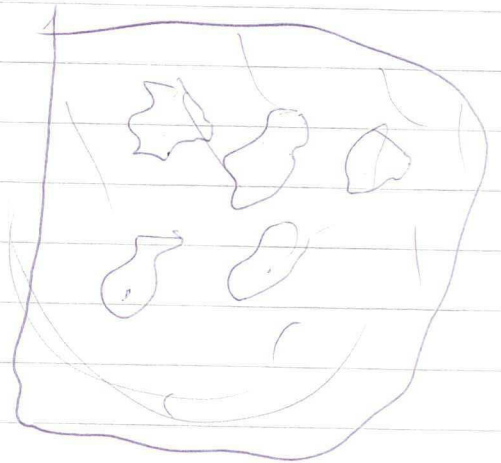
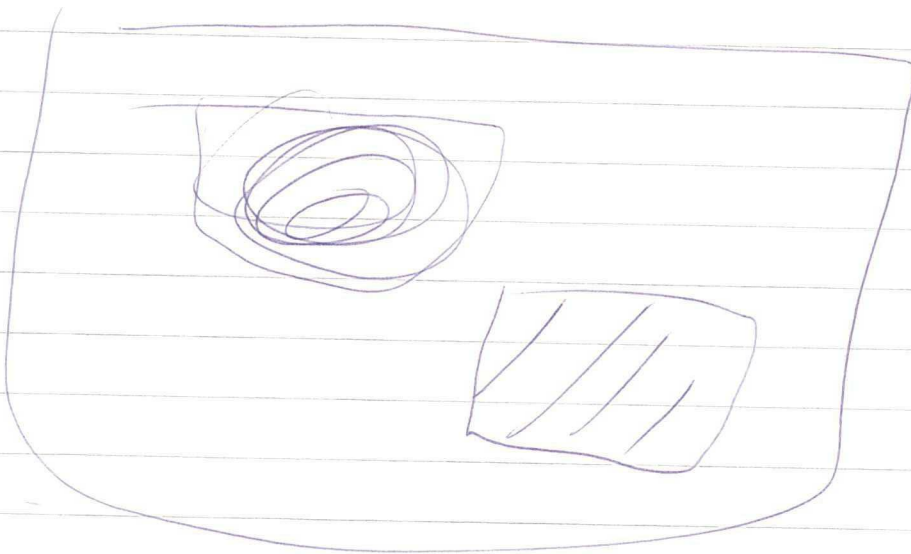
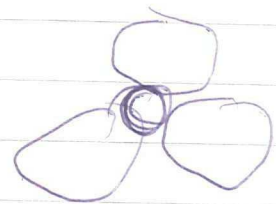
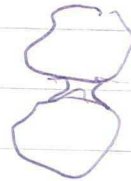


ϕ

porosity

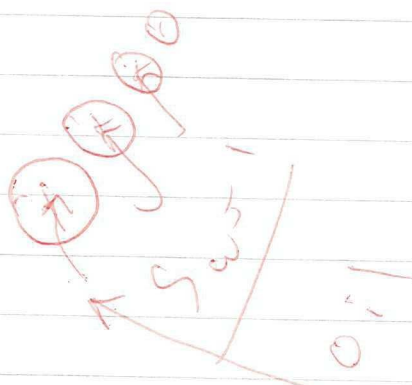
fraction of sand

~~4~~ ψ
thrive



$$k_{rw} = \left(\frac{S_w - S_{wc}}{1 - S_{wc}} \right)^{\frac{2}{\lambda} + 3}$$

$$k_{ro} = (1 - S_e)^2 (1 - S_e)^{\frac{2}{\lambda} + 1}$$



$$\frac{\partial p}{\partial x}$$

$$u = u_w + u_o = \left(-\frac{k k_w}{\mu_w} - \frac{k k_o}{\mu_o} \right) \nabla p$$

$$u_w = -\frac{k k_w}{\mu_w} \nabla p$$

$$f(x, y) = x^2 y$$

$$\left\{ \begin{array}{l} \frac{\partial f(x, y)}{\partial x} = \frac{\partial}{\partial x} (f(x, y)) \\ \quad \quad \quad = 2xy \\ \frac{df(x, y)}{dx} = 2xy + x^2 \frac{dy}{dx} \end{array} \right.$$

$$\frac{u_w}{u} = \frac{-\frac{k k_w}{\mu_w} \cancel{\nabla p}}{\left(-\frac{k k_w}{\mu_w} - \frac{k k_o}{\mu_o} \right) \cancel{\nabla p}} = f_w$$

Notes from Edited book on foam Chapter 1 physics of thin films

Forces due to ionic correlations from thin liquid films Chapter

$$\Pi \approx \Pi = \Pi_{vw} + \Pi_{el} + \Pi_{cor}$$

How to use this to determine nanoparticles sticking to bubbles

- Ask SIGMA about hydrophobic particles;
- Prepare a ~~short~~ document ^(after checking results) about our experiments ✓
- Send it to Krystare, Rowhi & Bill cc ✓
- Read Krystare's report. ✓

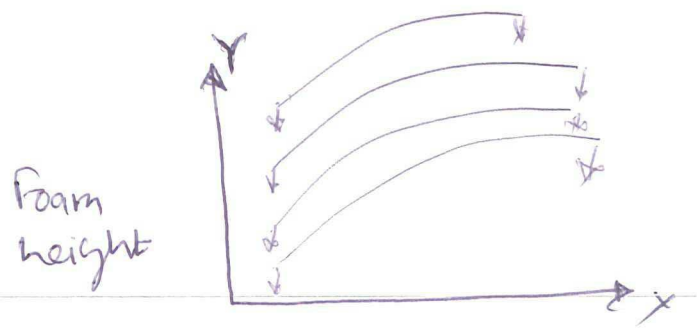
How can I use this book to the benefit of ~~our~~ our experiment.

- Check with Ellen & Han Henry about milli-Q water; water ✓ resin filtered & deionized

Why in our experiments height, no matter which with?

\$0.15 always gives lesser proportion of nanoparticle it is mixed

what is the permeability of our sand pack?



$$\frac{Q}{A} = \frac{K}{\eta} \frac{dp}{dz}$$

AES concentration

$$K = \frac{Q}{A} \cdot \frac{\eta}{dp/dz}$$

How to calculate viscosity of foam?

How to check ~~viscosity~~ viscosity of liquid with surfactant & nanoparticles — Grunberg - Nissan equation

~~Ubbelohde tube~~ Ubbelohde tube

How to measure the foam stability with respect to time?

AES — ?

Hallimond tube
buy

→ Du Noüy ring ? Critical micelle concentration

Bartsch technique for shaking?

Ellen

Tolanda

Gibbs Isotherm

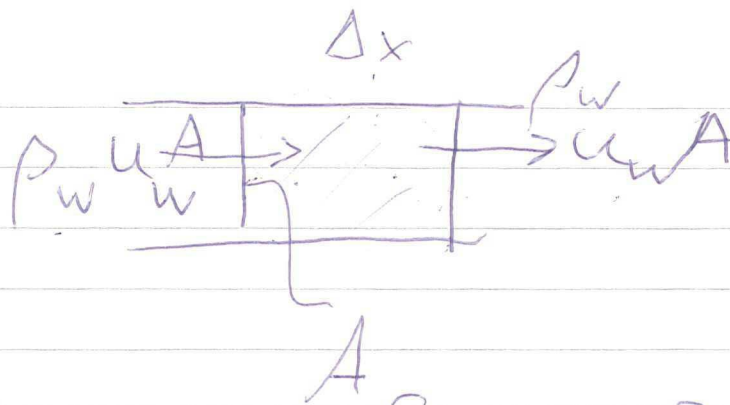
⊗

Surface tension (Nikos)

Cleaning the tube → What do we measure

→ Interfacial tension: of surfactant soln

mass balance Equation with Mass Burning



$$\frac{dm_w}{dt} = [\rho_w u_w A]_{in} - [\rho_w u_w A]_{out}$$

$\frac{\text{kg}}{\text{m}^3} \frac{\text{m}}{\text{s}} \text{m}^2$

$$m_w = \rho_w A \Delta x \phi S_w$$

$$\frac{d(\rho_w A \Delta x \phi)}{dt}$$

$$= [\rho_w u_w A]_{in} - [\rho_w u_w A]_{out}$$

$$\boxed{\phi \Delta x \frac{dS_w}{dt} = u_{w,in} - u_{w,out}}$$

$$\phi \frac{\partial S_w}{\partial t} = \lim_{\Delta x \rightarrow 0} \frac{u_{w,in} - u_{w,out}}{\Delta x}$$

$$\frac{S_w(t+\Delta t) - S_w(t)}{\Delta t} = \frac{u_{w,in} - u_{w,out}}{\phi \Delta x}$$

$$S_w(t+\Delta t) = S_w(t) +$$

$$\frac{(u_{w,in} - u_{w,out}) \Delta t}{\phi \Delta x}$$

15:00 Leegwater Overst 20

17/11/10

meeting with Ruhi &

Talk to Kryslaw

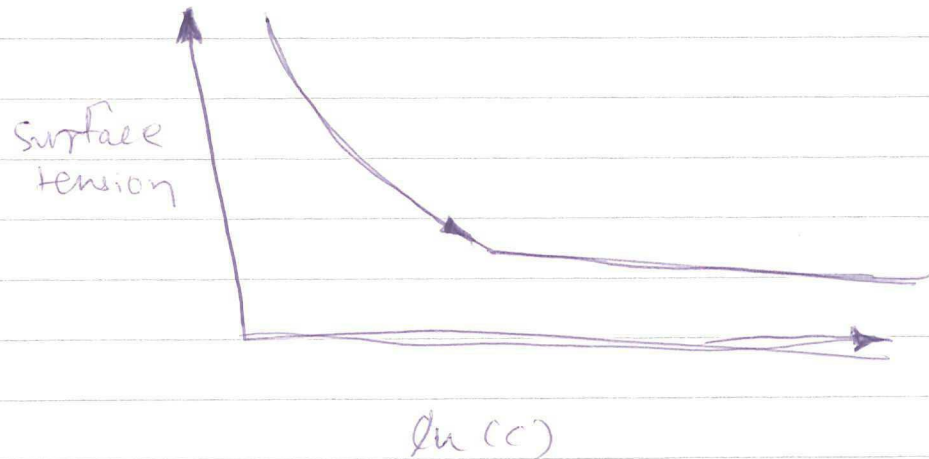
Less surfactant

Restrict to silica nanoparticles & porous media

Call sigma about hydrophobic particles

Permeability of our sand pack

* time dependence on the stability of the foam.



Rock Fluid Interaction: 2

Geo Cas

Lab 15 December

Buckley - Leverett flow ?

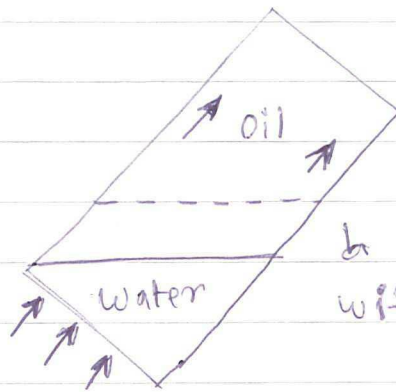
lot about saturation

Equilibrium between capillary forces & gravitational forces: →

X-dip mass balance: →

Connett Saturation ?

Interface angle



Interface moves with a fixed velocity

$$4 \times 4 = 16$$

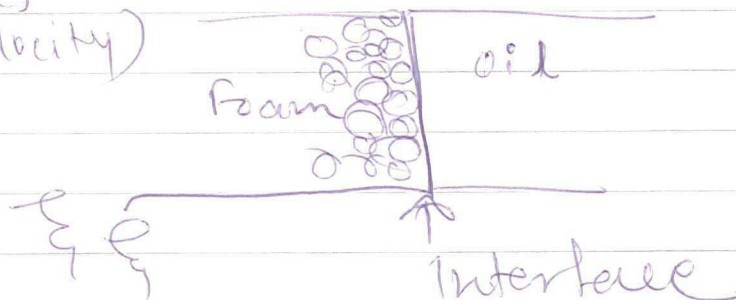
mobility ratio }
Gravity number } for stable interface

$$\frac{dy}{dx} = 0$$

Study relative permeability

{ 22nd Nov 2010

Correction in vesicular equilibrium: →
(characteristics curves & velocity)



{ { zeta

time & space

@ Dietz approximation

24/11/2010

Du Nouy Ring

Contact Ellen & Tolanda
for working with it.

Gibbs Isotherm : →

Surface tension

→ S.T. Vs Surfactant
Conc.

Done

Critical micelle concentration

Check doing experiment with ~~but~~ test tube following
thing (test tubes)

1. Clean it properly : →
2. Have only little liquid in the test tube : →

25/11/10

Du Nouy ring

~~At~~ 11 o'clock with

surface tension : → Interface tension : →

Critical micelle concentration

It is observed that nanoparticles are not that much
affecting the surface tension. ~~However~~ ~~the~~
increase in nanoparticles slightly decreases
surface tension.

29/11/2010

Interface models : \rightarrow
 Study Buckley-Leverette flow : \rightarrow
 Pseud-Dietz model \leftrightarrow Dake model

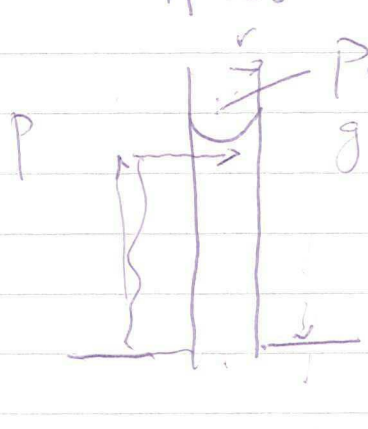
M: Viscous forces G: Gravitational forces

Surface tension measurement : \rightarrow

0.3 AS 0.075 SiO ₂	30.887, 31.02, 31.13
0.3 AS 0.15 SiO ₂	30.739, 30.83, 30.785
0.3 AS 0.3 SiO ₂	30.322, 30.520, 30.50
0.15 AS 0.075 SiO ₂	30.068, 30.25, 30.46
0.15 AS 0.15 SiO ₂	29.887, 30.05, 30.2
0.15 AS 0.3 SiO ₂	29.85, 30.07, 30.4
0.075 AS 0.075 SiO ₂	29.332, 29.633, 30.39
0.075 AS 0.15 SiO ₂	29.199, 29.71, 30.4
0.075 AS 0.3 SiO ₂	29.46, 29.75, 30.40

Nikos \rightarrow ^{contact} ~~surface~~ angle measurement
 Contact Henry for DAS
 ULL

Contact angle measurement of nanoparticles
 pp.128 Nanoparticle technology handbook.



$$P_g - P_g g h$$

$$P_g - P_g g h - \frac{2\sigma \cos\theta}{r}$$

$$P + P_g z$$

$$U = \frac{r^2}{\rho \mu} \frac{\Delta \phi}{\Delta r}$$

$$= \frac{r^2}{\rho \mu} \left(\frac{\partial P}{\partial z} + \rho g \right)$$

$$= \frac{P_g g \frac{2\sigma \cos\theta}{r}}{\rho \mu} + \Delta P g$$

What happens with particle size on the ability silica to absorb water.

Overbeck reference

Dynamic surface tension

Read Kamr, Ali, Florence paper reference
of Florence

Nguyen : Chapter 5

~~How to form~~

How to calculate ~~from foam~~ limiting capillary pressure?

Study of relative permeability for our studies?

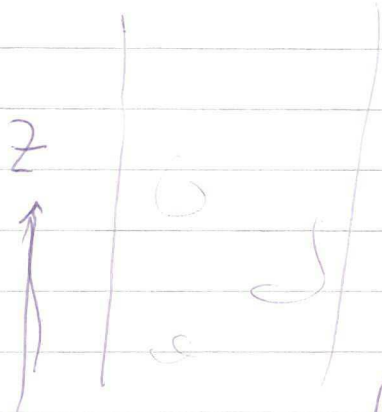
Permeability values for different liquids (air, nitrogen, demineralised water, mine, surfactant added, surfactant + nanoparticles added, nanoparticle added etc.

How can we use CT scan for our applications.



Two phase flow with Hans Bruining

$$u_w = - \frac{k k_{rw}}{\mu_w} \left(\frac{\partial p_w}{\partial z} + \rho_w g \right)$$



$$- \frac{u_g \mu_g}{k k_{rg}} \rho = \left(\frac{\partial p_g}{\partial z} + \rho g \right) \approx 0$$

$$u_w = - \frac{k k_{rw}}{\mu_w} \left(\frac{\partial p_w}{\partial z} - \frac{\partial p_g}{\partial z} - \rho_g g + \rho_w g \right)$$

$$u_w = \frac{k k_{rw}}{\mu_w} \left(\frac{\partial p_c}{\partial z} - \Delta \rho g \right)$$

$$p_c = \sigma \cos \theta \sqrt{\frac{\phi}{k}} J(L_w)$$

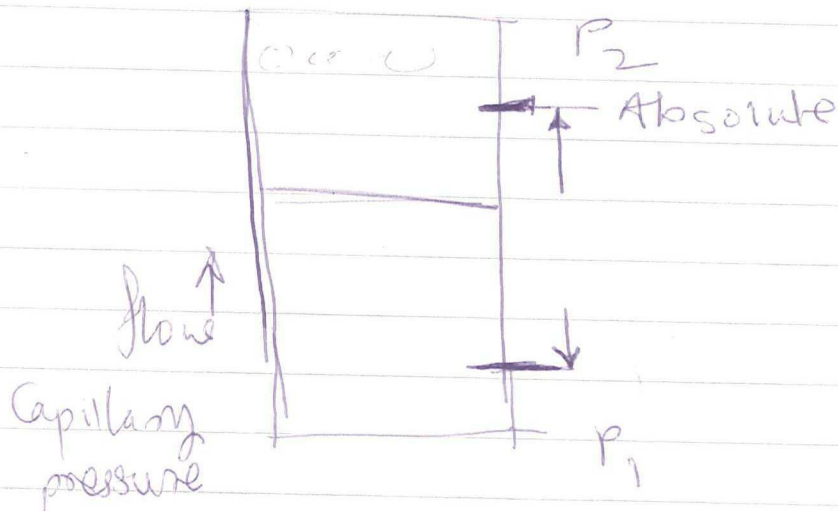
$$k = \frac{1}{150} \frac{\phi^3}{(1-\phi)^2} d_p^2$$

$$p_c = \sigma \cos \theta \frac{(1-\phi) d_p}{\phi} J(L_w)$$

Notes on Report Araydin & Kovscek (2000)

what is the porosity of our sand pack ϕ

① Saturation profiles : How to build (10 min, 5)



(Pressure difference between water & air)

what is gas breakthrough (pressure) condition

Can we measure the absolute pressure at the points ~~there~~ instead of pressure difference?

Transient foam displacements

Study multiphase flow

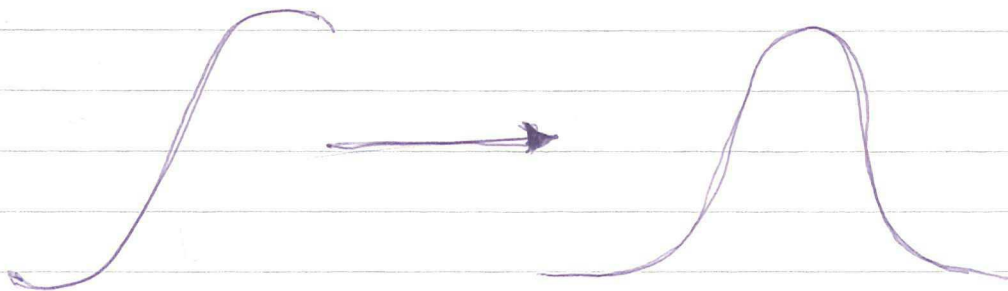
Measurement of bubble size at exit

Production for Dietz/Dake model

Google Dietz model

Interface model vs BL model
(Dietz - Dake)

Vertical equilibrium condition



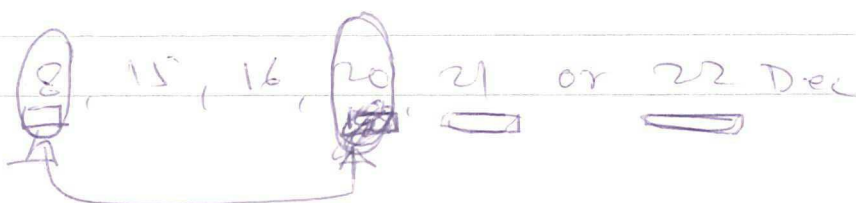
Stiles method → assume everything is simplified

$$P_c = P_o - P_w$$

$\frac{\partial P_w}{\partial x}$ change in ^{water} pressure in x direction

Incompressible two phase flow

Bill



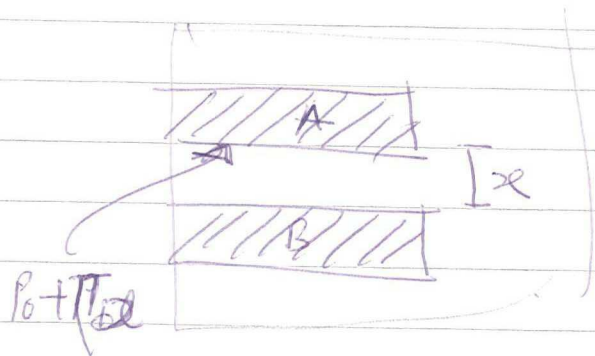
Capillary pressure in porous media from wikipedia

P_c is the force required to squeeze a hydrocarbon droplet through a pore throat (works against interfacial between oil & water tension) and is higher for smaller pore diameter. The Brooks-Corey correlation for capillary pressure reads

$$P_c = c S_w^{-a}$$

Revised J-function $J(S_w) = \frac{P_c(S_w) \sqrt{K/\phi}}{2 \cos \theta}$

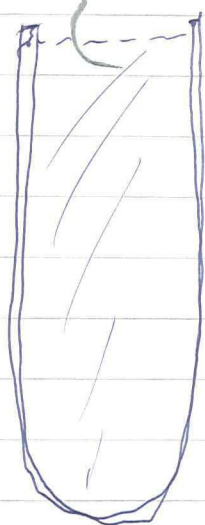
Disjoining pressure $\Pi_D = \frac{1}{A} \left(\frac{\partial G}{\partial x} \right)_{T, V, A}$



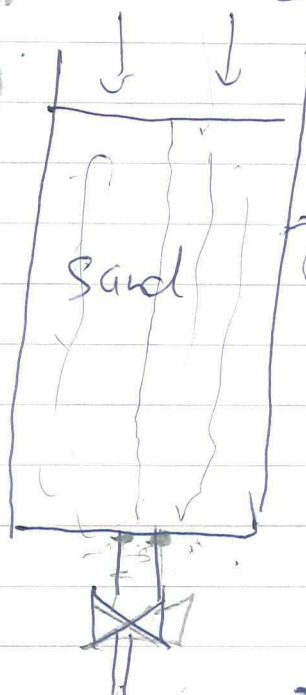
IBIS Stuttgart airport Hotel € 59 ✖
 Airport Hotel restaurant

Jacques Joesten (197...)
 Adv. Chemical Physics
 Laser Light Scattering

Vry



Scattering



bichromate
sulfuric
acid.

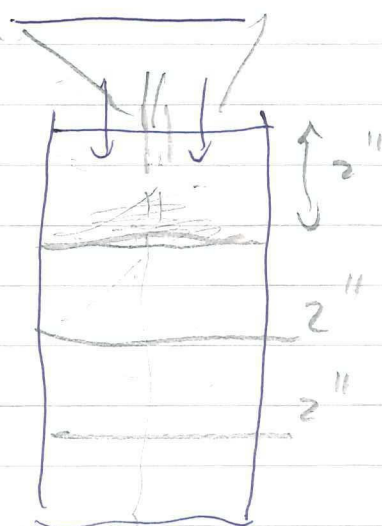
doubly
distilled
water.

glass
tube

Wysal
SPEJ

toluene

Dean Stark
extraction



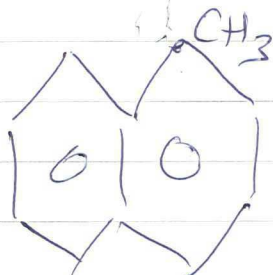
2 liters.

Ellen

{ fill with bichromate
sulfuric acid

leave for 24 hours.

then rinse with
doubly distilled
water until
pH is normal
of effluent



Rinse with HCl
solution

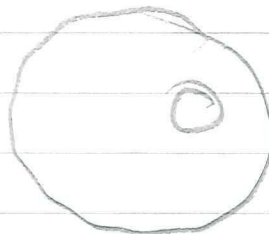
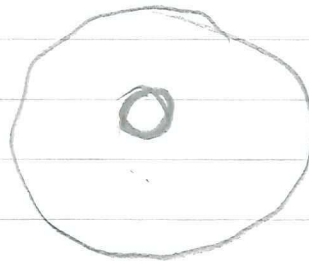
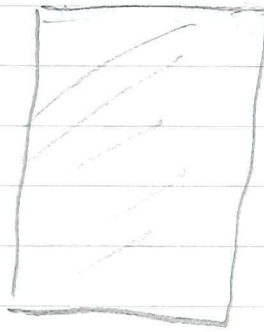
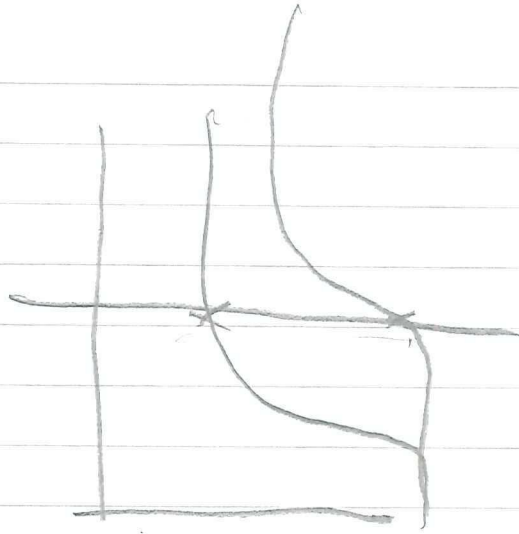
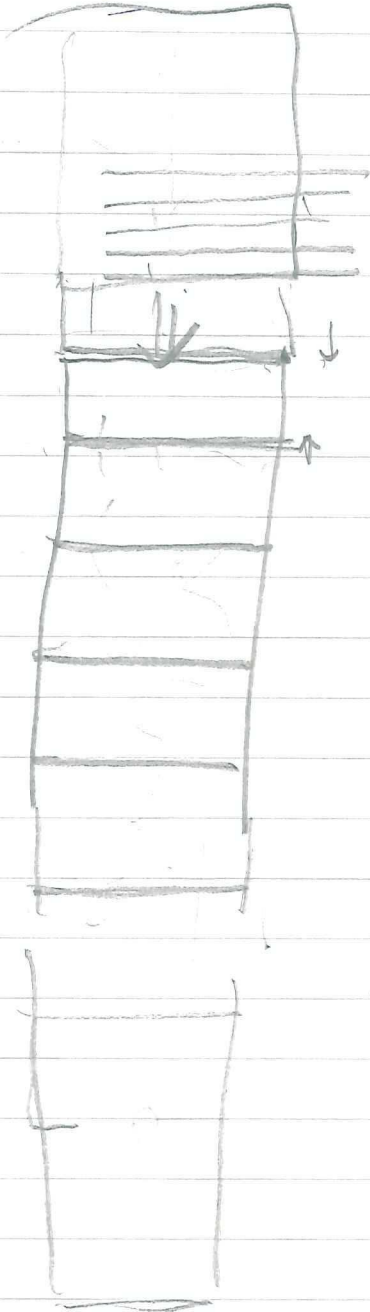
Rinse with water

Surface viscosity is higher in case of ~~water~~ surfactant added ~~and~~ brine ~~to~~ water.

How to calculate distribution of our surface-active material on the moving liquid surface (to determine surface forces) PP. 392 Levich

to find the velocity distribution, it is necessary to know the forces acting on the liquid surface i.e. the distribution of surface-active material.

PMA.



345
+

Surf

Viscosity measurement

$$\begin{array}{r} 287 \\ \times 28 \\ \hline 2296 \\ 2296 \\ \hline 7036 \end{array}$$

$$\begin{array}{r} 287 \\ \times 3 \\ \hline 861 \end{array}$$

703.6

Demineralized water

500

(i) Pilot expt

$t = 285 \text{ sec}$

Kinematic viscosity $\nu = K(t - u)$ Consider for now
 $= 0.0028(285)$ as 0.003×10^{-3}
 $= 0.470 \text{ mm}^2/\text{s}$

$K = 0.002862$

$= 0.47 \times 10^{-6} \text{ m}^2/\text{s}$

$$\begin{array}{r} 31 \\ 1431 \\ 2862 \\ \times 345 \\ \hline \end{array}$$

~~should~~ should be around

20°C to 30°C
1 or $0.8 \times 10^{-6} \text{ m}^2/\text{s}$

(2)

$$\begin{array}{r} 14310 \\ 114480 \\ 858600 \\ \hline 907390 \end{array}$$

$t = 287 \text{ sec} \times 0.003$
 $= 0.0028 \times 287$
 $\approx 0.8 \times 10^{-6} \text{ m}^2/\text{s}$

Temperature measured at 21°C on 2:30 pm

(3) $t = 345 \text{ sec}$

$t = 285 \text{ sec}$

$= 0.98 \times 10^{-6} \text{ m}^2/\text{s}$

(4) $t = 345 \text{ sec}$

$1.03 \times 10^{-6} \text{ m}^2/\text{s}$

Kinematic viscosity of water at 19°C

at 10°C 1.307, at 20°C 1.004

So $\frac{1.307 - 1.004}{10 - 20} = \frac{x - 1.004}{19 - 20}$

$\frac{0.303}{10} = \frac{x - 1.004}{-1}$

$-0.0303 + 1.004 = x$

$x = 0.9737$

$$\begin{array}{r} 1.0040 \\ - 0.0303 \\ \hline 0.9737 \end{array}$$

13 Dec 2010 (Viscometer)

1) 0.075% AS-40 ~~AS-40~~ + 0.075% SiO₂

A ~~AS-40~~ t = 373 sec

temp = 19.5°C

t = 374 sec

t = 375 sec

t = 365 sec

20°C

20°C

2.41

2.862

x 373

8586

200340

858600

1067.526

373 → 20

→ 19

$$\frac{373 \times 19}{20} = 354$$

1.067 mm²/s

14 Dec 2010 (Viscometer)

2) 0.3% AS-40 + 0.3% SiO₂

t = 6 min 25 sec

385 sec

20°C

$$\frac{19 \times 385}{20}$$

20 → 385
19 →

3) 0.15% AS-40 + 0.15% SiO₂

t = 6 min 7 sec

366 sec

18.5°C

0.075

0.15

0.3

19°C

354 →

366 →

385

354 → 366 → 385

Viscosities of ~~the~~ water with surf/nano par. 19°C

Brine - 345 sec

0.98739 mm²/s

0.075 - 0.075 - 354 sec

1.013148 n

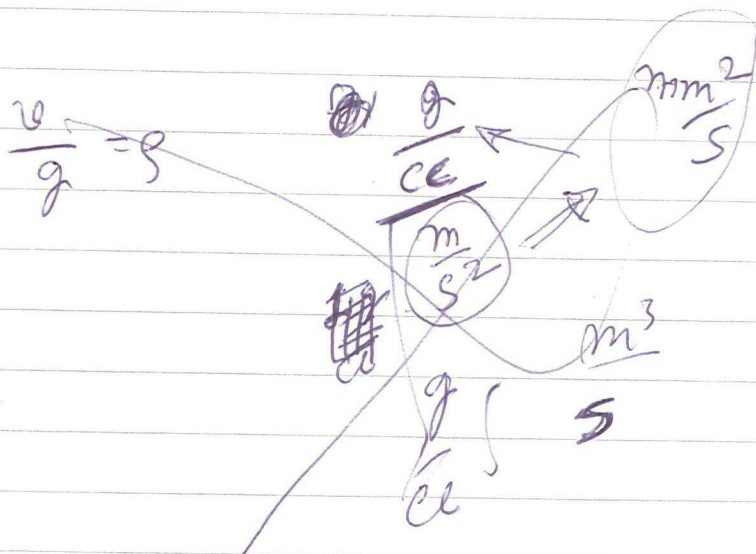
0.15 - 0.15 - 366 sec

1.047492 n

0.3 - 0.3 - 385 sec

1.10187 n

mm² × 10³ m



20/Dec/2010

No Back pressure

(why don't we get

Flow experiment (Re-run) any reading while the flow rate is low?
Initial reading when it was not flowing

ml/h	PD
50	0.2
75	0.4
100	0.4 - 0.5
150	

Bill Rossen meeting

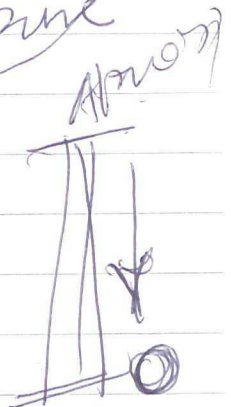
$$u_{\text{foam}} + u_w = \frac{\Delta P}{\Delta x} \left(\frac{k_w}{\mu_w} + \frac{k_f}{\mu_f} \right)$$

$$\Delta P = \frac{(u_{\text{foam}} + u_w) \Delta x}{\left(\frac{k_w}{\mu_w} + \frac{k_f}{\mu_f} \right)}$$

$$u = \frac{k}{\mu} \frac{dP}{dz}$$

Atmospheric pressure

$$\frac{d\phi}{dz}$$



$$u = \frac{k}{\mu} \frac{1.01325}{0.8}$$

$$\frac{q}{\text{sec}} = \frac{k}{\mu} \frac{1.01325}{0.8}$$

$$\phi = P_1 + 892$$

11 Jan 2011 11:54

Back pressure (20 bar)

Permeability Expt with new system

Double distilled water

Test 005

Q ml/hr	ΔP (mbar)	P_1	P_2		
50	0/1	20.8	20.15		
100	1	21.1	20.52		0.3
150	1	21.3	20.70		0.4
200	2	21.4	20.7		1.2
250	4	21.5	20.88	0.5	1.5
300	4	21.7	21.07	1.0	2.0
350	4	21.7	20.88	1.4	2.4
400	4	21.6	20.88	2.9	2.9
450	5	-	-	3.4	3.4

Q ml/hr	Instrument ΔP (mbar)	Computer P_1 bar	P_2 bar	Instrument ΔP mbar	Water
0	1	17.8	17.04	0.1	
50	7	20.7	20.15	0.7	
100	11	20.6	19.97	1.1	
150	15	20.6	19.97	1.5	
200	20	20.4	19.79	2.0	
250	23	20.4	19.79	2.3	
300	28	20.3	19.60	2.8	
350	32	20.3	19.6	3.2	
400	35	20.3	19.6	3.5	
450	40	20.3	19.6	4.0	
400	37	20.3	19.6	3.7	
350	32	20.2	19.60	3.2	

$$q = 0.38$$

$$q = 50 \times 10^{-6}$$

~~0.38~~

$\boxed{\text{WE of Sand in Reactor}} = 1471.75$ with sand
 $- 1395.50$ without sand
 $\hline 0076.25 \text{ gm}$

Ⓢ

2.70
 21.07 Ⓢ
 6.63 bur

300	28	20.1	19.42	2.8
250	24	20.1	19.42	2.4
200	20	20.0	19.42	2.0
150	16	20.0	19.42	1.6
100	12	20.0	19.42	1.2
50	4	19.2	18.69	0.3
0	2	19.0	18.50	0.3

~~11th~~ Jan 11 Experiment with foam

60 ml/min

0.9 ml/min

0.9 x 60 = 54 ml/hr

Eypt started 11:29 am

30	10	21.1	20.34	1.0
50	15	23	22.35	1.5
100	21	24.3	23.45	2.1
150	27	24.7	24.00	2.7
200	32	25.1	24.37	3.2
250	38	25.2	24.37	3.8

30

1.8 ml/min x 60

10.8 ml/hr

72 ml/min hr

36 ml/hr

720 ml/hr

72 ml → 60 min

72 → 60 min

$\frac{72}{60} = 1.2 \text{ ml/min}$

12 ml x 60

720 ml/hr

$+ 36 \text{ ml/hr}$
 $\hline 756 \text{ ml/hr}$

20

0.9 ml/min $\times 60$ 54 ml/hr Nitrogen
~~72~~ 72 ml/hr Liquid

0.45 ml/min $\times 60$ 27 ml/hr Nitrogen
~~54~~ 54 ml/hr Liquid //

~~30~~ $\frac{3}{37}$

~~27~~

~~9~~ $\times \frac{1}{2}$
~~54~~

1:2

Increase & decrease in the ~~rate~~ PdT
 inadequate gas to form foam

↓

0.9 ml/min $\times 60$ 54 ml/hr Nitrogen
~~36~~ 36 ml/hr Liquid |

~~27~~

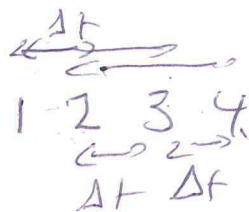
3:2

60:40

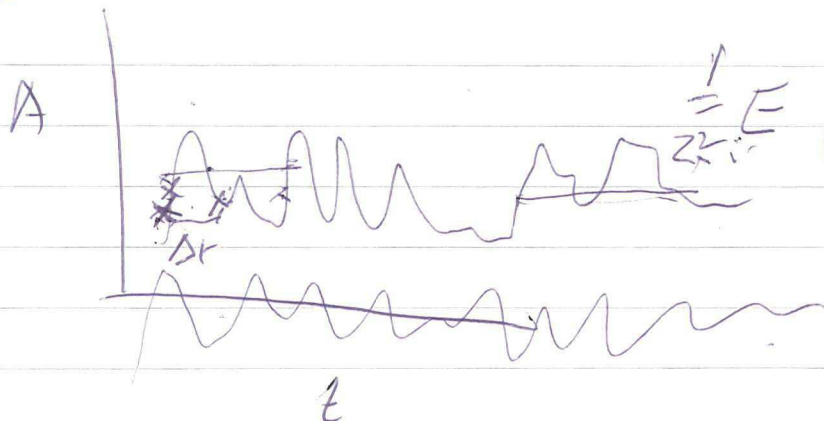
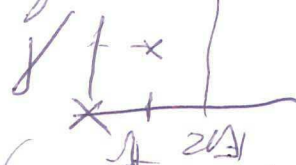
Gas : Liquid

0.45 $\times 60$ = 27 ml/hr
 36 ml/hr

Howing Hqs
the experiment



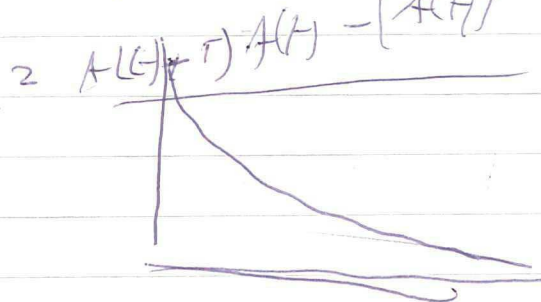
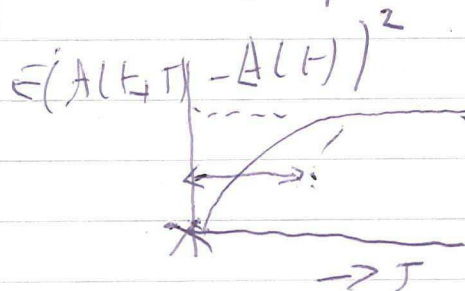
variogram



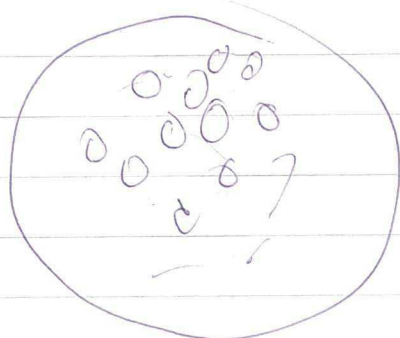
$$\frac{1}{2\Delta t} E \left(A(t + \Delta t) - A(t) \right)^2$$

$$E \left(A(t)^2 \right) - \left[E(A(t)) \right]^2 = \text{variance}$$

$$E \left(A(t + \tau) A(t) \right) - E(A(t))^2$$



$$P(H) q(t)^{+T}$$



Pres - Vettuliy.

Numerical Recipes
spectral density

12/01/2011

~~45~~ 45

0.075 AS-40 performance with different pressure
at 20 bar regular pressure

Q	ΔP	P ₁	P ₂	ΔP	
100	18.5	22.8	22.1	1.8	
150	35	24.2	23.42	3.5	1.7 8.1
200	45	20.7	20.15	4.5	1.0
250	73	21.4	20.70	7.3	2.8
100	6	21.8	20.7	8.6	
300	88	20.8	20.15	88	1.5
350	9.4	20.6	19.5	9.4	0.6

17/01/2011

Trying again to flow 0.075 AS-40 ~~again~~ through porous media

$$\frac{27}{32} \frac{2}{l} = \frac{9}{12} = \frac{3}{4} \quad 3:4$$

velocities m/day

Effective viscosity

$$\frac{K}{\mu} \frac{\Delta P}{L} = \frac{Q}{A}$$

1/2 ml/min

$$\frac{10^{-11}}{\mu} \frac{10^4}{0.1} = \frac{0.5 \cdot 10^{-6}}{60} \cdot \frac{1}{\pi \left(\frac{0.03}{2}\right)^2}$$

$$\Delta P = 1/10 \text{ Bar}$$

$$\text{Dia: } 3 \text{ cm}$$

$$K: 10 \text{ darcy?}$$

$$\frac{60 \cdot 10^{-6}}{0.5 \cdot 10^{-7}} \pi \left(\frac{0.03}{2}\right)^2 = \mu$$

$$12 \cdot 10 \pi 10^{-4} (1.5)^2 = \mu$$

$$10^{-2} \pi 2.5 = \mu$$

$$\mu \approx 0.07 \sim 70 \text{ cP}$$

$$0.7 \text{ cP}$$

$$1000 \cdot 2$$

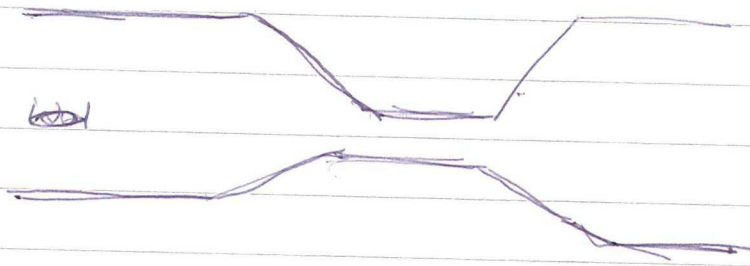
$$PS \quad 1000(9.8) \cdot 0.1$$

$$1000 \text{ Pa}$$

$$100,000$$

$$10$$

Fluid dynamics problem



No Capillary effect, ~~only~~ gravitational on

Below Reynold's number

① Easiest possible studies water through converging & diverging section

② water with surfactant

③ water with ~~nanop~~ particles in it (like blood)

④ Water with nano particles in it

⑤ Water with mixture of surfactant & nanoparticles

~~One:~~ → No Capillary effect, but gravitational

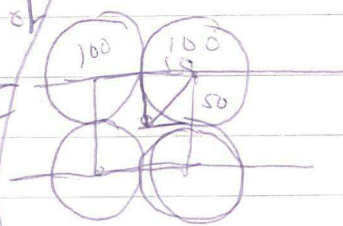
- + Procedure of changing the particle wettability
- + Tests for particle characteristics
- + ASK Rohi Ronhi for nano particles

Change particles with pH change
~~at~~ silane

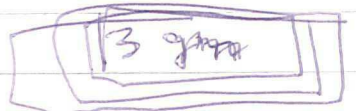
258

See in the literature about permeability with surfactant:

- Gas permeability expt
- Coating of Si & Ash particles
- Contact angle
- To test hydrophilicity of the particle



Grain size distribution & Zeta potential of 3 μm



$$50^2 + 50^2 = x^2$$

$$2(50)^2 = x^2$$

$$\sqrt{2} \cdot 50 = x$$

— Work —

1. Characterisation of the particles, Ultrasonno centrifuge
2. Tue 2
week 3 \longrightarrow 10 days \longrightarrow Friday 12 Feb

Send Prof. Kraster list of experiments to be done during the stay

Particle size 14 nm

Batch 098K004g

85505 - 100 G

Centrifuge → Ultrasonic →

Coating

A1 TUDelt 85505 - 500 G

Batch # 129K0017

Surface area

$200 \pm 25 \text{ m}^2$ per g

~~7/28/17~~

~~1x10⁻⁶ m~~

~~DP = DP₁ + DP₂~~

Nanoparticle handbook PP. 141 last paragraph
on the stability of dispersion of nanoparticles
in fluid. vimp

Static Interaction between particles +
fluid motion //

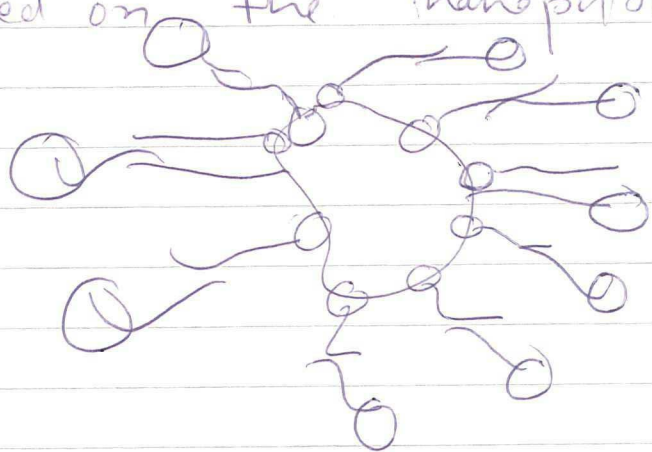
Dispersion is stable when the maximum peak
is large enough, e.g. $2kT$ — temperature
↑ Boltzmann constant

$$1.38065044 \times 10^{-23} \times (293) \times 20$$

surfactant adsorbed on the nanoparticle

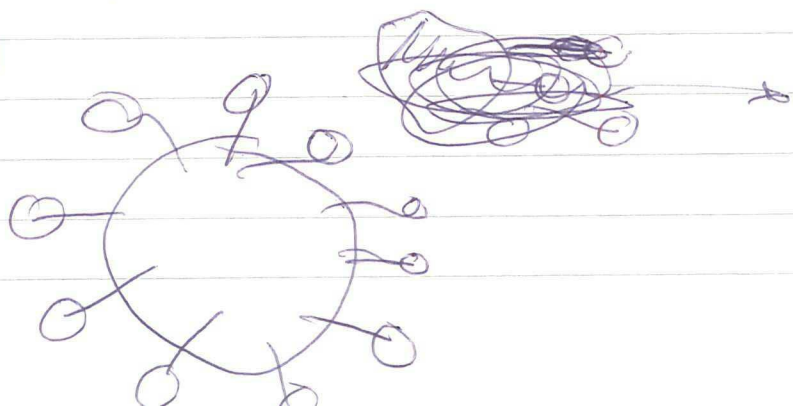
~~Hydrophobic~~ particles
hydrophilic

pH value of SiO₂
Expt.



hydrophobic particles

~~change~~



Dietz & Bonghe

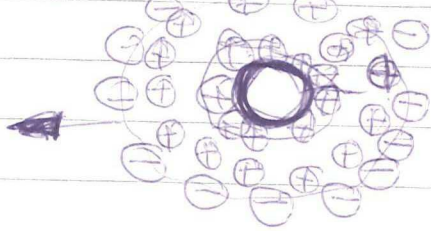
- (1) ~~water~~ controlling the drainage of water from the liquid film
- (2) Controlling gas permeability through the liquid film

Surfactant for our c.m. check Z. potential

In case of CTAB;

~~As the water~~ with more dilution, zeta potential shifts from +ve to -ve

What does it mean to have -ve zeta potential



+ve or -ve

~~What~~ ~~sto~~ what zeta potential would we want to have our system stable?

large number of zeta potential means ~~they~~ ^{particles} have large number of ions (+ve or -ve) around them, hence they are separated from other particles.

In case of AOs we need to have polymer layer on the particles to make them ~~to~~ bound with surfactant and make them work hydrophobic.

Experimentation Analysis

① 2.5 mg/ml SiO_2 + 4.88 mg/ml PEI / $1.01 \text{E}-4 \text{AOS}$
27 ml -
2.5 mg/ml SiO_2 + 10 mg/ml PEI / $1 \text{E}-4 \text{AOS}$
31.6 ml -

2.5 mg/ml SiO_2 + 10 mg/ml PEI / $1 \text{E}-5 \text{AOS}$
38.4 ml

2.5 mg/ml SiO_2 + 4.88 mg/ml PEI / $1 \text{E}-4$ 1
34.5 ml

(.5 mg) ml SiO_2 + 4.88 mg/ml PEI / $1 \text{E}-5$ ^{ohne} surfactant
48.0

Polyethylene Imine

Ultrasonic needs to be done for 1 hr, not 30 min
and it is needed to be done before mixing
with PEI or surfactant.

Ash particles (nm) ^{form colloidal solution} ~~do not~~ ~~disperse~~ no matter
how much ultrasonic you do. Silica particles (nm)
however ^{remain} do form nice colloidal soln and
~~remain~~ that way for long time (like months.)

We want lesser concentration of everything to
be able to get stable ~~colloidal~~ colloidal solution.

10-11 Zeta potential ~~is~~ not occupied: →

We need to check different surfactant combinations or we can see

2.5 mg/ml SiO_2 (NO PEI) with surfactant 1E-3 M CTAB 1.0×10^{-3}
28.

maximum zeta potential value is for AOS -70 .
(Negatively charged)

zeta potential for CTAB particle only ~ 60
(positively charged)

I get +ve or -ve zeta potential depending on the electrical charge ~~on~~ ~~surface of~~ coating particle

carries.

for certain cases, increase in PEI increases zeta potential in 2.5 mg/ml SiO_2 of 1E-3 M AOS!

Ash particles — Characterisation
 SiO_2 — Suitable

Tuesday 4 PM

Experiments with ash particles

10:38 Started.

- ① 10:40 ~~10:4~~ 2 -
- ② 10:48 10 -
- ③ 10:58 20 -
- ④ 11:18 40 -
- ⑤ 11:58 80 -

Ideally after this ~~start~~ ultrasonic bar 30 min

~~20~~ in a petridish 2 min

Composition of ash particles

Shaking expt with Ash particles with / without PEI

weighing of ash particles : →

2 min	0.0030 g	50
10 min	0.0026 g	
20 min	0.0070 g	
40 min	0.0105 g	
60 min	0.0290 g	

0.2 gms or 0.2 gms?

finding how much ~~ash~~ ash particles left after 2 days @ in those ~~test~~ test tubes.

mix the particles very well. before taking samples

Shake

2

30 min

15:45

+ 30

15:48 15:50, 16:00

16:20

16:48

17:18

15:45

~~17:00~~

~~17:20~~

17:38

2

20

32

~~60~~ 60

80

100

~~Start~~

Ash particles with PEI and surfactant (AOS)

~~0.03 wt%~~

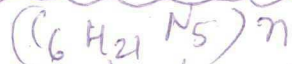
(0.03 wt% + PEI + AOS)

~~Same~~ Experiments with silica particles same as Ash particles

1.9960 gms
min) ~~2.0050 gms~~ 1.9946 gms
min) 2.0010 gms
min) 1.9990 gms
min) 2.0050 gms
min) 2.0020 gms

let.

Ash + PEI + AOS



PEI Polyethylenimine 100 g

Preparation of coated particles

2 Ash particles 2.5 mg/ml ~~so so for 50 ml~~

2.5 g/l

0.25 g/100 ml



4.88 mg/ml

4.88 g/l

0.488 g/100 ml




Mix. 0.488 g of PEI in 100 ml total 100 gm


1) Ultrasonicate for 10 min to ~~mix~~ dissolve PEI properly.

2) Put 0.25 g of ash particles in the soln. (Take only 0.25 g of soln first so that the whole soln would be equal to 100 g)

3) Put into ultrasonic for 20 min

4) ~~Vibrating~~ Putting the soln in  and putting it in vibrator

5) Putting the bottle in a tumbler for 30 min for mixing

6) Putting the sample into two  and centrifuging it 3500 rpm for 30 min

7) Put out the water, put 50 ml water so that you get the same amount soln as before

8) Ultrasonic for 5 min

9) Vibrate / tumble it for ~~10 min~~ 10 min

10) Centrifuge 5 min

11) from step 7 to 10 do it 3 times

Vibration

After ~~measuring~~ ~~the~~ taking two sample check the Zeta potential & particle size.
14:12 → 14:22 min

I have two 50 ml soln of 0.25 wt% Ash particles & hopefully coated with 0.48 wt% PEI. Next step is to coat these with Surfactant. (AOS & CTAB) The procedure is as follows.
 AOS & CTAB

① Ultrasonic for 30 min ~~both~~ both 50 ml bottles
 Started 14:50 → 15:20

② Out of these @ two 50 ml ~~bottles~~ I put 10 ml bottles and let it into centrifuge at 3500 rpm for 30 min. 15:33 → 16:00

40 wt of AOS

1 ml → 0.4 gm of AOS

x → 1 gm of AOS

$$\frac{1 \times 1}{0.4} = x = 2.5 \text{ ml}$$

5 ml contains 1 gm of AOS

2.5 ml of AOS for bull concentration

~~2.5~~ 0.3 wt% of AOS

0.25 gm of Surfactant

0.0366 ml @ in 50 ml

$$1 \text{ gm} = 2.5 \text{ ml}$$

$$0.25 \text{ gm} = x$$

$$x = 0.625 \text{ ml}$$

=

Three solutions prepared.

① ~~0.25 g Ash~~ ~~0.48 g PEI~~

10 ml of Surfactant soln (0.0366 ml in 50 ml)

1 ml of water & 1 ml of surfactant soln
~~1 ml of w~~

9.9 ml of water & 0.1 ml of surfactant soln

~~0.0366 ml~~ 2.5 ml contains 1 gm of AOS
∴ 0.0366 ml ~~would~~ would contain

$$\frac{0.0366}{2.5} = \frac{1}{1.464 \times 10^3} \text{ gms of surfactant}$$

$\times 10^3$ gms in 50 ml. ~~0.0732~~

2.5 in 1 ml
 2.928×10^3 gms

2.928×10^{-2} mg/ml

0.03 g/l

⇒ 0.003 wt%

~~0.003~~ 0.003 g / 100 ml

step is to separate these solutions into two
↓ for further test (1) foaming (2) ~~washing~~ washing
Done at 17:27

K to NIKOS for contact angle

AO5 + silica

z = potential
Feb

Petre Rem } To Delft
Peiter

10' clock next Tuesday with Hans

Sunday 20th February
10' clock in the evening

20th February

to make PEI coated ash particles?

height measurement. →

20 ml of 0.003 wt%	40 mm	At 11:30
1 ml of 0.003 wt%	5 mm	At 11:30
1 ml of 0.003 wt%	0 mm	with lower
10 ml of 0.003 wt%	40 mm	conc. of particle
1 ml of 0.003 wt%	5 mm	• With higher
0.1 ml of 0.003 wt%	0 mm	conc. of
		particle

~~At 11:30~~

~~wait~~

wait after half-hour

of the particles remained in the sample

0.147 gm
0.057
0.058
0.0086
0.0029
0.0024

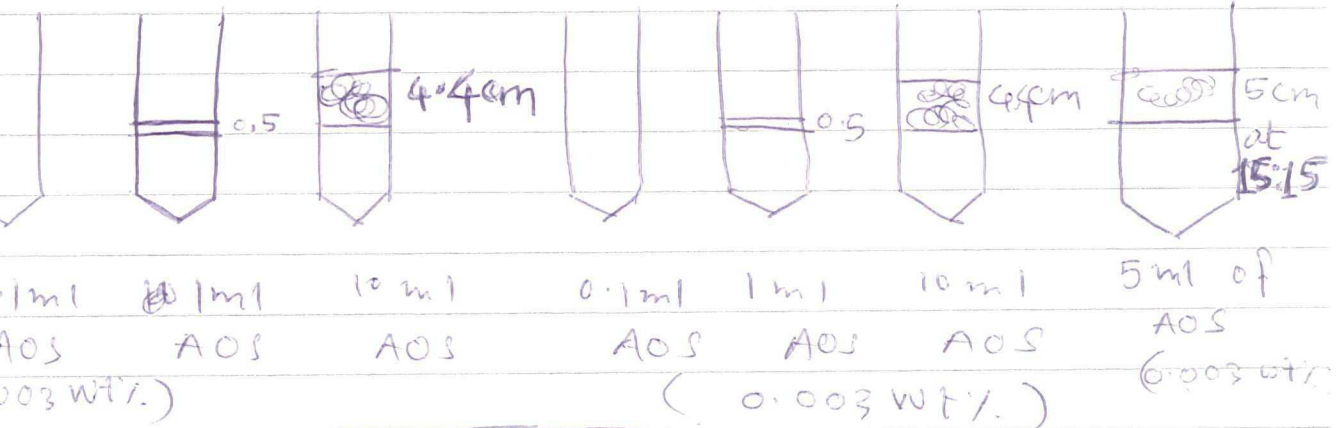
Washing of the particle from 5 ml solution

1. Centrifuge 3500 rpm 30 min
2. Surfactant solution out
3. 10 ml fresh water in
4. Centrifuge 3500 rpm 30 min
5. Water out
6. 5 ml fresh water in

Reutlingen-Bellingen train

65 Euro

~~Costly~~ ~~Costly~~ ~~Costly~~



~~More~~ 0.25 wt% Ash
lower portion
(sedimented)
0.48 mg/ml PEI
(can see the large particles)
the lamellae of foam

0.25 wt% Ash
Upper portion
0.48 mg/ml PEI
(You can see
winter foam
suggesting larger

smaller bubbles
(dry foam)

particles in foam)
larger bubbles
(dry foam)

Discussion with foam

Coating of ash particles with silica

0.448 g/L

0.25 wt%

4.5 wt% →

0.5 wt%

5 gm in 1000 ml

Coating of silica particles with water

Stability of silica particles in a solution

(1) Characterised silica particles

(2) Coated Ash particles

at particles

Tomorrow morning

Oil mix silica particles with higher
concentration and Ultrasonic and measure

check Zeta potential after mixing
& then after Ultrasonic

Tomorrow evening

AOS foam and compare it with ~~that~~ foam particles.



a ~~5 ml~~ foam from 5 ml 0.003 wt %
solution 5 cm height

prepare PEI Coated Ash particles concentration

~~200 ml of~~
ml ~~water~~ with 488 gm of PEI

or
8 gm of PEI and 95.12 gm of water
mix it properly
Ultrasonicate for 30 min

~~40 gm of Ash particles in 99.5 gm of~~
solution

Instead of solution Carry a paste
50 gm of Ash particles coated with PEI

8 gm PEI and 95.12 gm of water
10 gm of ash particles

PEI 6599

eta potential of as prepared 0.5 wt% silica
~~part~~ soln.

- -0.209 mV
- 0.0656 mV
- 0.418 mV

Please measure the weight of the sample
at 2, 10, 32, 60, 80, & 100 min.

pumping action is of significance. It is useful
for P_1 & P_2 ^(bar) than P_{AT} (mBar)

236 mL/hr of water pump ~~at~~ meter
was 0.6 P_1 & 0.38 P_2 when it is stuck
 P_1 & P_2 drops. We should neglect those slumps.

the experiment from top to bottom: →

14/02/2011

pilot expt with Brine + ~~water~~ 0.075 wt %

ADS

14 Feb Expt
Noted down

gas 2.7 ml/min } steady pressure diff
liquid 72 ml/hr } was at 1025 to bar

Reviewed on
21st March 2014

Run tomorrow at 1.8 ml/min gas
72 ml/hr

06/03/2013

$$\begin{aligned} \textcircled{Q} 36 &= \frac{18}{30} = \frac{18 \times 6}{15 \times 6} = \frac{72}{90} \\ &= \frac{72 \times 27}{90 \times 27} = \frac{1944}{2430} \end{aligned}$$

$$\frac{L}{S} = 1.2 \text{ ml/min}$$

peter Rem

Room No 2.08

015.278 3617

16/07/2011

All sets are clear

A new experiment is running

0.075 g wt i. ~~and~~ AOS

0.9 ml/min Gas

$f = 0.9 \text{ ml/min liquid}$

The ~~del~~ PdT keeps on increasing so it does it mean that system is keep on building pressure & To Bill

$$e^{ia} = \cos a + i \sin a$$

Dr. M.T. Kreutzer

Professor of Chemical Engineering

DelftChem Tech (Dept. of Chemical Engineering)

~~Page~~

Microchannels

00

Total superficial velo

$$= \frac{m^3}{s} \cdot \frac{m}{m^2}$$

Pressure differences:

$$ml/min = a/min$$

$$= \frac{cc}{60} \text{ sec}$$

$$1m = 100 \text{ cm}$$

$$1m^3 = (100)^3 \text{ cm}^3 \quad \text{the } 100 =$$

$$= (1 \times 10^2)^3 \text{ cm}^3$$

$$1m^3 = 1 \times 10^6 \text{ cm}^3 \quad \text{ice}$$

$$0.45 \frac{cc}{min}$$

$$0.45 \frac{m^3}{min} \times \frac{1}{10^6} = \frac{m}{s}$$

$$\frac{0.45}{1 \times 10^6} \times \frac{1}{60} \frac{m^3}{s}$$

$$\frac{0.45}{1 \times 10^6} \times \frac{1}{60}$$

17th Feb mixbrine experiment
with varying flow rates

Amount of Gas

$$0.005 \text{ mm/s}$$

$$0.90 -$$

$$4888$$

$$11155$$

$$1.8$$

$$1303.155 - 1345.707$$

$$11806 - 19950$$

$$1366.983 - 1366.983$$

$$\frac{0.45}{60} \times \frac{1}{5} \times 3.6$$

$$(21.637 - 1521.234 - 31.995 - 1526.553)$$

$$\frac{45}{6000} \times 7.5 \times \frac{ml}{s}$$

$$4285$$

$$60$$

$$4010$$

$$- 30$$

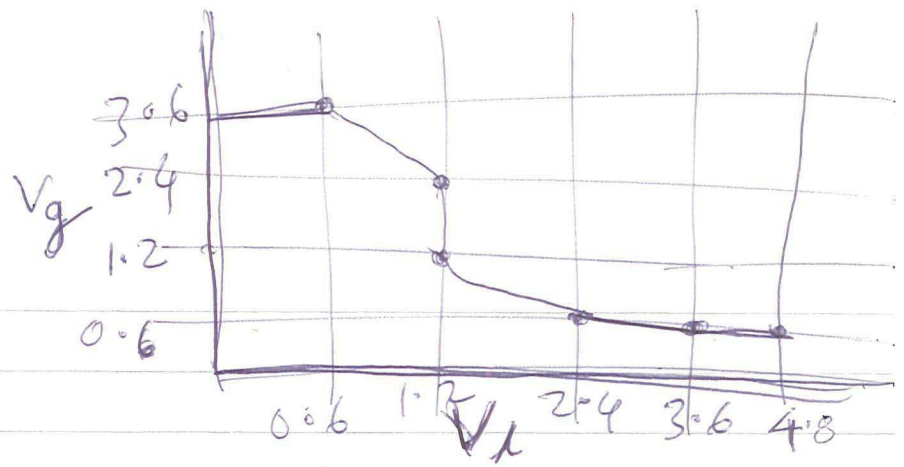
$$7.5 \times \frac{3}{5} = 4.5$$

$$\frac{7.5}{6} \times \frac{1}{1000}$$

$$1599 - \text{for } 18m - 3.6 \text{ ml/min Gas}$$

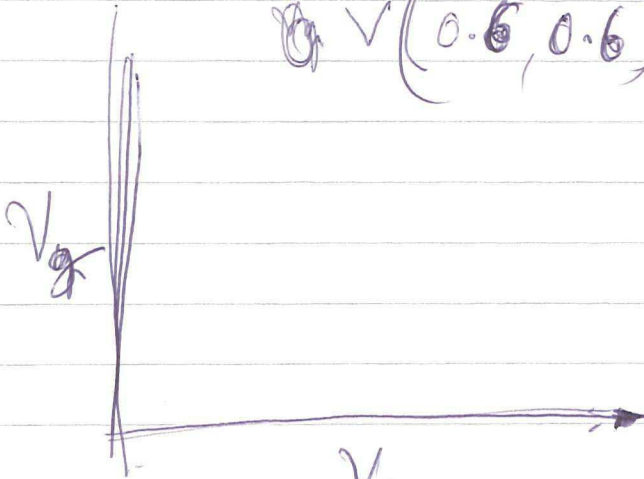
$$\frac{18}{3600} = \frac{180}{36} \times \frac{1}{1000}$$

$$\frac{105}{36} \times \frac{1}{1000}$$



$$V(0.6, 0.6) = 22040$$

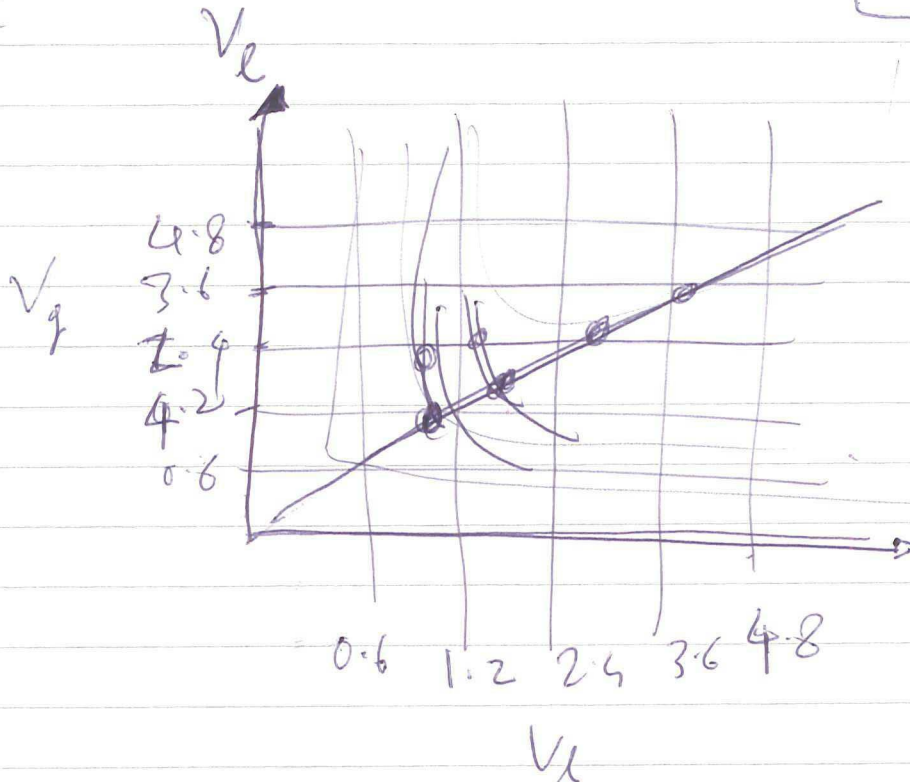
930 mbar
bar



30 mbar

3 bar

30 bar



$$\frac{48 \times 5}{90}$$

8 Rowhi Farajzadeh
 100 clock
 Resisen park i
 2088
 9:34 transition deff

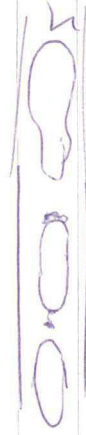
Mohamed Sinjoo

Mirazaki f Khafib

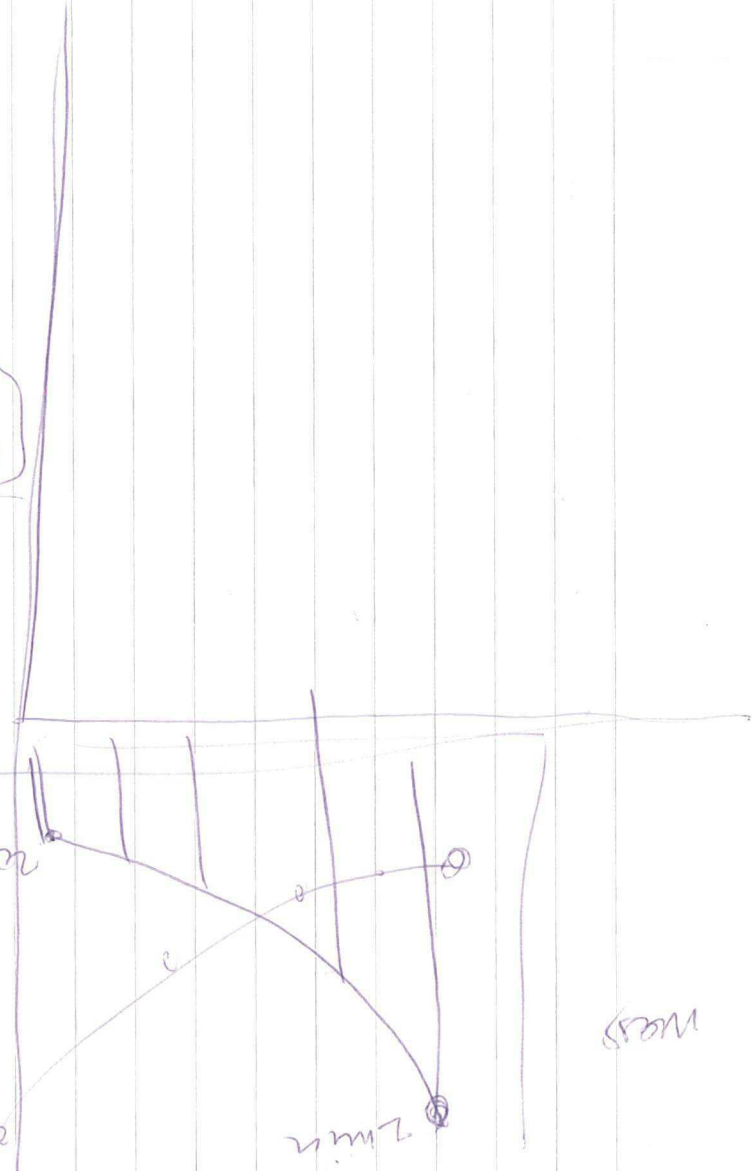
$$u = \frac{k}{\mu} \frac{\partial P}{\partial x}$$

$$\mu_{app} = k \frac{\partial P}{\partial x}$$

$$\mu_{app} = f(u, \sigma, -)$$



1) Paraphide // do the
 experiment
 2) Mass flow meter with pressure



$$u = \frac{k}{\mu} \frac{\partial P}{\partial x}$$

23rd Feb 2011

- ① Ultrasonication of silica soln 0.15%
- ② Passing it for no of times with different flow rates

23rd Feb 2011

Reinitialized experiments →

~~n water~~ water

~~Pressure~~

Flow
ml/hr

Pressure
mbar

100	26	No change in pressure
150	26	
200	26	
250	26	

Started to pump

0.075 wt % SiO_2 soln

at 300 ml/hr

5:35 PM

Experimentation Started

9
54 ml
—
hr
60, 10

0.9 ml
min

~~0.45 ml~~
~~min~~

0.9 ml
min

liquid

Gas

Started at 18:40 waiting till 22:40 & then

24/02/11

1.8 ml
min

1.8 ml
min

Test 014

C24H03

Start PdT 5 mbar

10 ml min 240 0.998-15000
220 20 - 23600
117 41 - 25000
62 81 - 26600

~~Test 014~~

~~1.8 ml~~

0.5 wt % Silica

~~0.5 gm in~~

5 gm in

0.075 gm in

~~1000 gm (0.5)~~

0.0625 0.5 gm / ml 100 ml

0.125
21

~~0.25 gm~~ 200 ml → 0.25 gm

400 ml

→ 0.125 gm / 100 ml

0.125 gm / 400 ml

↓ 800 ml

→ 0.0625 gm / 100 ml

21 100 ml

25.5
400 = 21
80
163.2

~~700 ml~~

75

400 ml - 0.125 gm

700 ml → 60

100 ml

0.075 wt% SiO_2 of 0.075 wt% AOS

700 ml 1.8 ml/min Gas 1.8 ml/min (108 ml/hr) liq. 700 ml

First Back pressure 40 bar // Double distilled Did I mix
Second flowing the soln through sand pack to see change in ρ PdT at 108 ml/hr In the reading it is diff

No flow at 108 ml/hr so the flow rate would be increased

25/02/2011

Test 15

Back pressure (bar)	Flow	Pressure drop
20	108 ml/hr	26 mbar

Gas injection at on 11 am 1.8 ml/min

MRF mobility reduction factor

Test 16

11:34

Liq flow	Gas flow
216 ml/hr	3.6 ml/min

Test 18

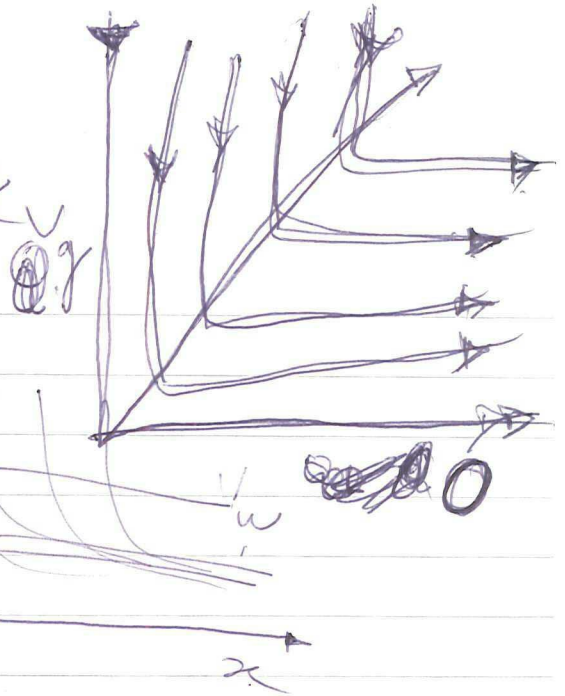
Liq flow	Gas flow	
108 ml/hr	1.8 ml/min	265 mbar
1.8 ml/min		

Test 19

1.8 ml/min water	5.4 ml/min Gas
------------------	----------------

24/02/

Han's meeting on Thursday



Volume ratio

3.6 ml/min
1.8 ml/min

1.8 x 6
100

3 bar

water



200 ml/hr

30 mbar

180 $\frac{N}{sq.m}$

6 cm length

$$180 \times \frac{1}{6} = 30$$

$$\frac{1.8}{0.06} =$$

$$\frac{200}{3600} \frac{ml}{sec}$$

$$\frac{1}{36}$$

22 E-06

24.2

Total velocity = Gas velocity + liquid velocity
counts (time)

3.3 ~~Cubic~~ Cubic spline

Numerical recipe

1 March 2011

Test 22

5.4 ml/min

Gas-
liquid

108 ml/hr

1.8 ml/min

$$\frac{5.4}{1.8 + 5.4} = \frac{5.4}{7.2} = \frac{3}{4} = 0.75 \text{ quality}$$

Stable 2300 mbar

$$\begin{array}{r} 2.7 \ 3 \\ \hline 0.9 \ 1 \end{array}$$

2.7 ml/min

Gas

3 g 10.8 ml/hr

liquid

test 23

$$\begin{array}{r} 2.7 \\ 0.9 \end{array}$$

$$\begin{array}{r} 2.7 \\ 3.6 \\ \hline 0.75 \end{array}$$

0.9 ml/min

$$\begin{array}{r} 4 \\ \hline 5 \end{array}$$

3.6 ml/min

$$\begin{array}{r} 0.9 \end{array}$$

$$\frac{4}{1}$$

1.8 ml/min

3.6 ml/min

3.6 ml/min

21.60 ml/hr

$$\begin{array}{r} 3.6 \\ 1.8 + 3.6 \end{array}$$

$$\frac{3.6}{3.6 + 2.4} = \frac{3.6}{6.0} = 0.6$$

$$\frac{3.6}{3.6 + 2.4} = \frac{3.6}{6.0} = 0.6 \quad \frac{1.8}{3.0} = 0.6$$

2.7 ml/min

$$\begin{array}{r} 4 \\ 2.7 \\ \times 60 \\ \hline 16.2 \text{ ml/hr} \end{array}$$

2.7 3.6

3.6 ml/min
108 ml/hr
(1.8 ml/min)

Gas
liquid

$$\begin{array}{r} 81 \\ 60 \\ \hline 20 \end{array}$$

$$\begin{array}{r} 3.6 \\ 0.9 \\ \hline 4 \end{array}$$

$$\begin{array}{r} 3.6 \\ 1.2 \\ \hline 3 \end{array}$$

Test 23

810
60
10.2 ml/min
1500 mbar

0.3

50 ml

50 ml

0.15 ml/gal

$$\begin{array}{r} 0.5 \text{ g in } 1000 \\ 1000 \div 400 = 2.5 \\ 2.5 \times 0.025 = 0.0625 \end{array}$$

0.5 gm in 1000 ml
0.25 gm in 500 ml
0.5

0.075
100 ml

62.5

12.5

100 ml

0.5

100 ml

0.25

200 ml

200 ml

0.125 400 ml

0.65 800 ml

160 ml
200 ml 62.5
240 ml 75

$$\frac{75 \times 200}{62.5} = 240$$

3000

$$\frac{100 \text{ ml} + 600 \text{ ml}}{12.5} = \frac{3000}{12.5} = 240$$

0.5 12.5 50 ml

$$\frac{3000}{12.5} = \frac{6000}{25} = 240$$

0.25 100 ml + 100 ml = 0.125 ml

+ 180 ml

0.9

0.625 ml

$$\begin{array}{r} 0.9 \\ 0.9 \times 0.6 \\ \hline 0.54 \end{array}$$

25 ml of air
180 ml of water

0.025 in 50 ml

$$\frac{17}{400 \text{ ml}} = 0.0425$$

$$\begin{array}{r} 0.9 \\ 0.9 \times 0.6 \\ \hline 0.54 \end{array}$$

0.025 in 400 ml

0.6

100 ml

$$\frac{25}{400} = 0.0625$$

48

2.5 ml 0.5%
50 ml 0.25%
100 ml 0.125%

+

100 ml 0.625%
200 ml

50 ml
100
100
150

410 ml

for 0.075 wt% $\frac{1}{8} = 0.125$

$$\begin{array}{r} 1.8 \text{ ml/min} \\ + 0.8 \\ \hline 2.6 \end{array}$$

Test 26

Gas @ 3.6 ml/min

Thursday ^{3rd} March
12:56

Water 1.8 ml/min

Foam is weak 2900 mbar ΔP P_1 1.786
(~~2.93~~ 46) P_2 0.183

With new filter there is no formation of foam in visual cell but there is a foam coming out of core, so the foam generation is in the core

15:53 Very dense foam 1615 mbar ΔP
 $P_1 = 2.926$ $P_2 = 0.183$ No foam in visual cell

18:54 $P_1 = 2.92$ $P_2 = 0.183$ $PdT = 1811$

19:46 $P_1 = 2.85$ $P_2 = 0.183$ $PdT = 2020$

foam quality ~~3.6/1.8~~ $\frac{3.6}{3.6+1.8} = \frac{3.6}{5.4} = \frac{4}{5} = \frac{2}{3} = \frac{21}{31} = 0.66$

2.5 g/100 ml

0.125 g/ml

0.125

25 g

$$1000 \text{ ml} \phi A \Delta x \frac{\partial p}{\partial t}$$

$$= \rho^A (u_{in} - u_{out})$$

$$\frac{\phi \mu c_t \left(\frac{k}{\mu} \right) L^2}{\Delta x} < 2$$

$$\phi \mu c_t \frac{\partial p}{\partial t} = \frac{k}{\mu} \frac{\partial^2 p}{\partial x^2}$$

25 g

1000

0.025 g

$$0.3 \times 2 \times 10^{-5} P_g \leq \frac{1}{5 \times 10^{-5}} \times ?$$

~ 100

0.25 g per 1000 ml $(5 \times 10^{-4})^2$

$$\phi \mu \frac{\partial p}{\partial t} \frac{\partial p}{\partial t} = \frac{k}{\mu} \frac{\partial^2 p}{\partial x^2}$$

$$0.25 \text{ g} / 10 \text{ LTR} = \frac{L^2}{D}$$

$$\frac{1 \times 2 \times 10^{-5}}{2 \times 10^{-5} \times 5 \times 10^{-4}} \frac{\phi \mu c_t}{k R} \frac{\partial p}{\partial t} = \frac{k}{\mu L^2} \frac{\partial^2 p}{\partial x^2}$$

$$t_R = \frac{4 \phi \mu L^2}{k}$$

0.25 g / 100 ml



2.5 W/W

10 ml contains 0.25 gms

0.25 10

0.3 10

0.0375 wt%

0.0375 wt%

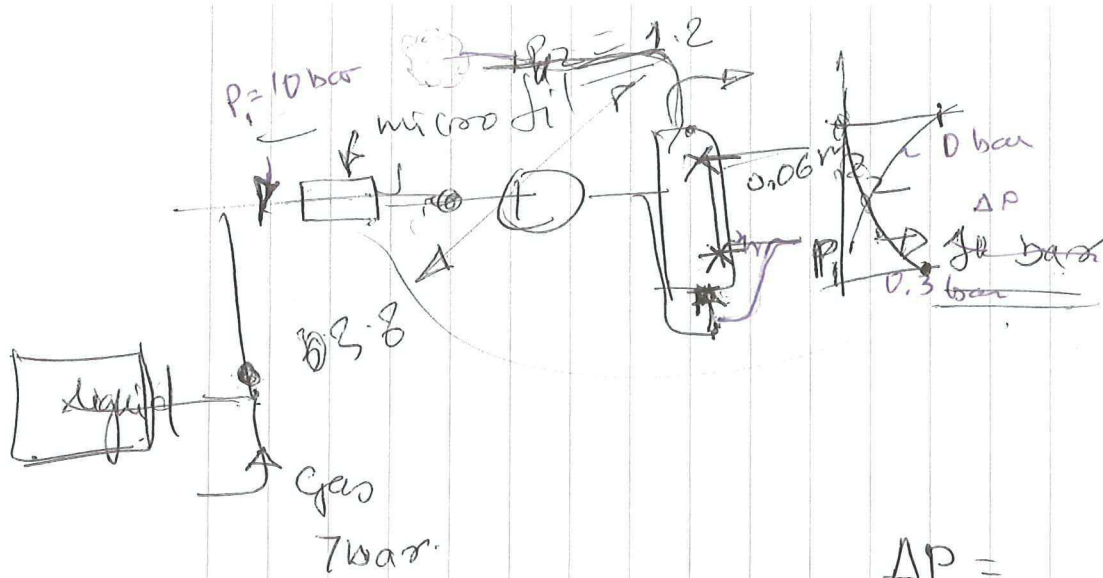
0.0375 wt%

0.025 1000

2.5 g / 100 ml

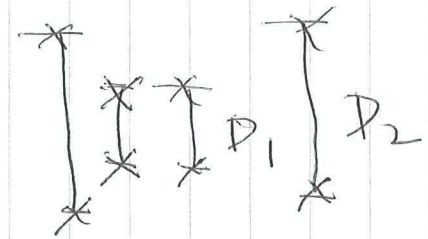
0.4 gm per 1000 ml

$$\frac{40}{1000} = 0.04$$

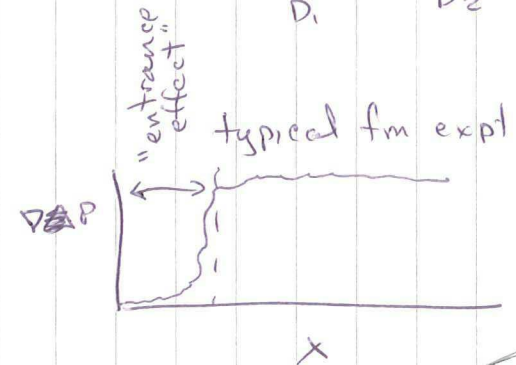


$$P_2 =$$

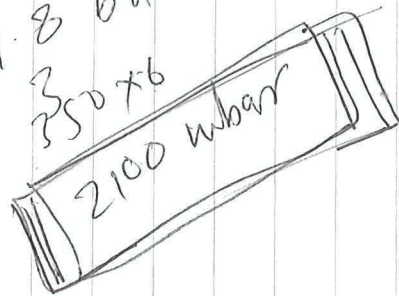
$$P_1 = 3.8$$



$$\frac{\Delta P}{D_1} \approx \frac{P_1 - P_2}{D_2}$$



3000×0.06
 1800 mbar
 1.8 bar
 350×6
 2100 mbar



low concentration
 $0.01 + 0.01 \text{ Slu}_2$

- ① Plot the earlier graph logarithmic scale
- ② Plot the experiment with 0.017
- ③ Case of 0.0375 AOS & 0.075 biO_2

Surfactant concentration when
 weam foam & then add
 the particles

0.01 Expt: with diff. surfactant ~~con~~ concentration

0.02



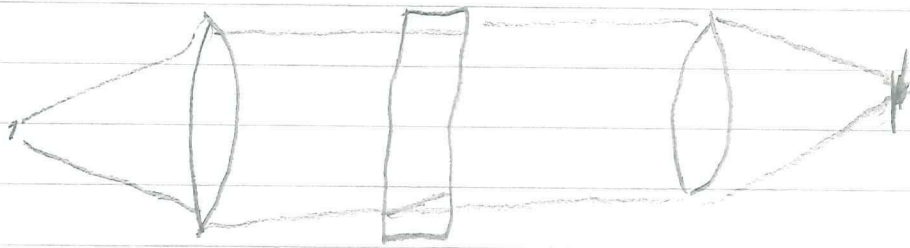
0.03

see the strong foam & then
at least one step back.

Next monday: →

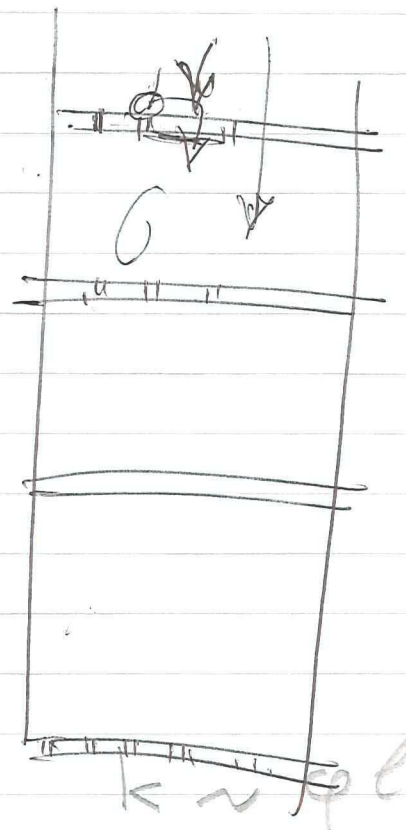
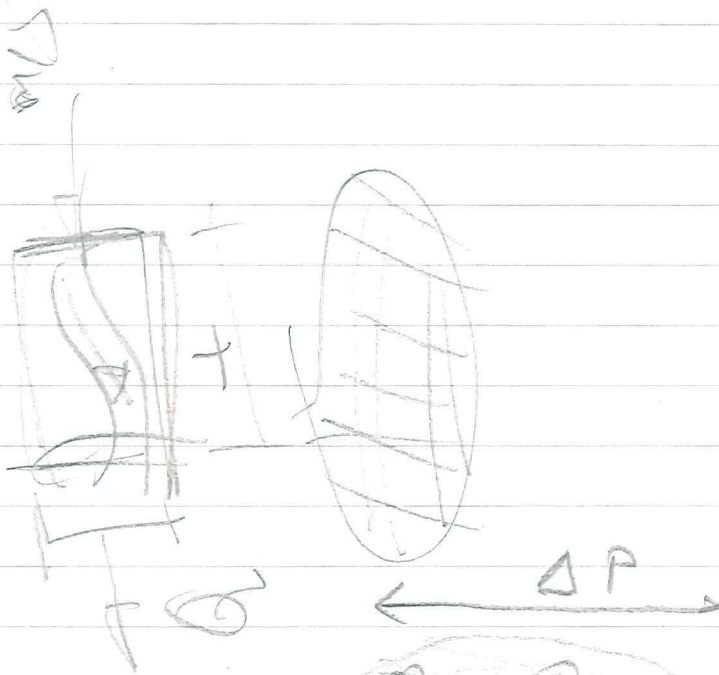
Flushing the new surfactant in the evening to start
experiment in the morning.

Schlieren

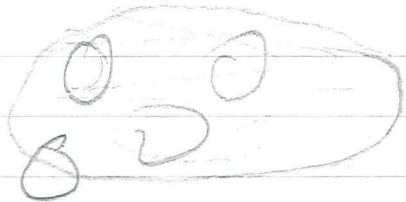


4

$$\frac{dI}{dz} = \frac{dn}{dz}$$



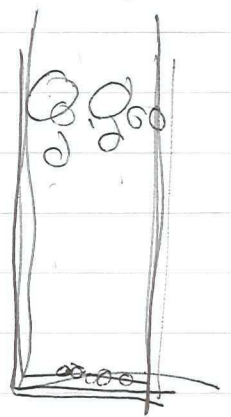
$$\frac{\text{Pa s m/s}}{\text{m}^2} \sim \frac{\mu u}{k}$$



$$\sim \frac{P_{ei}}{l} \sim \frac{\sigma}{l} \sqrt{\frac{\rho}{\mu}}$$

$$\frac{\mu u}{\sigma} \sim \frac{\sqrt{\rho k}}{l} \sim \frac{\sqrt{\rho^2 l^2}}{l} \Rightarrow \frac{\mu u}{\rho \sigma}$$

Program Vani d Perer Salami
abund mi coo. mo del



~~10~~

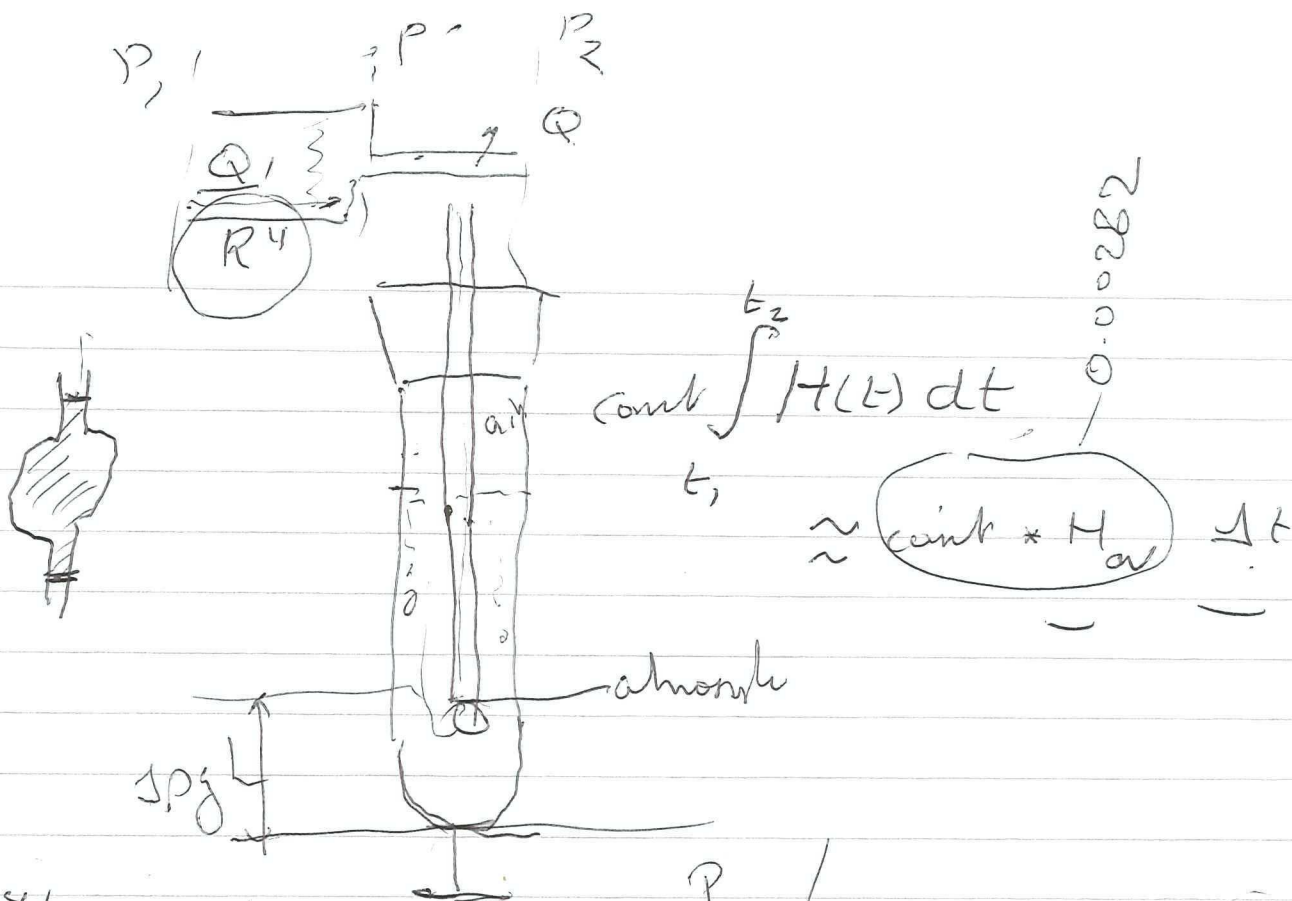
~~10~~
28-03-2011

① Single expts.

① Kinematic viscosity of pure water

Reportshell

Meeting with Hans 4:40-6:00 4th April

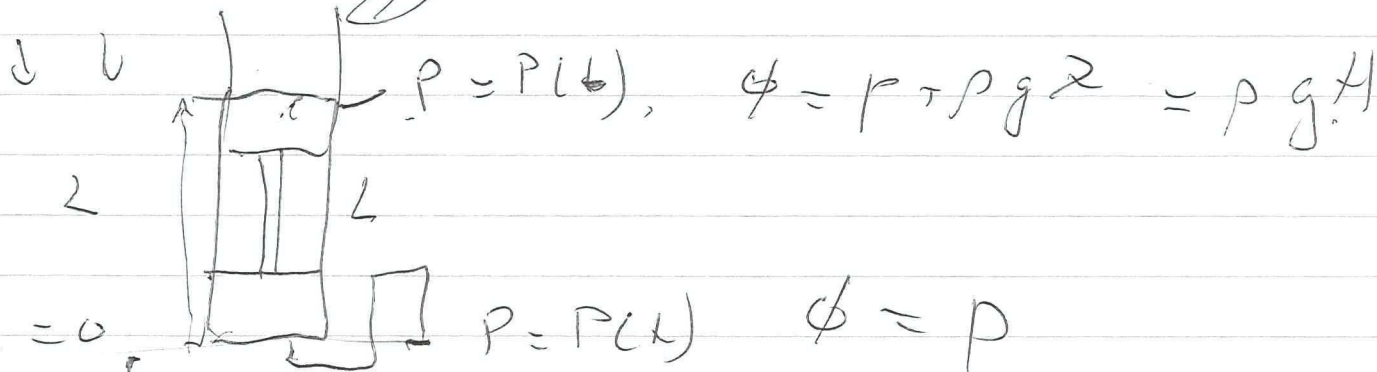


$$\frac{\pi \tilde{R}^4 (P' - P)}{L} = \frac{\pi R^4 (P - P')}{L} \quad \text{Pa/m}$$

$$\frac{dQ(t)}{dt} = \frac{\pi R^4}{\mu P_{as}} \frac{\Delta p g h(t)}{L}$$

$$\frac{\partial p}{\partial x} + \Delta p g$$

$$V = \frac{\pi R^2}{\rho \mu}$$



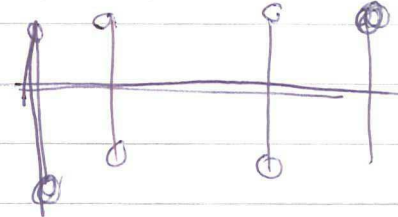
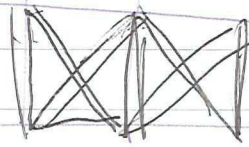
$$\frac{dV}{dt} =$$

Shaking experiment with Ash particles

1% wt% of Ash soln

Ash Particle	0.0375	0.075	0.15	0.3	0.5
1	32	15	30	42	32
0.5	32	74	32	74	34
0.25	32	25	37	21	32
0.125	31.5	17	32	74	32

Internal diameter 14.4 mm
Height of the soln →



32

0.0625 - None Ash particles

0.075 -

Laser particle Size Analyzer

write it in report

BIRD

$$F_{fr} = 6\pi\eta r v$$

$$F_{gr} = \frac{4\pi r^3}{3} (\rho_p - \rho_f) g$$

$$v = \frac{1}{6\pi\eta r} \frac{4\pi r^3 \Delta\rho g}{3}$$

$$= \frac{4}{18\eta} r^2 \Delta\rho g$$

$$v = \frac{2}{9} \frac{r^2 \Delta\rho g}{\eta}$$

$$\frac{2 (10^{-7})^2 \eta}{9 \times 10^{-3}} \frac{300 \times 10}{g}$$

Sedimentation
in
overbeck

@ $\frac{2 \text{ cm}}{15 \text{ min}} = v$

$$\frac{1 \text{ cm}}{7.5 \text{ min}} = v$$

$$\frac{6}{5} \frac{10^{-11} \text{ m}}{10^{-3}} \frac{1}{5} = \frac{2}{3} \times 10^{-8} \frac{\text{m}}{\text{s}}$$

$$\approx 2.5 \times 10^{-8} \frac{\text{m}}{\text{hr}}$$

$$2.5 \times 10^{-8} \frac{\text{m}}{\text{d}} \approx 5 \times 10^{-7} \frac{\text{m}}{\text{d}}$$

~~Double~~ Surface tension measurement: → 5 April 2011

	Surface tension	Std dev
Double distilled water	69.847	0.026
0.0375 AS40	33.266	0.188
0.075 AS40	30.255	0.072
0.15 AS40	31.526	0.033
0.3 AS40	31.772	0.02

(The dial of Pump showing 20 bar)

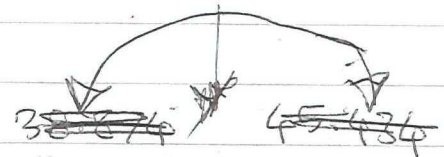
But computer shows different permeability test

7 April 2011

Back pressure 20 bar

P₁ (bar) P₂ (bar)

Flow rate (ml/hr) dP (mbar)

50	23	
100	26	
150	26	38.87 45.43
200	26	38.87 45.436
250	26	38.87 45.436
300	26	38.87 45.43
350	32	38.87 45.43
400	32	38.87 45.430
450	32	38.87 45.250

Another expt

with no back pressure

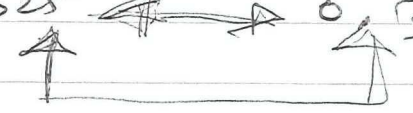
Flow rate

dP (mbar)

P₁ (bar)

P₂ (bar)

50	32	0.939	0.220 0.220
100	32	1.409	0.220
150	32	2.055	0.367
200	32	2.525	0.367



Some fault with dP meter always showing 32

Preparation of sample

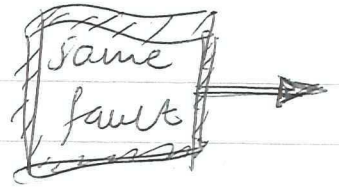
0.3% 25 ml + 25 ml

0.15% 100 ml + 100 ml

0.075% 100 ml + 100 ml

0.0375 400 ml

Effect of particles on
Bill Pave



Form stability permeability,

① Visual studies

② Particle flow

③ Reservoir

④ Determination particles

⑤ Comparison with the theory of Pave

2 papers by the end of the year

③ Reservoir impairment

② Electrical charge effect

June 2011 Conference

RAHUL 4:00 meeting on

~~Monday~~

Tuesday

2:00 meeting Monday

Q

~~8 April 2011~~

13 April 2011

Wednesday

for

Another expt. ~~with~~ permeability measurement

ml/hr

Pd T (mbar)

50

15

100

15

150

16

$$\left(\begin{array}{cc} 4 & \dots & 6 \\ 8 & & 1023 \end{array} \right) \quad \begin{array}{r} 1023 \\ 6 \\ \hline 1017 \end{array}$$

Q

$$\left(\begin{array}{cc} 4 & \dots & 0 \\ 10 & \left\{ \begin{array}{c} 1 \\ 20 \end{array} \right\} & 60 \end{array} \right) (60) \quad 15$$

15

Another experiment

After the lunch

ml/hr

Pd T

50

Q

Initial conditions

ml/hr

Pd T mbar

P_1 (bar)

P_2 (bar)

0

- 5

0.15

0.073

50

11

2.48

2.496

100

15

4.65

4.62

Pressure values (P_1) & (P_2) keeps on increasing even if flow rate did not increase

150

16

4.65

4.624

200

16

4.66

4.624

250

16

4.67

4.554

300

17

4.67

4.551

350

17

4.69

4.551

400

18

4.72

4.551

450

18

4.76

4.477

liquid ~~54 ml/hr~~ ~~108~~ 54 ml/hr

14th April 2011
11:00/⊙ 0.0375 SiO₂ &
Nanoparticles

P₁ 3.66 P₂ 3.67
PdT 11 mbar
at 0 flow rate

Test 028(1)

liquid 1.8 ml/min
gas 3.6 ml/min

3.6
3.6
2.6 ml

72
~~108~~ ml/hr

— ⊙ —
— ⊙ — 2.7

Initial Conditions

P₁ 0.24 P₂ 0.073 PdT 11 mbar

14:00 Gas flow really started.

P₁ 0.44 P₂ 0.073 PdT 25 mbar

14:10 & foamy liquid outside, 10% foam visible in visual cell

No strong foam yet

14:20 P₁ 0.57 P₂ 0.147 PdT 32

14:30 no strong foam yet P₁ 0.56 P₂ 0.147 PdT 27
40% of visual cell is foam, perhaps should wait till it gets full

15:15 no strong foam yet

P₁ 0.6 P₂ ~~0.147~~ 0.147 PdT 27

15:30 ~~0.65~~ P₁ 0.65 P₂ 0.220 PdT 27

~~Not much~~ weak foam visual cell 80% full with foam

15:28 Nice foam but still no pressure build up

P₁ 0.59 P₂ 0.073 ~~27~~ PdT 27 mbar

80% foam in visual cell (would it be case that foam is bypassing the core?)

Doing the ~~flow~~ water permeability experiment

@ 19th April 2011 Surfactant study

0.0375 ~~A540~~ + 0.0375 Nanoparticle
Back pressure 20 bar

P_1 0.251 P_2 0.367 PdT 0 mbar at 50 ml/min

Flow rate	P_1	P_2	PdT
50	0.251	0.367	0

New experiment log @ 72 ml/hr
Gas 3.6 ml/min

PdT measured 26.6

PdT	Time	PdT (mbar)	P_1 (bar)	P_2 (bar)
26.6	11:00	2	0.281	0.147
(foam)	11:30	45	0.341	0.147

Stopping the experiment & Starting
with top entry test 031 top entry 14:00

14:30	P_1 0.471	P_2 0.147	PdT 42.6 mbar	Foam
15:00	P_1 0.581	P_2 0.147	PdT 48.0 mbar	Foam
16:00	0.581 1.2	1.2	1.2	1.2

Expt stop

12 ml/min

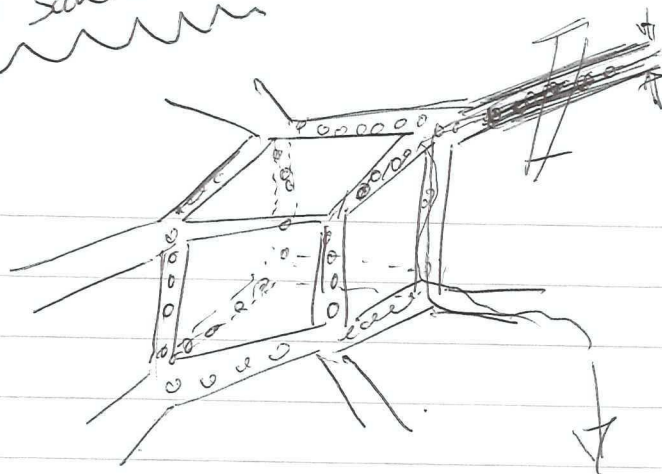
3.6 ml/min

$\frac{72}{67}$ ml

$\frac{72}{361}$ ~~2.0~~ ml/s

Berger sandstone

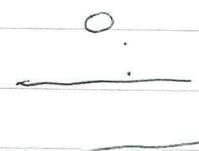
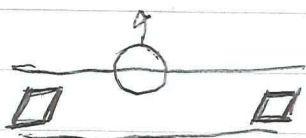
Morrow



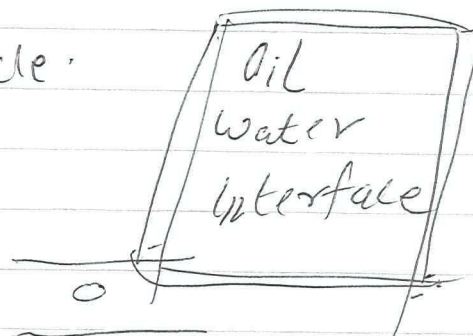
$$\frac{72}{60} \cdot 1.2$$



Theory: General position of particle.

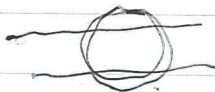


hydrophobic



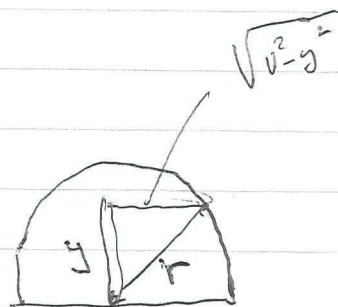
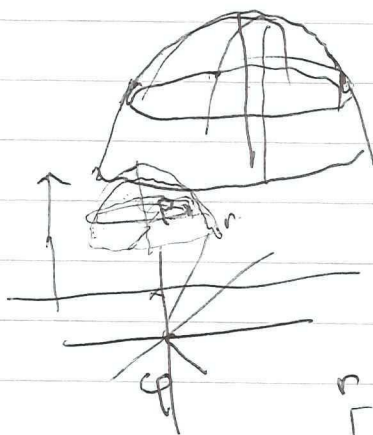
completely hydrophobic

hydrophobic



Surface energy:

$$4\pi r^2$$



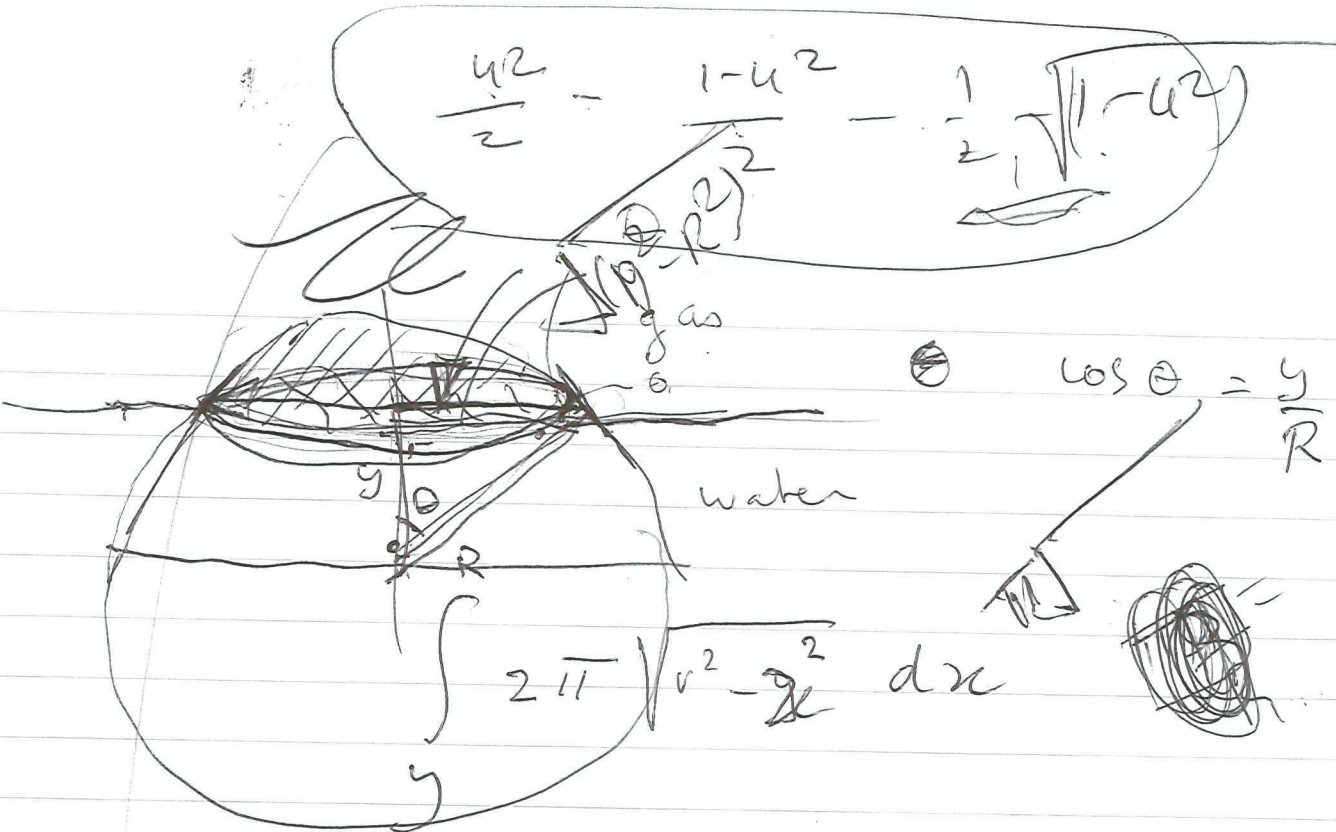
Surface energy

$$2\pi(r-y)$$

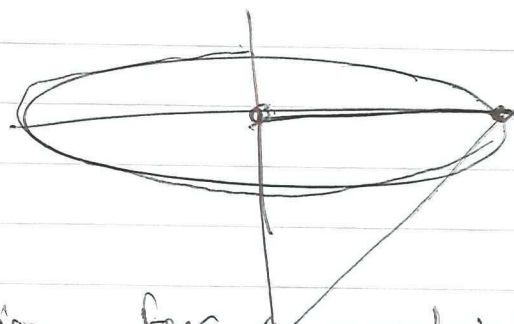
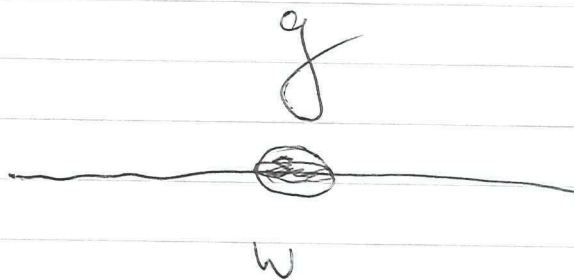
$$\int_0^r \pi(r^2 - y^2) dy$$

$$= \pi \left(\frac{2}{3} r^3 + r^2 y - \frac{1}{3} y^3 \right) \Big|_0^r$$

$$\frac{u^2}{2} - \frac{1-u^2}{2} - \frac{1}{2} \sqrt{1-u^2}$$



$$S_{wg} \text{ area} = 2\pi \sqrt{r^2 - y^2} \delta_{wg}$$

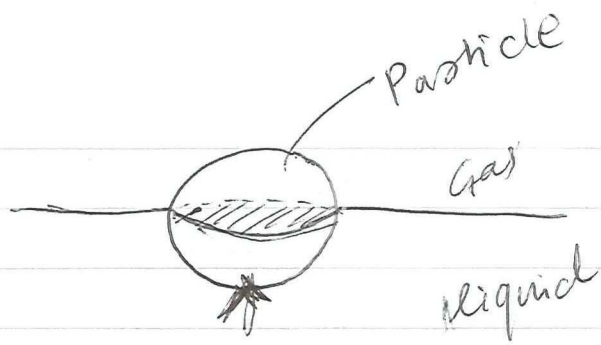


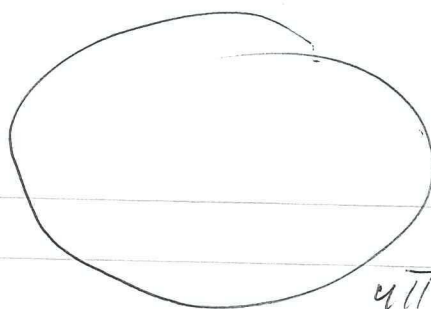
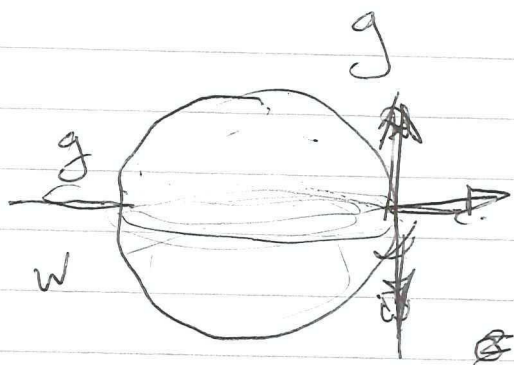
surface energy calculation for particle at the boundary of water & gas

$$\cos \theta = \frac{\sigma_{gs} - \sigma_{ws}}{\sigma_{gw}}$$

$$\frac{u^2 - 1 + u^2}{2} - \frac{1}{2} \sqrt{1-u^2} = \frac{u^2 - 1 - 1 - u^2}{2} = -2$$

$$u^2 - 1 - \sqrt{1-u^2}$$



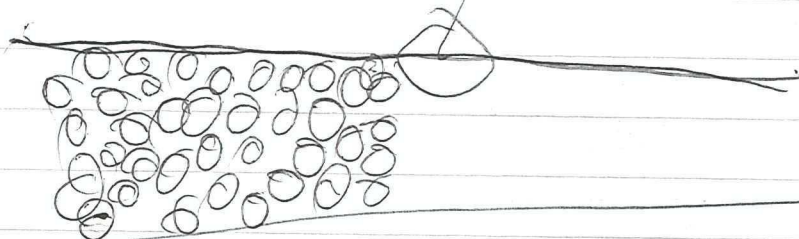
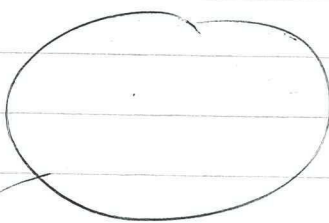


$$4\pi r^2 \sigma_{gs}$$



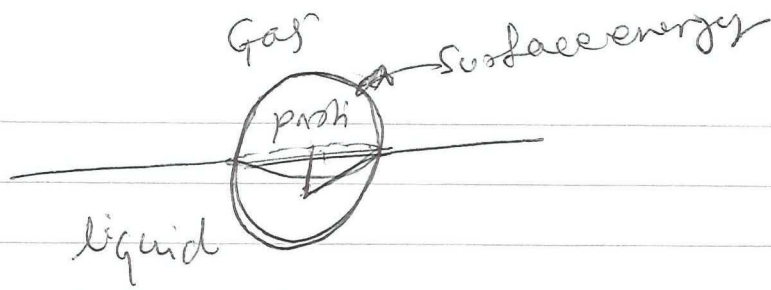
$$2\pi r^2 \sigma_{gs} + 2\pi r^2 \sigma_{ws} \rightarrow \pi r^2 \sigma_{wg}$$

$$4\pi r^2 \sigma_{ws}$$



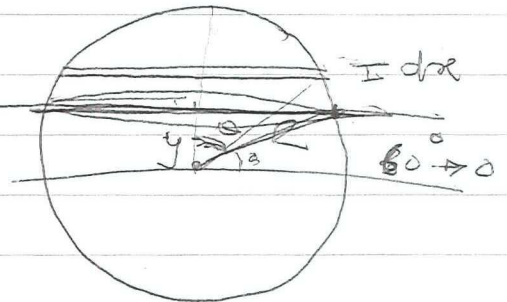
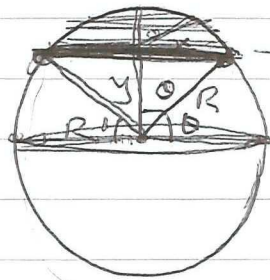
Morrow lecture 21 April 2011

Need to something over enhanced oil recovery



$$2\pi \int_{-y}^{x=R} \sqrt{R^2 - x^2} \cdot dx$$

$$W(y) = 4\pi R^2 - 2\pi R^2 \left(-\frac{1}{2} \right) \\ = 4\pi R^2 - 2\pi \left(-\frac{1}{2} \sqrt{R^2 - y^2} \right)$$



$$\frac{y}{R} = \cos \theta$$

$$\int_y^R dx$$

$$= \int_{\theta=0}^{\theta=\theta} (R - y) \cdot \sqrt{R^2 - y^2} \sin \theta \cdot d\theta \cdot d\phi$$

$$= \int \int$$

$u = 105.19$
 $\theta = \text{contact angle}$

$$\int_{60}^{\theta} \int_0^R \pi \left(\sqrt{R^2 - y^2} \right) dx \cdot d\theta$$

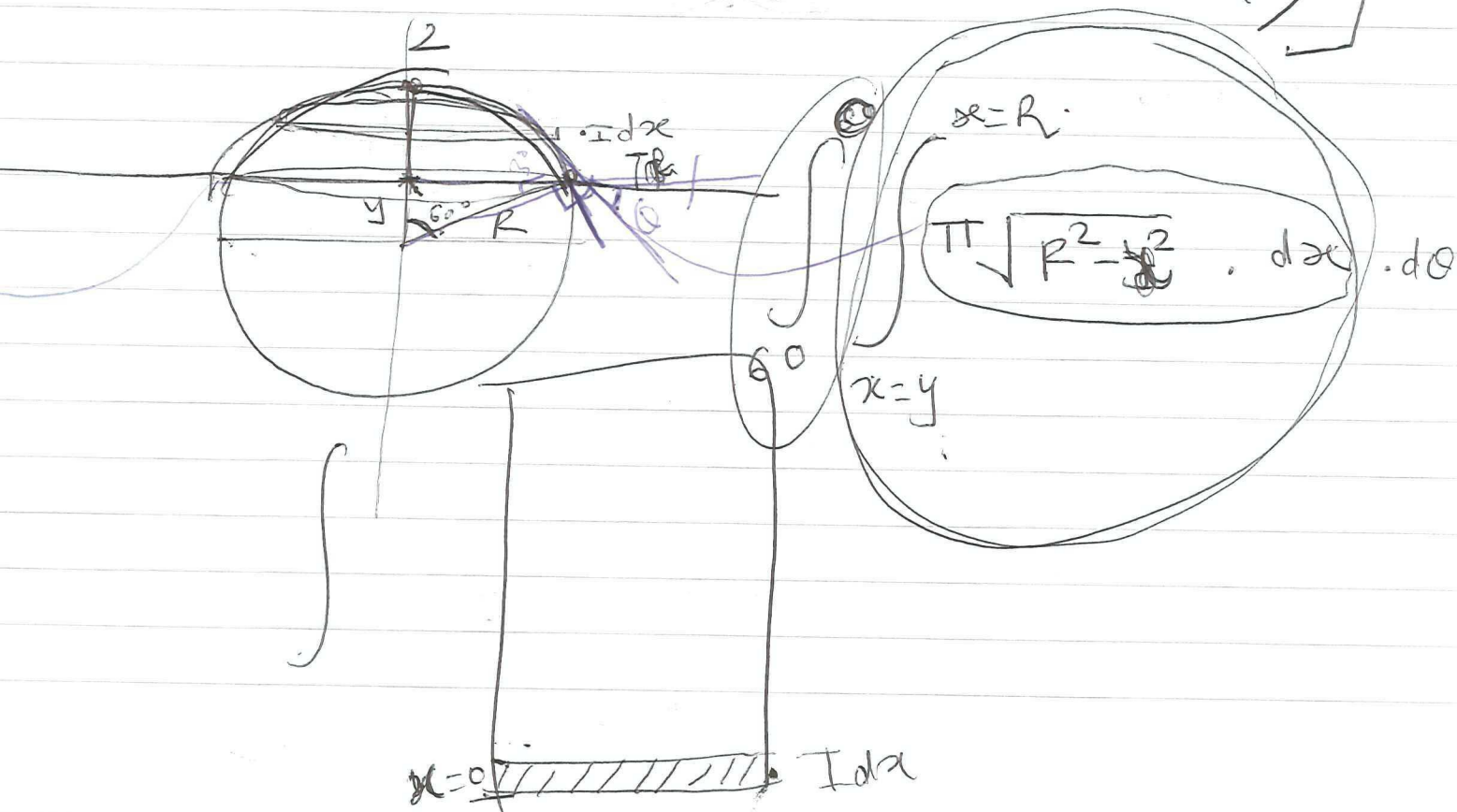
$$+ \frac{2\pi R^2}{2} \left[\frac{u \sqrt{1-u^2}}{2} - 1 + \frac{1}{2} - \frac{1}{2} \right]$$

$$\left(\frac{1}{2} \arcsin u + \frac{\pi}{4} \right) \sigma_{sg}$$

$$4\pi R^2 \sigma_{sw} \left(\dots \right) \sigma_{sw}$$


$$2\pi R^2 \left(2\sigma_{sw} + (\sigma_{sg} - \sigma_{sw}) \right) *$$

$$* \left(\frac{-u \sqrt{1-u^2}}{2} - \frac{1}{2} \arcsin u + \frac{\pi}{4} \right)$$



①

$$-\frac{1}{2} \cos^2 \theta + \frac{1}{4} \cos^2 2\theta$$

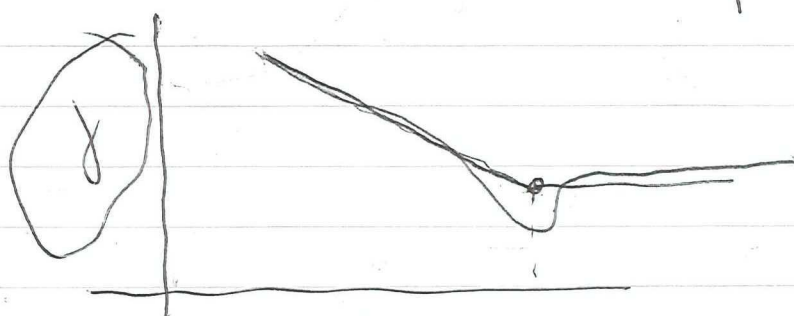
$$-\frac{3}{4} \cos^2 \theta$$

$$-\frac{21}{84} \cos^2 2\theta$$

$$(1 + \cos \theta)^2$$

$\frac{1}{RT} \frac{\partial \ln c}{\partial \ln c}$

$$= \frac{1}{1}$$



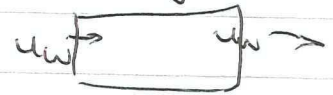
$\ln c$

$$\partial_t = \frac{\partial}{\partial t}$$

$$\phi \partial_t S_w + \partial_x u_w = 0$$

Disregard capillary forces so $P_w = P_g = P$

$$u_w = -\lambda_w \frac{\partial P}{\partial x}$$



$$u_g = -\lambda_g \frac{\partial P}{\partial x}$$

$$\phi \partial_t S_g + \partial_x u_g = 0$$

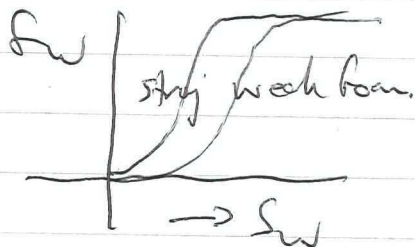
$$S_w + S_g = 1$$

$$\partial_x (u_w + u_g) = 0 \Rightarrow$$

$$u_t = \frac{\lambda_w}{\lambda_w + \lambda_g}$$

$$u_w + u_g = u(t)$$

$$u_t = \frac{u_w}{u_w + u_g} = \frac{-\lambda_w \partial_x P}{-\lambda_w \partial_x P - \lambda_g \partial_x P} = \frac{\lambda_w}{\lambda_w + \lambda_g} = \frac{\lambda_w}{\lambda_w + \frac{k_{rg}}{k_{rw}}}$$



$$u(x) \begin{cases} = 0 & x < 0 \\ = \text{undeter.} & x = 0 \\ = 1 & x > 1 \end{cases}$$

$$\lambda_g = \frac{k_{rg}}{k_{rw}}$$

Putting eqs from Hanks & Rosen for convection & destruction of lamellae

~~3108~~ 3/05/2011

Top
~~Bottom~~ entry

Checking the permeability of ~~water~~ sandpack
with water

Backpressure 20 bar

Q	PdT comp mbar	PdT device mbar	P ₁ bar	P ₂ bar
0	0	0.001	0.061	0.073
50	0.131	0.220		
50	0.131	0.220		
50	-5.3	-4	0.351	0.514
75	0	1	0.501	0.734
75	16	17	10.171	20.258
100	16	17	10.171	20.479
150	16	18	10.171	20.552
200	16	17	10.171	20.405
250	16	18	10.171	20.479
300	21.3	19	10.171	20.552
350	21.3	19	10.171	20.479
400				

$$u_w = -\lambda_w \frac{\partial p_w}{\partial x}$$

$$\lambda_w = \frac{k k_{rw}}{\mu_w}$$

$$u_g = -\lambda_g \frac{\partial p_g}{\partial x}$$

$$\frac{\partial C}{\partial t} + \frac{\partial F}{\partial x} = 0$$

$$u_w + u_g = u(t)$$

$$u_w + u_g = u_w \left(-\lambda_g \frac{\partial p_w}{\partial x} \right)$$

$$- \lambda_g \left(\frac{\partial p_g}{\partial x} + \frac{\partial p_w}{\partial x} \right)$$

$$p_g - p_w = p_c$$

$$u = u_w \left(1 + \frac{\lambda_g}{\lambda_w} \right) - \lambda_g \frac{\partial p_c}{\partial x}$$

$$u_w = \left[\frac{\lambda_w}{\lambda_w + \lambda_g} u + \frac{\lambda_g \lambda_w}{\lambda_g + k_r} \frac{\partial p_c}{\partial x} \right]$$

f_w

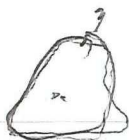
$$\phi \frac{\partial S_w}{\partial t} + \frac{\partial u_w}{\partial x} = 0$$

$$\frac{\partial n_e c_n}{\partial t} + \frac{\partial n_e c_n u_g}{\partial x} = 0$$

$$\frac{1}{2} \left[1 + \frac{e^x - e^{-x}}{e^x + e^{-x}} \right]$$

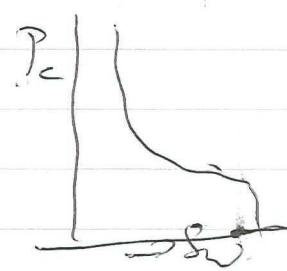
silica / Ash

$$\frac{dW}{dt} = \text{fund}$$



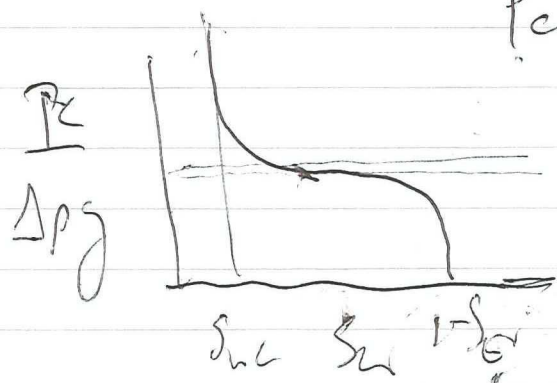
$$\frac{\partial p_0}{\partial z} = -\rho_0 g$$

$$\frac{\partial p_w}{\partial z} = -\rho_w g$$



$$\frac{\partial p_0}{\partial z} - \frac{\partial p_w}{\partial z} = (\rho_w - \rho_0) g \quad \equiv \quad \frac{\partial p_c}{\partial z}$$

$$p_c = p_c + (\rho_w - \rho_0) g (z - z_0)$$



$$\left(u - \epsilon \frac{\partial u}{\partial z} \right) \Big|_{z=0} = u - \epsilon \frac{\partial u}{\partial z} \Big|_{z=0}$$

$$r_f = k_f$$

$$r_b = k_b n_f$$

$$r_f = r_b \quad : \text{Equiv.}$$

$$k_f = k_b n_f$$

$$n_f = \frac{k_f}{k_b} = K$$

complete functions

—: 23rd May :—

Pd T Camp	Pd T Apparatus	P ₁	P ₂	Flow rate
21.3	22	191	73	100
21.3	22	251	73	150
21.3	22	351	73	200
21.6	14	421	73	250
16	15	501	73	300

changing Sand packs

New Sand (But coarse sand or fine question from 29 Nov 2011?)

~~Box~~ Pack without sand 859.62 g one end
Pack with sand 935.19 g

1481.88 g both ends
1638.21 g fixed

Pack with rods & ends closed

This is the number to compare after flooding the water inside

57.3 55 501 53
57.3 55 501 53

comb 59.1 69.1 8 65 6-10m work

Bill's remark on

① On page 2 about ③ apparent viscosity

② On page 5 about model

③ On page 7 about ~~the~~ ~~the~~ ~~the~~ ~~the~~ ~~the~~ ~~the~~

$$A = \pi r^2 =$$

$$99 \quad 1000 \text{ kg/m}^3 \times 9.81 \text{ m/s}^2$$

$$981$$

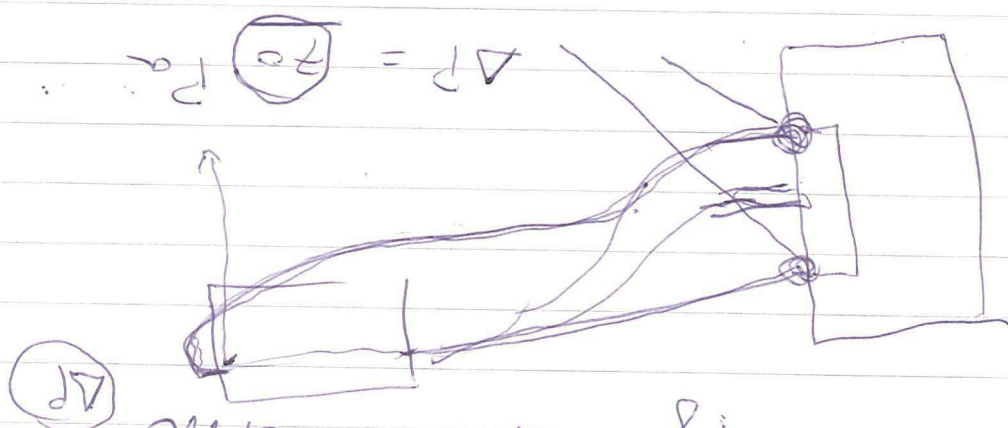
$$\frac{70}{0.06} = \frac{7000}{6} - 981 = \frac{7000 - 4086}{6}$$

$$\frac{m^2 \times 600 Pa}{1000 kg \times 0.06}$$

$$= 600 Pa$$

$$99 \times \frac{9.81 m}{s^2}$$

$$1000 kg/m^3$$



$$1 \text{ mbar} = 0.001 \text{ bar} = 10^{-3} \text{ bar} = 10^{-3} \times 10^5 \text{ Pa} = 100 \text{ Pa}$$

$$34$$

$$51$$

$$48$$

$$\frac{N}{59 m}$$

$$485.6$$

$$100 \times 10^3 \text{ Pa} = 1 \text{ bar}$$

$$1000$$

$$4086$$

$$482914$$

$$2914$$

$$24$$

$$4086$$

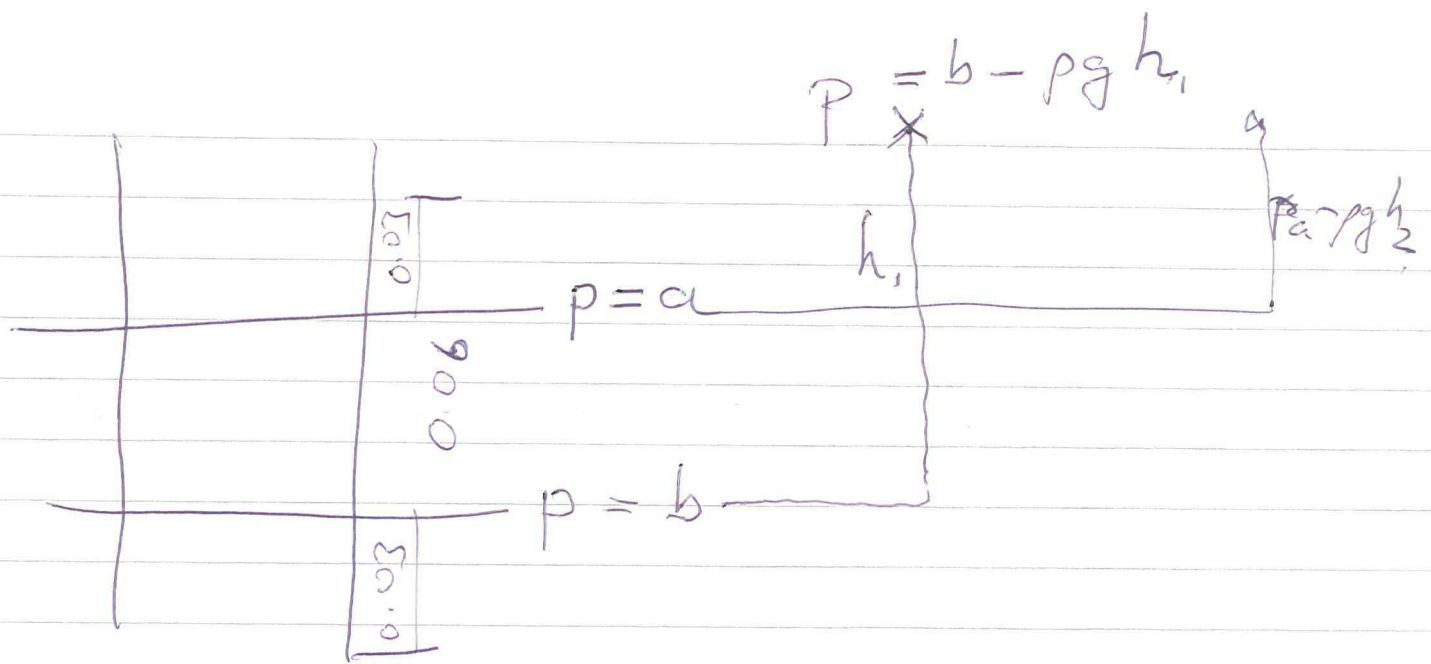
$$x 6$$

$$981$$

$$4$$

2 PM with Pavel Beertenmarkt 30

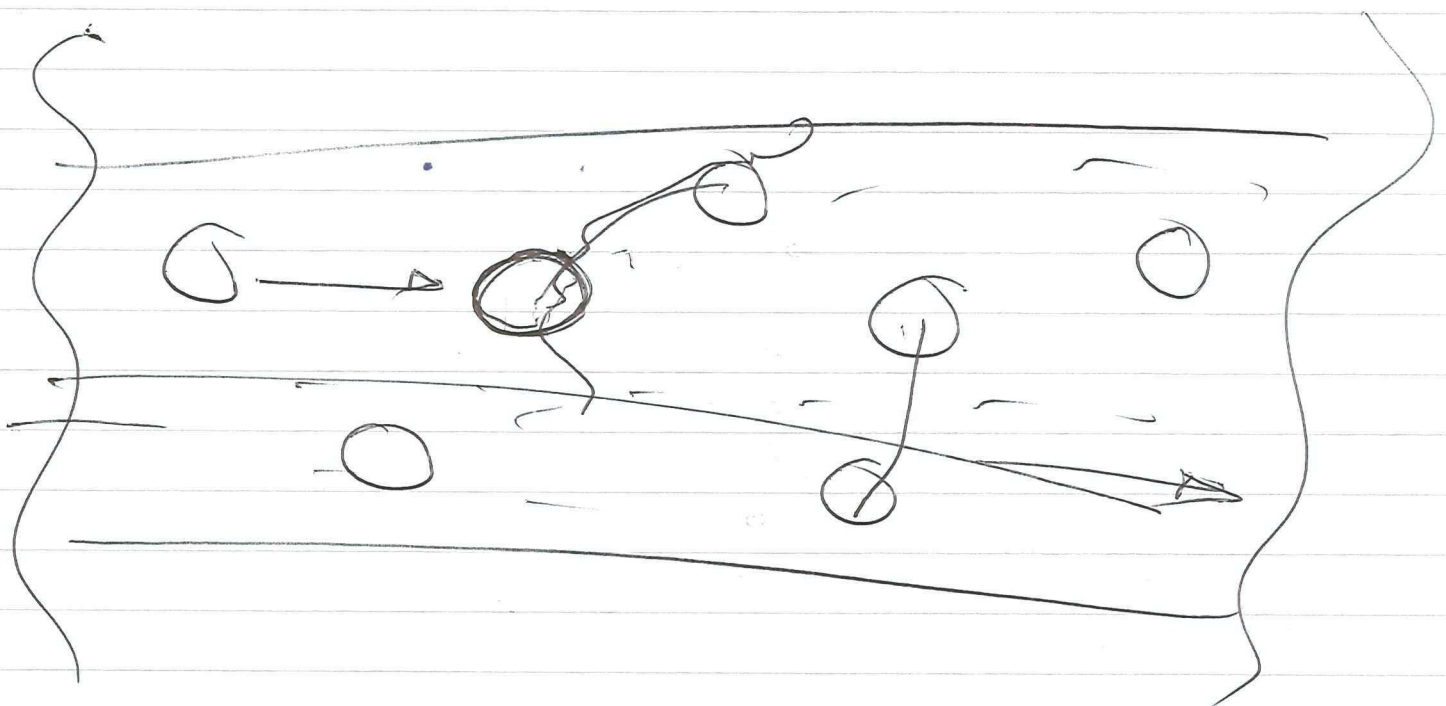
~~entering~~ the graph of 60% into the ~~system~~ data
plotting



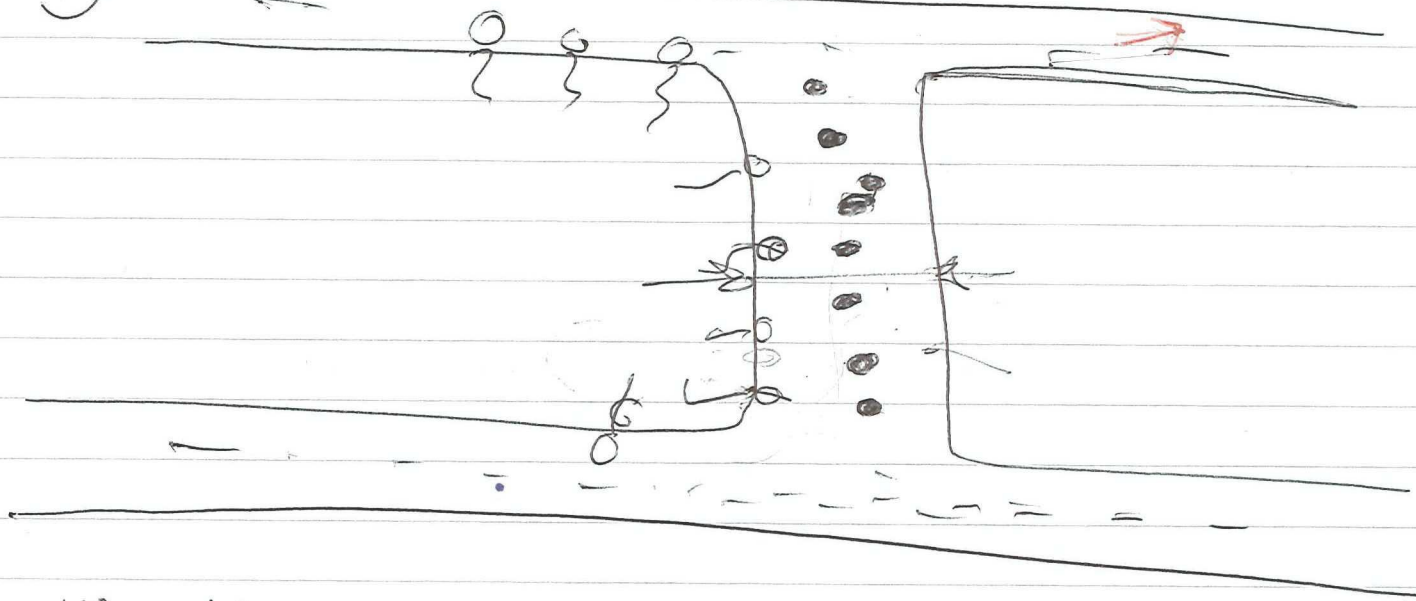
$$\Delta p = a - \rho g h_2 - (b - \rho g h_1)$$

$$= a - b + \rho g (h_1 - h_2) = \Delta \phi$$

$$\phi = p \pm \rho g z$$



2 Juni 2011



Hirazaki paper

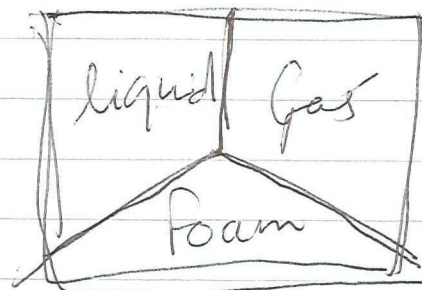
energy

150 V cells

Gibbs' analysis for binary mixture

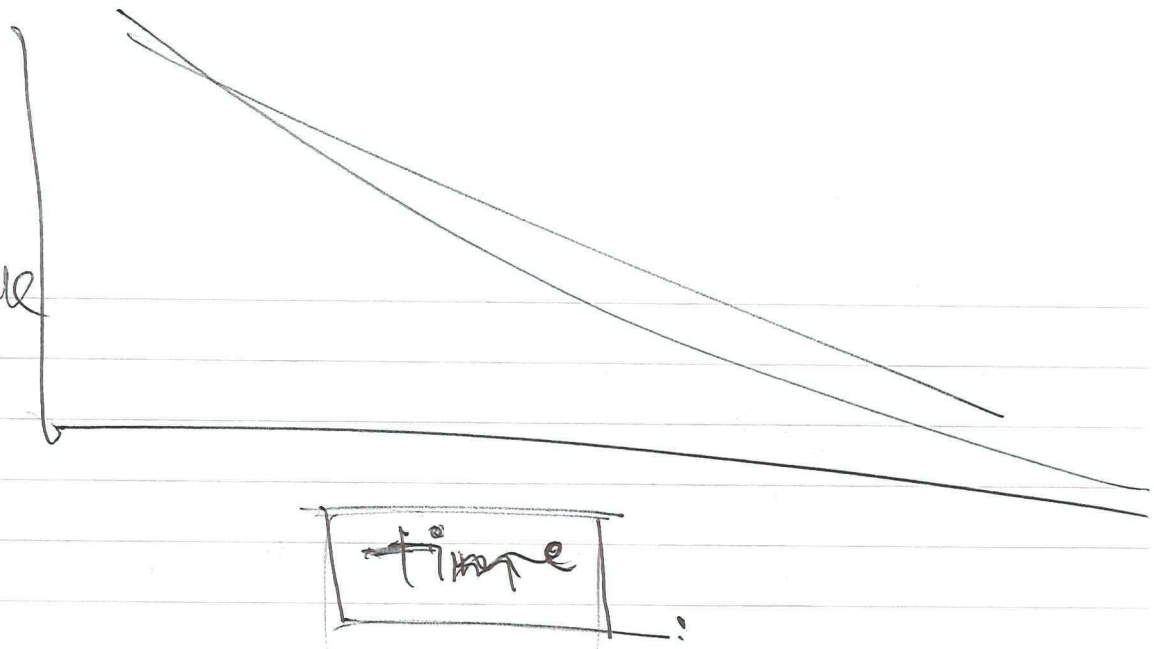
Morrow's paper : Journal of chemical physics

surfaces of



Rowhi : → Give him the composition
before the flow & experiments

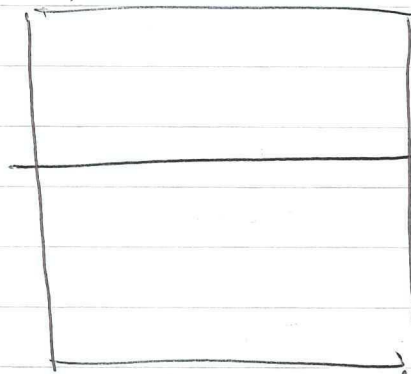
% wt of
the particle



Slopes low \rightarrow

Experiment without foam

with tracer



multiple
permeability
xpt.

Ali

Formation Damage

with ash

Ash nano particles only \rightarrow

Occasional conference call: skype

14 June 2011

Passing water through new sand pack
at 100 ml/h

Objective is to check the permeability at
no back pressure.

flow rate
~~100 ml~~ 100 ml/h

pressure (mbar)

10 m

15 min

measuring beaker at 10:12 + 10:27 = 25 gm
28 gm in 15 min
1 min

$$\frac{1.66 \text{ gm/min}}{25} = x$$
$$\frac{15}{15}$$

P₁ (bar) 0.251 P₂ 0.220 (bar) PdT 10.7 mbar

Total wt with water inside and closed plugs (g)
1673.04 gms

One plug 7.62 gms Two plugs 15.24 gms

The earlier wt 1673.04 - 15.24 = ~~1657.80~~

$$\begin{array}{r} 1673.04 \\ - 15.24 \\ \hline \end{array}$$

1657.76 gms

Earlier noted wt was 1638.21

so wt of water inside 1657.76
1638.21

29.55 gms \approx 30 gm \approx 30 ml \approx 30 cc

Pore volume available

14:00

Experiment with Back pressure 20 bar

at 100 ml/h. Objective is to check the permeability at 20 ~~bar~~ bar back pressure

On screen 10.7 mbar on pressure 15 mbar

14:12 Experiment to measure the velocity measuring beaker

15:39 ~~20 gms~~ 20 gms

39
12

27 min 20 gm
1 min x

27 min

Test with 200 ml/min 15.22
27.95 gm 15:35

$$\frac{20}{27} = x = \frac{0.74 \text{ gms}}{\text{min}} = 0.075\%$$

~~50 ml/min~~

13 min

~~0.0375~~ Repeat expt. 26 with AOS-40 + Ash particles
Gas 3.6 ml/min Water 1.8 ml/min

① 13 min 27.95 gm $x = \frac{27.95}{13} = 2.15 \text{ gm/min}$
1 min x

0.075%

First with only AOS-40 0.0375%. Double distilled water

0.3% AOS + 100 ml + 100 ml Distilled water
= 200 ml of 0.15 AOS

0.15 AOS 200 ml + 200 ml Distilled water
= 400 ml of 0.075 AOS

0.075 AOS 400 ml + 400 ml Distilled water
= 800 ml total of 0.0375 AOS

The idea is to check foam with 0.0375 AOS & then add 50% Ash particle solution and recheck the pressure differences at the same flowing conditions.

16 June

10:20 Experiment with Ash particles

0.0375 AOS + 0.0625 Ash particle
total 800 ml

Pump flow rate 54 ml/h

~~Gas~~ 10:30 ~~Back~~ Back pressure ~~held~~ given

10:31 Expt measurement begin Test 038 P₂
Computer 5.3 PdT ~~0.071~~ 0.071, 0.073

pressure transducers 10 mbar
P₁

measuring the velocity at 10:37 13.85 g
at 10:52

15 min 13.85 g

1 min 0.923 g

velocity 0.923 ml/min

11:35 P₁ 0.12 P₂ 0.073 PdT 10.7

lot of ash particle accumulated at the bottom

11:45 Back pressure released & Gas flow started

Gas flow meter doing trick 3.6 program ~~2.7 ml/min~~

But keep on varying

Foam seen at 11:50 P₁ 0.101, P₂ 0 PdT ~~0~~
5 mbar

13:25 Foam is coming out ~~0~~
but the PdT 5 mbar

P₁ 0.141 P₂ 0.073 so P₁ is increased

Gas Flow 3.1 ml/min Water 54 ml/h

Checking the foam velocity 13:25 ^{14.53 g} 13:40
so 1 g/min

could it be because of low surfactant 0.0375?

15:30 Foam out but still the pressure is 5 mbar

15:35 Flow is changed ~~from bottom to top~~ ^{top entry} Flow more

measured value 16 mbar

Test 039

No foam generator and Flow will ~~appear to~~ go to visual cell after sand core.

P1 0.101 P2 0.000 PdT 21.3 mbar 15:40

measuring velocity 15:56 $\xrightarrow{34.15g}$ 16:35
34.15 g in 39 minutes
1 minute

$$\alpha = 1.14 \text{ g/lm}$$

16:40 No high pressure so it is consider to use the foam generator before the water enters sand pack.

17:30 No change in PdT (25 mbar)

P1 0.241 P2 0.00

~~Suggestion~~ No foam in visual cell but foam in outlet
(Suggested to use this)

17 June experiments with pressure build up

~~for 1 hr~~ for ~~changing~~ foam generator

$$0.075 \times 0.3 \times 100 \text{ ml} + 100 \text{ ml} = 0.15 \times 200 \text{ ml}$$

$$0.15 \times 200 \text{ ml} + 200 \text{ ml water} = 0.075 \times 400 \text{ ml}$$

10:35

After discussion with Rouhi Started using 0.075 ml and flushing in the sand pack

measuring the velocity 11:15

After checking Back pressure valve 13:40

Pushing the AOS-60 in the Sand pack

14:10 : Releasing the back pressure & starting gas flow (3.6 ml/min) & water (108 ml/hr)

weak foam 14:15 PdT 0

Test 040

Foam started 14:40 But PdT - ~~0.03~~ 3 mbar

measuring velocity @ 14:44

Another experimentation : →

P₁ 2.295 bar P₂ 2.275 bar PdT 10.7 mbar

liquid flow rate 108 ml/hr Gas flow rate 3.6 ml/min

~~5 bar~~

Another experiments : → 5 bar backpressure

P₁ 5.445 P₂ 5.358 PdT 10.7 mbar
14 mbar

~~Gas flow~~ liquid flow 108 ml/hr

The problem is that once we ~~start~~ reduce back pressure, P₁ tends to be lower than P₂ giving the whole system PdT ^{almost} -ve, though ^{-160 mbar} it is foam in at exit.

20 June

With 0.0375 mg/ml

Back pressure 7. bar

P_1 28.122 }
 P_2 7.066 } bar

PdT 26.7 camp
24 Pressure
(measurement) } mbar

Flow rate 154 ml/hr

velocity calculated

30 min 68.50 kg
1 min 2.283 g

~~Back~~ P_1 27.594 }
 P_2 6.973 }
PdT 26.7
24

Flow rate 254 ml/hr

velocity calculation 14.06

0.3 25 + 25

0.15 50 + 50

0.075 ~~100~~

~~100~~

Expt 41

Pushing gas to show Bill

P_1 0.176

P_2 0.073

PdT 48.1

Flow rate 056 ml/hr

Gas leak ~~3.8~~ ml/min
3.12g 3.6

P_1 0.176

P_2 0.073

PdT 10.7 mbar

velocity measurement

14:33 14:48 15 min

15 min 14:45 g

1 min ~ 1 g

0.6 ml/s
3.6
61

~~21 June~~ 22 June

P_1 12.32g P_2 3.083 PdT 21.3 mbar

Flow rate 054 ml/hr Gas 3.6 ml/min

Pushing gas by ~~gas~~ gas cylinders with
pressure around ~~7.6~~ 10 bar

54 ml/hr liquid

Test 043

P1 2.467

4.5
ml/min Gas

10 bar

P2 0.00

Flow of foam

measuring flow velocity

16:10 → 16:26

~~12.37~~ 12.37g

16 min 12.37g

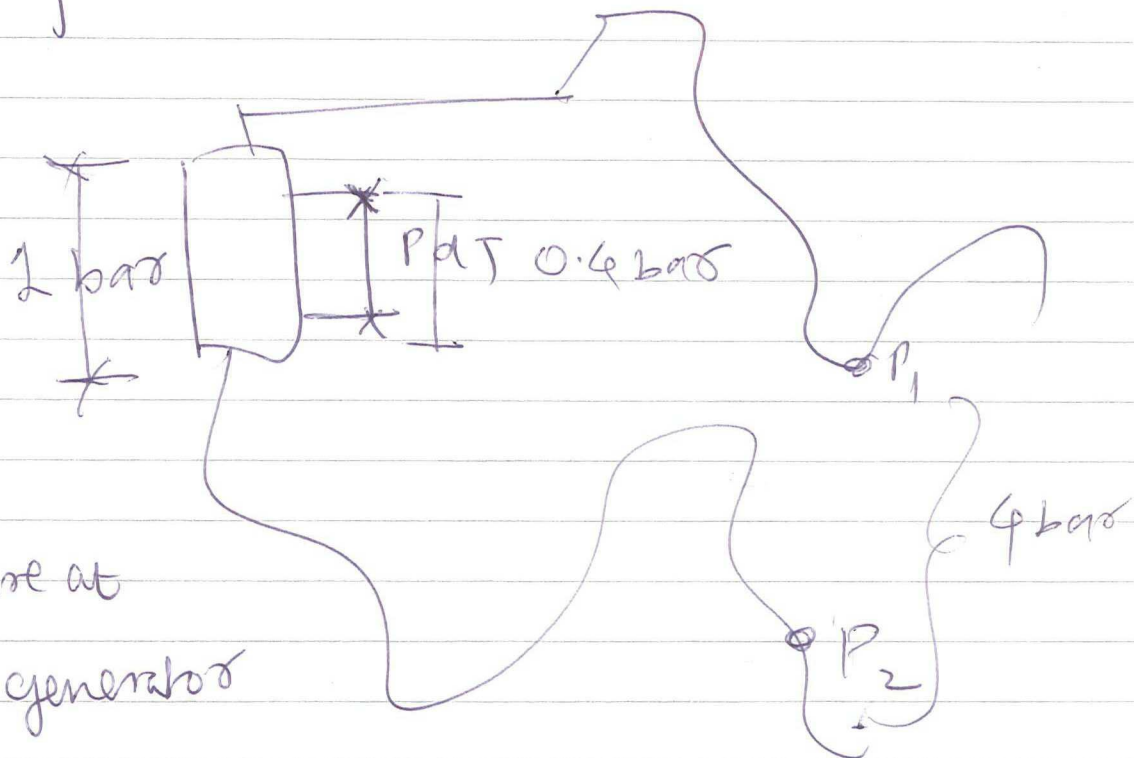
1 min 0.77g/min

P1 4.286

P2 0.073

PdT 233.6

16:10 time



check pressure at

foam generator

increases till 14000 ubar/m 6.5 PV and then decreases. The decreasing portion has not been used in the graph to compare

Test 0000

23/06/11

$PdT_{original} = 130 \text{ mbar}$

Flow rate 0.54 ml/hr without gas

13:40 $P1 = 1.526$ $P2 = 0.000$ $PdT = 260$

Try to find out what is happening with liquid flow after foam flow

Pressure ^{$P1$} dropped drastically ~~after~~ (from 1.526 to 0.2)

after foam generator was opened on its exit side

System is stabilised at $P1 = 1.292$ $PdT = 150 \text{ mbar}$

Measuring at 100 ml/hr

16:50 $P1 = 1.585$ $PdT = 138 \text{ mbar}$

16:30 $P1 = 1.761$ $PdT = 164.6 \text{ mbar}$

Measuring at 150 ml/hr

18:15 $P1 = 2.231$ $PdT = 185.8 \text{ mbar}$

24/06/11

Tomorrow ~~0.025~~ with ~~0.0125~~ Ash particles
~~to do~~ 24/06/2011

Test 0001 Repeating 0.025 expt to see the ~~stability~~ repetitiveness
checking the velocity of liquid.

09:49

light microscopy of particles 10:04 $12 \mu\text{m}$

$12 \mu\text{m}$ in 15 min , so $0.8 \mu\text{m/min}$

Injecting gas $10:32$ ~~$10:10$~~ 4.5 ml/min

measuring flow rate

P1 4.89 P2 0.073

PdT 286.6 mbar

10:53 - 11:23

water 30 min \rightarrow 24.24 gms, 1 min 0.808

0.3 50 ml + 50 ml 0.15 100 ml

0.15 100 ml + 100 ml 200 ml of 0.075
water

0.1 50 ml + 50 ml ^{water} 0.05 100 ml

0.05 100 ml + 100 ml 0.025 200 ml

400 ml + 400 ml
0.0125

so 0.075 AOS + 0.0125 Ash particles
200 ml 200 ml

Pushing this solution into the system 11:30

12:30

P1 5.930 P2 0.093 PdT 403.6

There is increase in PdT, P1 but we are not sure it is because of 'plugging of system (sand pack) ~~due to~~ by Ash particles or the combination of ash particles & surfactant. Because the PdT & P1 was already increasing without ~~prop~~ particles addition.

Actually the ~~pressure~~ PdT, P1 is decreasing

14:52 P1 4.168 PdT 154.0
~~Press~~

15:15 P1 4.345 PdT 111.5

It can be ^{concluded} ~~drawn~~ from this experiment that foam
pressure difference of foam flow across san-
-d pack is a function of surfactant
concentration. In fact for the diluted concentration
of surfactant (when Ash particles ~~in the~~ ^{solution}
~~concentration~~ is added) pressure difference
is significantly ~~low~~ lower.

Foam Flow Combinations

0.075 AOC + 0.125 Ash particle solution
200 ml 200 ml

15:27 measuring flow

16:28 52.05 mg in 60 min
0.867 mg/min 1 min

875.766
 $8.75 \times 10^5 \frac{\text{Pa}}{\text{m}}$

interesting to note at 54 ml/hr liquid

0.075 AOC liquid 0.8 gm/min

0.075 AOC + Gas (4.5 ml/min) 0.808 gm/min

0.075 AOC + Gas (4.5 ml/min) + 0.125 Ash 0.867 gm/min
200 ml 200 ml

17:36 P1 4.462 P2 0.0 PdT 138.0
~~mm~~

Pushing particles only to see the effect of
particles

$\frac{1}{50} = 0.02$ $\frac{1}{200} = 0.005$
 $\frac{1}{2} = 0.5$ $\frac{1}{20} = 0.05$
 $\frac{1}{20} = 0.05$ $\frac{1}{20} = 0.05$
PdT 28690 4.5
X 6

0.075 ml + 0.128 ml ^{AOS} from the start
200 ml 200 ml 200

27.0 ml

measuring Flow rate of foam (which is still present)
at 18:00 P1 4.403 P2 0 PdT 127.6 mbar
18:18 18.63 gm5

foam is collapsing
18:20 P1 2.407 P2 0 PdT 376.9

21:45 P1 1.233 P2 0 PdT 69.

Foam is ~~more~~ weaker, watery Stopping the experiment.

27th June experiment with De-min & De-distilled water

Permeability check 50 ml/hr

Built pressure 20 bar ~~18~~ ~~18~~

Actual P2 18.717

P1 60.002

PdT 10 mbar (14 on Apparatus) P1 is

According to Pump ~~is~~ 20 bar

138.7 g at 15:37
+ 30

162.9 g 16:07

Note : You shall see some surfactant

16:40 increasing ~~to~~ ~~PdT~~ flow rate 100 ml/hr

16:44 169.7 g

16:44 210.3 gm

slight increase to 16 bar

P1 60.002 P2 17.469

210.3
169.7

50.6 gm in 30 min
16:50 measurement

219.1

284.05 15:28

P1 60.002 P2 16.882

Increasing the flow rate 150 ml/hr

16 mbar

no increase

Raising again the flow rate 200 ml/hr

17:35 - 300 gm P1 60.002 P2 16.588 16 mbar

16:05 - 377.08 gm P1 60.002 P2 16.221 16 mbar

Filling the 0.075 at 10 bar backpressure 18:10
closing the experiment at 18:50

28th June 2011

Gas 0.45 — 6

Pushing 0.075 AOS 9:45 Water 0.3 — 4

10:26 P1 15.852 P2 4.037 PdT 16
(which is wrong)

10:25 Releasing the backpressure & letting the
gas flow gas 4.5 ml/min

P1 0.881 P2 0.073 PdT -0.39 mbar

No foam yet

P1 0.135 P2 0.073 PdT 14 mbar 10:43

P1 4.345 P2 0.073 PdT 63.8 Foam 11:16

foam 202.88 g
231.25 g in 31 minutes 11:47

Curve for 0.075 P

14:05 133.70 gms P1 10.157 P2 0.073 PdT 1088.0

On computer 10.157 but on pump it's ^{reading} 1114. something

14:35 156.4

14:40 Pushing 0.075 A₀₁ + 0.125
(200ml (200ml))
At Point 18000 P1 10.685 PdT 1100 mbar

15:00 340.41 gm for mix

15:30 368.40 gm

15:00 ~~Foam~~ PdT is not dropping, is it because of
aftermath of ~~stability~~ stability with ~~foam~~
surfactants only? measuring velocity

15:30

Foam is still coming & no sign of drop in PdT

P1 10.979 amp P2 0 PdT 1130.5 Computer

@ P1 25 Pump PdT 1155. Instrument

16:30 PdT is just keeps increasing

20:50 Change of solvent 40000 point
P1 11.214 P 0.00 PdT 1236.6

22:32 Pressure dropped & ^{liquidity} ~~foam~~ foam

Change to water after 47000

22:44 Changing to water now

29th June 2011 9:47 Pumping stopped

14:41
Pushing 0.075 + 0.125 in with ^{Gas} 4.5 ~~g~~ ml/min

P1 2.348 P2 0 PdT 47.0

There are some ash particles in the pump

Steady state at 1400 mbar stopped at 22.26

31 July 2011 9:45 Passing Demin. Dechlorin
~~for without anything~~ to rinse the sand pack for
one hour or so

12:40 changing the solution from water to
only Ash particle solution Test 0005

P1 ~~2.348~~
Go

P2 ~~1.565~~

20 bar Back pressure

13:55 Pushing the gas

P1 is increasing P2 0 PdT -5 mbar

waiting to mix the gas with liquid

14:17 P1 1.565 P2 = 0 PdT 15 mbar

~~some~~ foamy water due to foam from previous
cases Flow rate changed to 54 ml/min

Observation 16:00 little bit of foamy water

not increase in PdT 14 mbar

P1 1.937

~~2.348~~ $g = 350.72$ at 16:00

at 16:30

Fault in the measurement starting all over again
P1 1.703 P2 0 PdT ~~0~~ 1 mbar

Test 0006

17:00 wt 125.89 gms

1st July experiment with 0.0375 pumping at a
constant flow rate (Gas & liquid) Time 9:09

Backpressure 7 bar

Gas 3.6 ml/min ~~3~~ 4

water 0.9 ml/min 1

Reading Flow rate 100 ml/hr P1 29.76 P2 7.413
PdT 7.13 mbar 9:36

Reading Flow rate 200 ml/hr P1 29.707 P2 7.413
Observation foamy ~~the~~ water
PdT 14 mbar 9:46

Reading Flow rate 300 ml/hr P1 29.942 P2 7.487
PdT 15 mbar 9:49

lowering the back pressure & injecting the gas
9:50

Test 0007

11:40 Pump restarted

Exp stopped @ 21:30

New Experiment on 4th July with water drainage
name
~~36~~ 36 ml/hr

The goal is to check how the water decreases the PDT and if there is a instantant content in the drainage water

5th July experiment with 0.075

1. 9:35 : 0.075 solution started to push with back pressure ~~0.075~~ 7 bar & rate 100 ml/hr waiting to see its performance
name 0.075 - 5th July

Visual cell 97% full & the flow is taking place

P1 4.941 P2 7.340 PdT 14.1 mbar

measuring the flow rate

197.34 at ~~219.94~~
219.94 10:31
~~219.94~~ 10:52

Test 0009

Pushing the gas now at

Gas 3.6 ml/min
water 0.9 ml/min

8th July
9th July
10th July

P1 0.241 P2 0 PdT -16.0

13:30 ~~0.781~~ P1 0.781 P2 0 PdT 85.3

Pumping action is erratic

average ~~130~~ mbar
130

Always having lot of fluctuation, need to compare with earlier expt. 17:15

Stopped at 19:30

Test 0010 Rissing with water at 36 ml/hr 9th July

Coming back before 11:00 than we see how things work.

Monday 9:45

11th July

36 ml/hr

Checking the ~~flow~~ water flow and measuring the permeability (Back pressure 7 bar)

Test 0011

12 mbar

w = 166.38 g 10:30

7.516 7.613

10.7 mbar 13 on instrument

w = 179.83 g 11:00

72 ml/hr 14 mbar

7.441 P₁ P₂ 7.340

185.02 g at 11:08

211.38 g + 30
A 11.38

100 ml/hr

~~11.38~~

14 mbar

226.30 g at 11:54

+ 30

261.31 g at ~~12:22~~ 12:22

150 ml/hr

7.531

7.413

261.31 g 12:25

315.19 12:52

50 ml/hr

PdT = 13 mbar

327.45 g at 13:18 P₁ 7.336 7.267

~~315.19~~

~~327.45~~

342.82 g

13:48 P₁ 7.021 6.973

16:00

⊗ filter - foam generator 13 mbar
(400 micron) removed

Started the experiment again with 50 ml/hr

P₁ 3.346 P₂ 3.303

PdT 13 mbar

P₁ 7.386

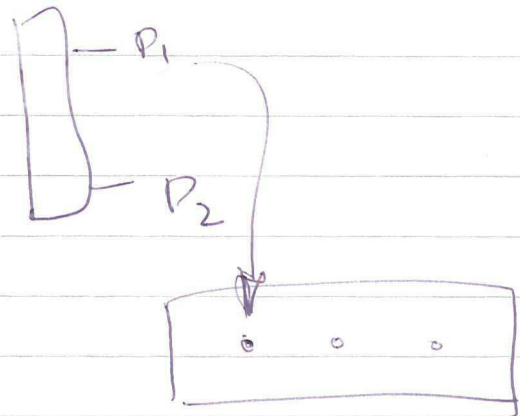
P₂ 7.267

17:50 stopped something around 80 mbar

The profile shows
interruptive
pumping action.

structure suggesting

Kees van beek
Steinz



13th July 2011

Kees fixed the data machine so onwards

~~and it~~ conducting first water experiment. 7.27g
~~50 ml/hr~~ (back measure)

Flow rate	P ₁	P ₂	PdT	Flow rate	P ₁	P ₂	PdT
50	7.330	7.338	15.8	100			16.2

Flow rate 100 ml/hr 163.04 g at 14.57
+ 10.30
15.24 36 g/min

14th July

14th July

Gas permeability experiment

Back pressure 7 bar

Mass Flow PdT P_1 P_2

Abandoned 10:15 after discussion with Ioannis
relative permeability may be 15 permeability we
get when passing gas & water together
through sand pack

Test 0013 water displacement by gas Back pressure

water saturation $S_w = 1$ } Initial conditions 7 bar

Gas saturation $S_g = 0$ }

Gas is pushed through the system

Assumption: nitrogen is not dissolving in ~~gas~~ water
Gas 3.6 ml/min

we started injecting at 2:50 PM

~~16288.0~~ at 3:00 pm

0.75 m at 3:30 pm

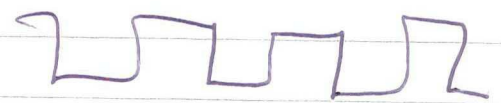
1

Stopped at 5:00 pm ~~Test 0014~~

15th July

~~The~~ Pump problem: pump is cleaned &
reassembled

Though pump is still showing



Operation closed 14:50

18th July Monday

AOS-40

AS-40

pump replaced

Test 0011(1)

pumping at 0.8 ml/min

Pumping at 1.6 ml/min

wt 338.98 at 10:31

wt 412.22 at 11:02

412.22 11:01

461.15 11:32

Rate	P ₁	P ₂	Pd/T	Rate	P ₁	P ₂	Pd/T
0.8	7.68	7.69	16	1.6	7.701	7.704	17
2.4	7.70	7.69	17.2	3.2	7.712	7.704	17.9
4.0	7.68	7.67	18.3	4.8	7.69	7.68	18.8
5.6	7.69	7.68	19.2	6.4	7.69	7.67	19.6

Experiment stopped at 15:36

wt 461.15 at 11:34

536.09 12:04

~~42.05~~

~~wt 536.09 12:04~~

~~12:35~~

wt 186. at 12:52

287.87 13:22

wt 174.30 at 13:25

309.19 13:55

wt 158.48 at 14:00

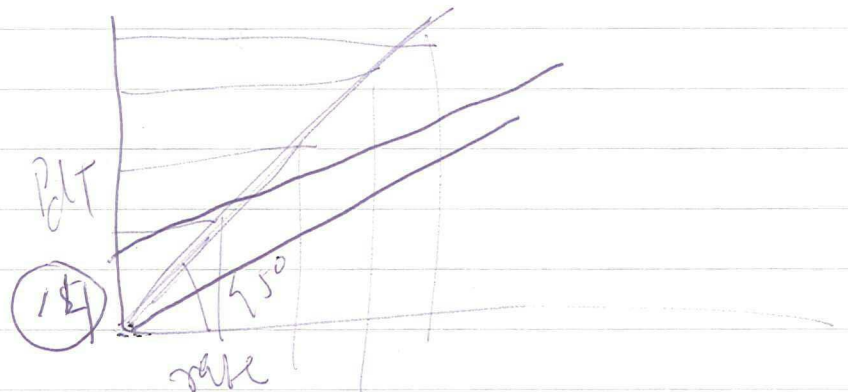
310.45 at 14:30

wt 138.56 at 14:33

312.45 15:03

wt 141.02 at 15:08

335.46 at 15:36



19th July tried to see if we get ~~14 mbar~~

○ flowrate ~~on~~ 0 mbar difference but everywhere
no flow \longleftrightarrow it is 14 mbar

20th July

Beaker wt 

Same experiment again
with compensation

11:25

162.45g

0.5 ml/min Pat 11

Wt ~~0~~ 0 12:04

14.89 12:38

1 ml/min Wt 17.27 at 12:45

47:00 1:16

1.5 ml/min Wt 47:00 at 13:18

89:53 at 13:46

2.4 ml/min Wt 89:53 at 13:50

8 163:20 14:20

3.2 ml/min Wt 0 at 14:23

98.04 14:53

4.0 ml/min Wt 0 at 14:56

123.37 15:28

21st July

Permeability of 18th July experiment is 1.3 Darcy
just realised that we have not changed the
sandpack. Further experiment to be done with
change in sandpack. 16:36 21st July 2011

Permeability

~~10th~~

10th July

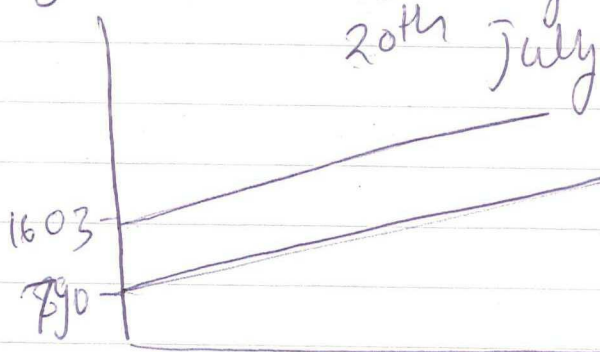
1.29 Darcy

20th July

1.23 Darcy

8th July

20th July



22nd July

~~Time~~ Sandpack Filling

of sandpack

Wt with one lead 861.91 g

Wt of one lead with filters 545.35 g

Wt with two leads & sand 1482.30

— 11 — 11 — f screws 1624.04

— 11 — 11 — f 11 — f ~~fast~~ closed with
4 nuts & — 11 — 1654.60 gm

Replaced the sand, so starting pumping water to see the performance

25th July

11:50 measurement shows 0 reading ~~when~~ when 0 flow
so after lunch start the water experiment

0.8 → 5.6 name of the file 25th July 2011

~~16~~ Wt of the beaker is 161.33 g

~~Wt~~ (The usual cell has not yet filled)

Start of water dropping 12:50 + 13:20 = 21.60 g
at 13:25 — 13:55 → 51.01 g

2.4 ml/min ~~on~~ 14:00 → 14:30 = 72.00 g

3.2 ml/min 14:31 → 15:01 = 95.00

4.0 15:02 → 15:32 = 121.83

4.8 15:33 → 16:03 = 146.19

5.6 16:05 → 16:35 = 170.00

26th July

12:50 Changed the soln to 0.0375 wt% surfactant soln
going to prepare for the experiments where for a
given flow rate (water & fees), ΔP changes according
to increase in surfactant concentration

Plan of action : →

12:50 to 13:50 ~~filling~~ pumping the solution 0.0325 till surfactant is filled in the sandpack

13:50 to 14:50 ~~wait~~ : wait to have ~~zero~~ flow rate → zero ΔP condition. If not adjust screws to get it

15:00 onwards pushing the gas at flow rate 3.6 ml/min
liquid flow rate 0.9 ml/min

13:48 Already started ~~the~~ surfactant flow & going to wait for an half hour before pushing Gas flow rate.

14:20 Pushing the gas

14:36 Gas pushed u can see it pressure & ΔP drop
Gas flow is not proper so checked for sometime & made some corrections (increase the cylinder)

Next check, 15:10

No formation of foam : 16:30 Pumping stopped

27th July

11:30 Trying again

27th July 0.0325 - repeat

1:00 Pushing the gas

28th July

Nothing is happening with the push of the gas 11:30

cleaned the gas flow meter & started again 16:10

Increase in the ΔT

morning sunshine (or no sunshine) so I see Louise, but could not manage any rapport & I see she is in bit better (or bigger) hands and she liked it. So here I am 7 am in the morning doing my life mission! It is actually not the sad at least if the experiment running good! 29th July 2011

Gas flow 6.5 ml/min Back pressure 7.5 bar to be used till the flow reaches regular trend
Water 0.9 ml/min

Correction : Back pressure cut-off because does not seem that is necessary to keep

7:25 Cannot wait long pushing the gas
 P_1 0.2 mPa Back pressure 2 bar or 0.2 mPa
so P_1 & P_2 are matching well each other
~~P₂~~

7:30 Reduced back pressure to zero

7:35 Pump is stopped to get some clean foam

31st July

~~Valve~~ Gas flow meter not working properly

1st August

Gas flow meter is required.

IdT ~~stays~~ needs to be ~~down to~~ down to 12 or 14 mbar to start the injection of gas

50 mbar it remains constant so I am going push it there. 10:45 am

2nd August

File name

~~27th July~~

~~27th July repeat~~

27th July 0.0375 repeat 1

Back pressure ~ 2.5 bar

Gas pressure ~ 6.25 bar

Still ~~no~~ no good reading so I am going to push ^{water} water

~~water~~ 0.0375 is diluted to 0.018 by adding ~~it~~ ^{water} to 0.

Test 061

Flowing the foam: P_1 1.22 P_2 0.10

PdT 23 mbar

19:40 Observation

P_1 1.39 P_2 0.10

PdT 24 mbar

~~is~~ erratic but within limit

Backpressure & Gas pressure are same as before
though we now know that putting exit liquid
in the bottle for entrance liquid is ~~same~~
bit difficult to explain surfactant conc.
Anyway, this experiment is for the stability

* We added 40 ml of 0.075 ml oil to maintain surfact-
conc in depleted entire bottle liquid 19:45

3rd August

ΔP is small ~~24~~ 24 mbar, so we are going to use some other thing like back pressure or something like that

Back pressure ~ 6 bar

Gas pres ~ 12.5 bar

10:00 pumping the water Test 062 (1)

11:00 pushing the gas at 12.5

4th August

~~Viscosity~~ Surface tension measurement

0.0375 AOS water inlet

Outlet

After that demineralized water ^{(~ 300 ml) at solvent change rate} is pushed through sand pack to ~~push~~ rinse 0.0375 surfactant trace. The rinsed water is stored for further research.

Passing 300 ml of normal water to reduce the surfactant concentration from the sand pack 0.9 ml/min
Test 063 (1)

ml/min	PdT
0.9	23
1.8	23
2.7	24
3.6	24
4.5	24

Observation the difference is so small that it is difficult to conclude the effect of increase in flow rate on the pressure difference across the measurement points in sand pack.

It is decided to check one more time with the 0.0375 again. Also needs to check ~~viscosity~~ surface tension of all the water

~~viscosity of~~

surface tension of rinsed water from 0.0375
11 — of rinsed water demineralized
11 — of ~~test~~ — from ~~water~~
— of — from Demin water

5th August

Test 064 repeat 0.0375
0.9 ml/h liquid 22 mbar P_1 & P_2
7.9

Pushing the gas

~~edit~~ 11:00 PdT is 36 problem is that
 P_1 is lower than 12

~~test~~ Date 6th August 2011

Pumping the outlet water of earlier experiment

Pumping the 0.0375 one more time (produced from
~~0.0375~~ 0.0375) Repeating the same experiment

Date 7th August

Analyzing the data & sending it to Hans, Bill etc.

Calculating 1st value of the experiment from
25th July water experiment

$$y = a + bx$$

~~$$dp = p_1 +$$~~

Pressure difference = Intercept + Slope (Flow rate)

$$\Delta P = \Delta P_1 + \frac{\mu L}{KA} (Q)$$

$$\frac{\mu L}{KA} = 4.07285E10$$

$$K = \frac{\mu L}{4.07E10 \times A}$$

8th August 2011

Test 068 without Back pressure

* Test without Foam generator Test 071

* Test without Sandpack to see where the pressure drop is. Test 072

~~8th~~ 9th August 2011

Doing the experiment without foam generator
Problem there is no water (soln) in the system

System stable around 100 mbar

P1 1.75 P2 0.17 bar

15:26

wait till 15:46 & then shut off

10th August 2011

9:35 Sandpack set loose from so ~~try~~ trying to push the liquid at 0.9 ml/min without back pressure

10:15 Pushing the gas

1 ml = 1 cc

$$0.9 \text{ ml/min} = 0.015 \frac{\text{ml}}{\text{sec}}$$

$$= \frac{0.015 \times 10^{-6} \text{ m}^3}{0.001256 \text{ m}^2} \text{ sec}^{-1}$$

$$1 \text{ cc} = 1 \times 10^{-6} \text{ m}^3$$

$$11.94 \times 10^{-6} \text{ m}^3$$

$$1.2 \times 10^{-5} \text{ m}^3$$

11th August 2011

(demineralised)

Doing the water experiment Expt 74
without sand pack, without backpressure, without
foam generator

{ Before next experiment, open the Backpressure valve for
maintenance }

19:45 Experiment stopped. Tomorrow new experim
ent with Backpressure

12th August 2011

Figuring out how the microarray works

15th August 2011

Repaired the structure with Hans

16th August 2011

First water experiment with new fixes. Test 076

Again the correction, $PdT = 1 \text{ mbar}$

Tomorrow experiment with water again

17th August

~~Start~~ Starting temp 21°C

Test 77

39.1 wt% AS-40 soln

soln

\therefore Every 100 gm (ml) of AS-40 contains 39.1 gm of AS-40 soln

So to get 0.3 wt% of 100% AS-40

\Rightarrow 3 gm of 100% AS-40 in 1000 gm

to get 3 gm of 100% AS-40 we need to have

$3 \times 3.21 = 11.73 \text{ gm of added in } 988.27 \text{ gm of water}$

$$\begin{array}{r} 5.865 \\ 2 \overline{) 11.73} \\ \underline{10} \\ 1.73 \\ \underline{1.60} \\ 13 \\ \underline{12} \end{array}$$

~~$1.5 \times 3.91 = 5.865$~~ 5.865 gm in

500 ml of 0.3 wt% As₄O₆ contains 150 ml of As₄O₆ & Rest 350 ml of water

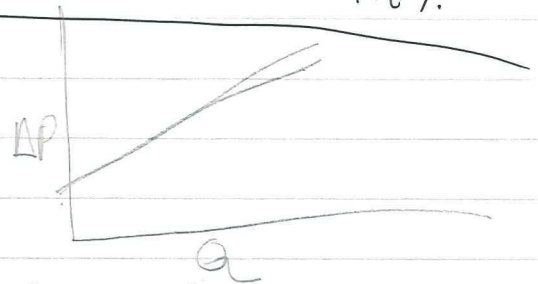
1000 g_{As₄O₆} = 5.865 g_{As₄O₆} / 100 g_{water}

494.135 ml of water

50 ml 0.3 wt% + 50 ml of water = 100 ml of 0.15 wt%
 100 ml of 0.15 wt% + 100 ml of water = 200 ml of 0.075 wt%
 200 ml of 0.075 wt% + 200 ml of water = 400 ml of 0.0375 wt%

So 50 ml of 0.3 wt% & 350 ml of water = 400 ml of 0.0375 wt%

Flow rate (ml/min)	Pd T	Temp
6.3	16	22°C
5.4		



The temp is constant on 22°C
 15:30 Water experiment completed & now flowing the 0.0375 wt% freshly prepared.

Flow rate ml/min	Temp (23°C) Pd T (mbar)
0.9	6
4.5	14 (24°C)

$$Q = \frac{KA}{\mu} \left(\frac{\Delta P}{L} \right) + x$$

Ethanol flushing on Sunday; 1 pore volume

17:30 End of experiment 4.5 ml/min → 14 mbar at 24°C

August 18 2011

Pushing the gas at 3.6 ml/min of water 0.9 ml/min Temp 20°C

Test 079

9:47 Gas pushed

wt of beaker 57 gm. started 10:05

$$1 \text{ cm} = 1 \times 10^{-2} \text{ m}$$

$$1 \text{ cc} = 1 \times 10^{-6} \text{ m}^3$$

$$1 \text{ ml} = 1 \times 10^{-3} \text{ m}^3$$

0.9 ml/min

ml/min

$$0.9 \times 60 = 54 \text{ min}$$

ml/min ⇒

$$Q = \frac{\Delta P K A}{\mu L}$$

3
1.5
0.75
0.375

Visual well removed & then checked the flow pressure difference. It is OK PdT none 11:17

P1 0.38

P2 0.10

PdT 191

if remove the nut

① Near T-joint, just after P1 measurement

— Both pressure goes zero & PdT -ve

so No pressure drop

② just before the sand pack

— Both pressure goes zero & PdT -ve

So No pressure drop

③ just after the sand pack

P1 0.33

P2 0.04

PdT 194

so there is a pressure drop across the sand pack

④ Just before the P2

P1 0.32

P2 0.04

PdT 181

So we loose ~10 mbar

⑤ After the P₂ valve, before Back^{pressure} valve

P1 0.31

P2 0.04

PdT 181

so nothing much happens.

Test 80

P1 0.29 P2 0.11 PdT 2110 Temp 21°C

very ~~easy~~ rough but OK graph Next is to pump 0.0375 wt for couple of hours and morning repeat the experiment

Test 81

0.0375 wt% at 0.9 ml/min rate to stabilise the

things

Test 82 0.0375 wt% at 0.9 ml/min for 15 min & then pushing the gas

Temp 20°C 8:00 in the morning

$$\frac{200}{1200} \frac{60}{1} \frac{0.9 \text{ ml/min}}{3.6 \text{ ml/min}} \approx \frac{25}{r} \approx \frac{2 \times 0.03 \frac{N}{m}}{10^{-3}} \approx 60 \frac{N}{m^2}$$

$$60 \times 10^{-5} \text{ bar} \approx 0.06 \text{ mbar}$$

1/9
Gas
0.9 ml/min
3.6 ml/min

0.0375 — 6 hours

0.	Gas	Water	Concentration
①	3.6	0.9	0.0375
②	6.0	1.5	
③	3.6	0.9	0.0375

3.0 | 0.2

0.0352

0.0

0.0

0.0352

0.0352

0.0352

0.0352

0.0352

0.0352

0.0352

Test 083

0.27

P1

0.11

P2

115

PdT

21°C

Temp

Test 086

1.5 ml/min

liq

25°C

6.6 ml/min

Gas

Temp 25°C

from

16:30 till

18:30

25°C

Correct it

Too much of erratic behavior, need to check it again.

Interview

Conducting water experiments 20th August at 21°C

Erratic in one word

Pumping 0.15 wt% for one hour & then we see

22nd August

Test 087 0.15 wt% & high flow rate
Gas 6 ml/min & water 1.5 ml/min
PdT 1090 looks like stabilising

highest reading with this instrument

Test 088

1.5 ml/min \times 6.6
 $\frac{1000 \times 100}{15}$ 660 min
 $\frac{1000}{15}$ 11 hr

11.1 hr
6.6 min

6.1 pressure

1.5
31
15
90
1000
109.0 1100

109 ml 12.2
 $\times 10$
1090 ml

23rd August

conducting Test 089 0.0375 wt% Gas 6 ml/min & Water 1.5 ml/min

1.6625 gms in 1000 ml

998.5 gms of water

24°C at 17:00 hrs

569 15969

569 - 15900

24th August

Stabilisation from previous sept occurred at
240 mbar

Experiment with AS-40 lower flow rate
started at 8:30

21°C, 17:33 stable at around 50 mbar
20:45 stable @ 45-50 —

26th August

Low flow rate experiments with 0.15 wt % AS-40

Test 91

Test 92

27th August Test 93

Problem in liquid flow P2 seems to be bigger than P1
while flow is occurring. Trying to correct the
situation by flow normal water & checking the
flow profile

Test 94

28th August Test 95

R

correcting water gas exchange 50 mbar

30th August 2011

Preparation of particle solution in 0.0375 wt% AS

0.0375 wt% AS-40 — 600 ml

~~2.5 gm/l~~ 0.0375 gm/l AS-40

Suppose I add 1 ml of 2.5 gm/l in AS-40 soln (600 ml)

0.025 gm/ml in 600 ml of 0.0375 gm/l AS-40

2.5 gm / 600 ml of soln

~~0.04 wt%~~ gm/ml

4 gm/lb.

0.4 wt%

Suppose I add 0.025 g/ml (10 ml i.e. 0.25 gms in 600 ml of AS-40 soln) then

0.25 gms / 610 ml

4×10^{-4} gm/ml

0.04 wt%

0.4 gm/l

~~4×10^{-4} gm/ml~~
~~0.4 wt%~~

Suppose I add 0.025 g/ml (5 ml i.e. 0.125 gm in 610 ml of AS-40 soln) then

0.125 / 610

2 gm/ml

0.2 wt%

0.2 gm/l

0.2×10^{-3} gm/ml

Prof. Kraster

First experiment with AS-40 & particle send by

① AS-40 solution 0.0375 wt%. 0.0375 gm/100 ml
(600 ml) 0.375 gm/1000 ml

② Kraster solution 0.4 gm/1000 ml
0.04 /
Power Plant Erlingen Ash-particles Ultrasound
treatment PH=11
Conc. 0.025 g/ml 2.5 gm/100 ml
(10 ml) 2.5 wt%
25 gms/1000 ml

80
610 ml of solution contains 0.0375 gm/100 ml
of AS-40 & 2.5 gm/100 ml of Ash particles

∴ 610 ml contains 0.225 gm of AS-40
& 0.25 gm of Ash particle
610 ml 0.225 gm AS-40
610 ml 0.25 gm Ash particle

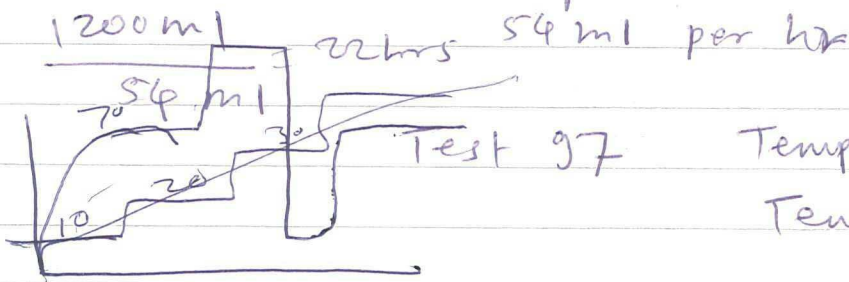
The solution is magnetically stirred for half an hour before starting to use.

The solution was continuously ^{magnetically} stirred at 100 rpm
 for during the experiment
 start 96

Flow of liquid started at 14:02 & in 15 min gas valve
 is opened. Pressure is steadily building though there
 is not yet foam like structure at the outlet
 ($P_2 > P_1$ still).

15:25 Nice foam but $P_1 \sim P_2$ & PdT 2g mbar

Should have prepared more solution



Temp 20°C 13:00

Temp 23°C 17:00

~~Flow of~~ 1st September 2011

Data gathered. A similar sort of experiments
 are supposed to carry out, beginning with
 Water

2nd September 2011

Water	penmeability	experiment	Test 98	Temp 20°C 10.75
Q	P1	P2	PdT	
0.9	0.07	0.05	75 →	0.375 g

610 ml contained 0.225 gm AS-40 0.375 g/ml

610 ml 0.25 gm AS-40 0.4 x 10³ gm

or 0.375 mg/ml

& 0.4 mg/ml

0.0375 g

0.4 x 10⁻³ gm
 0.04 x 10⁻² gm
 0.04 gm

① Particle experiment : Particle solution + Gas Test 101?

② Gas + just water experiment

9th September 2011

Amin expt with viscometer

505

$$t = 805 \times 0.002862$$

$$= 2.3075 \text{ mm}^2/\text{s}$$

1.44

Kinematic viscosity ν

$$\rho \cdot \nu = \eta$$

0.3 wt %

0.3 gm/100 ml

$$\textcircled{2} t = 503 \times 0.002862$$

$$= 1.44 \text{ mm}^2/\text{s}$$

New experiment with high concentration
after permeability experiment

6 gm AOS and 994 ml water for 0.15 wt %

~~0.4 gm~~ For 0.4 gm/100 ml 4 gm/1000 ml of Ash

Soln: 0.025 gm/ml

So 4 gm

$$\frac{0.025}{4} = 1$$

$$x = \frac{4}{0.025} = \frac{4000}{25}$$

~~25 gm/1000 ml~~ 25 gm — 1000 ml

0.025 g/ml

0.25 g/10 ml

2.5 g/100 ml

0.25 gm in 1000 ml
0.25 gm
1000 ml

~~0.25~~ 0.025 g/ml/100 ml
0.025 wt %

~~0.25~~ 1000 ml contains 6 gm of AOS 0.15 wt %

~~0.25~~ 1.5 mg/ml

~~0.25 g/ml~~
§ ~~18 g/ml~~ ~~0.4 mg/ml~~

0.25 g/ml in 10 ml soln

0.4 gm

0.04 wt %

0.4 gm
100 ml
16 ml

$$\frac{0.4}{0.25} = \frac{40}{2.5} = \frac{400}{25} = 16 \text{ ml}$$

~~0.4 gm~~

1000 ml → 0.15 wt % soln ~~1.5~~ mg/ml AOS
16 ml Ash → 0.04 wt % 0.4 mg/ml

0.4 gm in 1000 ml

$$\frac{0.4}{1000} \text{ g} = \frac{0.04 \text{ g}}{100 \text{ ml}}$$

= 0.04 wt % Ash }
0.15 wt % AOS }

15:20 - starting test with 0.15 wt % AOS + 0.04 wt % Ash
Temp 23°C waiting to start one hour to start

Monthly Rent

160

150

Monthly Income

Monday 20/09/11

11:40

Passing Ethanol at 0.9 ml/min

13:00

Passing CO_2

13:15

Passing Water

14:50

Running water experiment

10Cp

Temp 22°C

17:30 Expt stopped.

Wednesday 21/09/11

Find out if anybody has done experiments like us.

Thursday 22/09/11

Repeat 0.0375 0.9 ml/min Test 105 11:40

Started to pump the soln 0.0375 at 11:52 so going to wait for one hr before gas Temp 21°C

PdT 8 mbar but weak foam at exit

13:40

PdT 13 mbar so weak

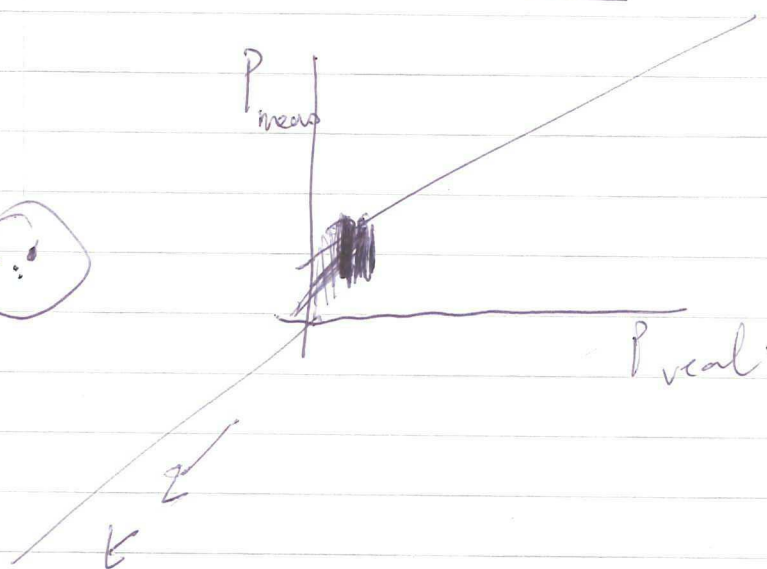
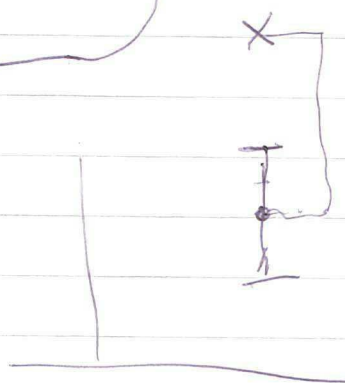
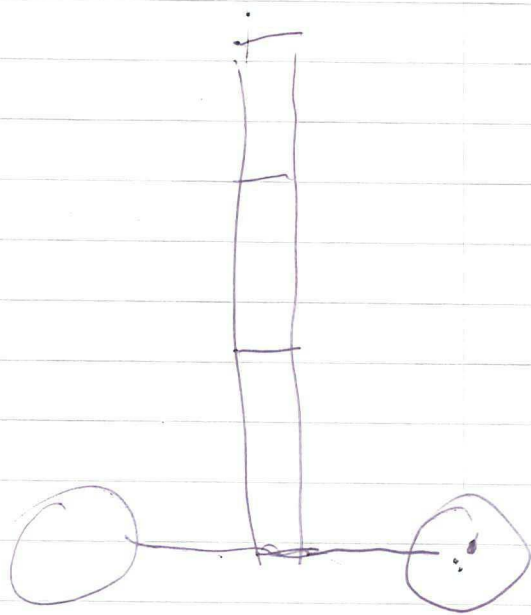
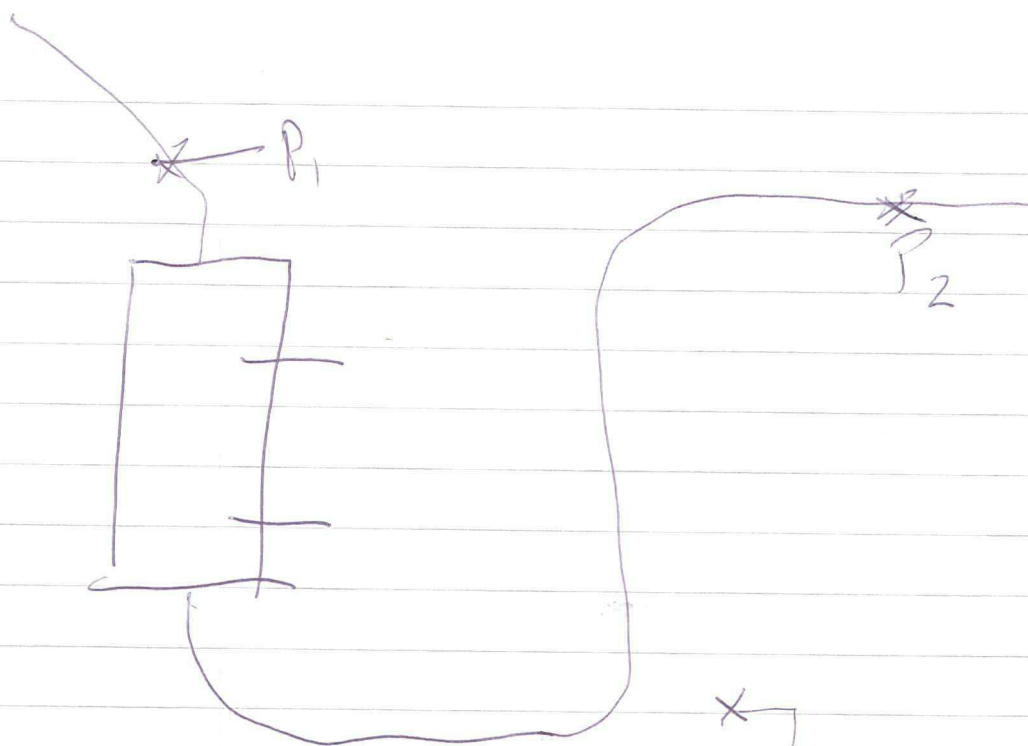
18:15

Try to check if we could get PdT as $P_1 - P_2$ as in previous expt. As of now $P_1 - P_2 \approx 60 \text{ mbar}$ while PdT shows $\approx 14 \text{ mbar}$

Calibration P_1 & P_2

Accuracy & precision

Check about repeatability experiment: →



~~P1 & P2~~

Remediation with Apparatus

- ① Electrical conductivity & pH meter
- ② Temperature control → All three ~~at the~~ ~~three places~~ → ~~with~~ with computer connection

$$\frac{1.5 + 6}{6} = \frac{7.5}{6} = \frac{6}{7.5} = 0.8 \quad \frac{3.5}{4.5} = 0.8$$

Write to Kraster
permeability

17 Oct 2011. ~~Viscosity~~ calculated, $1.47 \text{E}-10 \text{ m}^2$ by

Carmen-Kozeny relation as follows

for $d_{\text{par}} = 0.392 \text{ mm}$

$$\frac{\Delta P}{L} = \frac{150 V_0 \mu (1-\epsilon)^2}{\phi_s^2 d_p^2 \epsilon^3}$$

$\phi_s^2 \approx$ neglected

porosity ratio

$$\epsilon = 0.38$$

$$\frac{(1-\epsilon)^2}{\epsilon^3} = 7.00$$

V_0 superficial velocity $\frac{Q}{A}$ in m/s for various condition

$$\frac{Q}{A} = V_0 = -\frac{K}{\mu} \frac{\Delta P}{L}$$

for $V_0 = 1.2 \text{E}-06$ $K = \frac{V_0 \cdot \mu}{\frac{\Delta P}{L}} = \frac{1.2 \text{E}-06 \times 1 \text{E}-03}{\frac{\Delta P}{L}}$

$$\frac{\Delta P}{L}$$

$$= \frac{8.14}{1.47 \text{E}-10}$$

$$= 0.0147 \text{E}-12 \quad 147 \text{ Darcy}$$

$$= 0.0147 \text{ Darcy}$$

Pelt specification Endress + Hauser

KEMA 03 ATEX 1561

PMD 75-1AA7HB1B4AV : Order Co

AB024E01090 : Ser. No

4 - 20 mA HART

Span 0.03/3 bar

Endress + Hauser

Technical information

Deltabar S PMD 70/75

Material 1.4435/316L C22.8

FMD 76/77/78

Cal./Adj. -3...3 bar

pH & Electrical conductivity

20 Oct 2011

Always in KCl solution

Electrical cond. pH

20°C

181 cm

6.52

Electrical cond. (181 cm)

at 20°C

pH

6.54 6.09

6.34

Double Distilled water

DI + 0.0375 wt%

121

(When there is no sign up or down on pH meter, it means it is stabilised)

21st Oct 2011

0.0757 DI

219 (20.6°C)

6.38

0.157 DI

373 (20.4°C)

5.35

0.375 DI

689 (20.5°C)

6.075

0.0375 - 3 August

530 (20.4°C)

7.06

0.0375 Rinsed at exit

14 (20.5°C)

6.42

Outlet - 4 August, 0.0375

531 (20.7°C)

7.05

Outlet - 5th August 0.0375

158 (20.7°C)

6.57

0.3% NaCl

0.075 AS40 + 0.3 NaCl (water unknown)
0.15 AS40 + 0.3 NaCl (water unknown)
0.3 AS40 + 0.3 NaCl (water ... 6.52
0.5 AS40 + 0.3 NaCl

E. Cond. pH
6.26 (20.5°C) 6.51
3.34 (20.7°C) 6.61
6.12 (20.8°C) 6.78
~~6.12~~ 6.96 also
55.4 7.11 shaken for 30 min
6.80 at 300 ppm
6.16

samples ~~shaken~~ ^{ultrasonicated} for ~~30 min~~ before checking the pH

0.075 AS40 + 0.075 SiO₂
0.075 AS40 + 0.15 SiO₂
0.075 AS40 + 0.3 SiO₂

0.15

0.125 wtl Ash

45
(22°C)

~~0.125 wtl~~

Note: Silica particles have become coagulated & is difficult to redisperse in the solution. Ultrasonic (2400) & shaking (30 min) seems to have no effect on it. Nevertheless we will check something.

check DD+0.15AS pH values

Final test 087 & before data ^{except} to ~~to~~ ~~check~~ the problem of high flow rate 0.15 wt i.
Karl-Heinz Wolf thesis

THREEQC program for correction
Example Input Files

$$V = \frac{\pi R^2}{\rho \mu} \frac{\Delta \phi}{\Delta L}$$



$$\frac{\text{volume open to flow}}{\text{wetted perimeter}} = \frac{\pi R^2 h}{2\pi R h} = \frac{R^2}{2} = R_h$$

$$V = \frac{\pi R_h^2}{2\mu} \frac{\Delta \phi}{\Delta L}$$

$$a_v = \frac{4\pi R^2}{\frac{4\pi R^3}{3}} = \frac{6}{D_p}$$

$$a_v = \phi \left(\frac{4\pi R^3}{3} \right) \frac{1}{1 - \phi} \frac{1}{4\pi R^2} = R_h$$

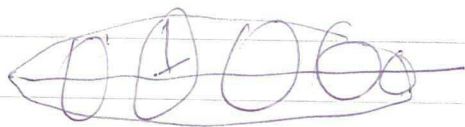
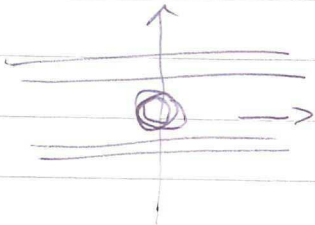
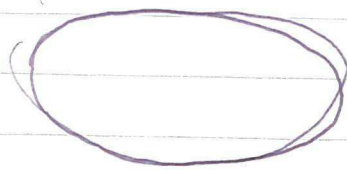
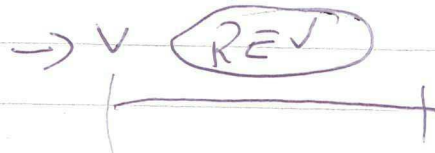
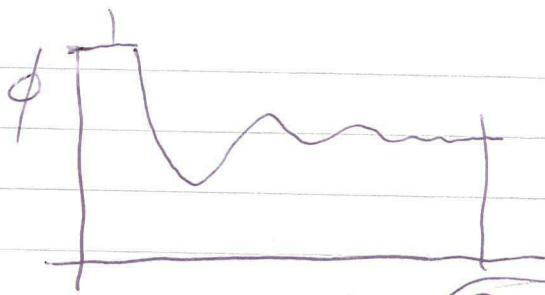
$$R_{h, \text{corrected}} = \phi \frac{D_p^3}{6(1-\phi) D_p^2}$$

$$v = \frac{\phi^2 D_p^2}{2 \cdot 36 (1-\phi)^2}$$

$$u = v \phi$$

$$u = \frac{\phi^3 D_p^2}{72\pi (1-\phi)^2}$$

150



prolate ellipsoid



pan cake
shape: oblate
ellipsoid

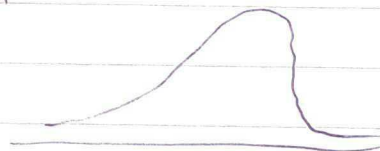
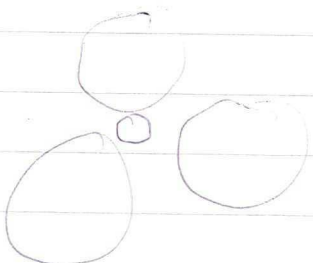
$$\frac{4\pi R^2}{\sqrt{\pi/3} R^3}$$

$$\frac{V}{S} \sim a_v \quad : \quad a_v = \frac{6 E_2}{E_3}$$

$$\sigma^2 = \int_0^\infty D_p^2 f(D_p) dD_p -$$

$$2 \int D_p \bar{D}_p f(D_p) dD_p + \int \bar{D}_p^2 f(D_p) dD_p$$

$$= 2 \bar{D}_p^2 + \bar{D}_p^2$$



{10 Nov 2011}

Gas permeability measurement

Coarse sand :-

① $m =$ $= 590$ gms
total (with the holder)

$m_{\text{holder}} = 550$ gm
~~knob: large~~ ~~Pressure~~ 0.5 bar \rightarrow Above the scale
knob ob: ~~above the line~~
(large) Pressure 0.1 bar \rightarrow 125 mm

Observation ϕ : ~~It is too difficult~~ Every time you open the regular, the balls ~~just~~ from the measurement tubes hit the roof, so out of scale.

knob : large, Pressure on the dial 0.1 bar
① weight 125 mm
② 130 mm

Fine Sand Expt: \rightarrow

m_{total} (with the holder) $= 590$ gms
knob: large
Pressure 0.1 bar \rightarrow 65 mm
0.2 bar \rightarrow 120 mm
0.3 bar \rightarrow Above the scale 130 mm

Similar effect for other knobs

Glass from the pump is broken, so need to fix. 11 Nov 2011
 Hans suggest ~~we~~ expt on sand in glass expt.

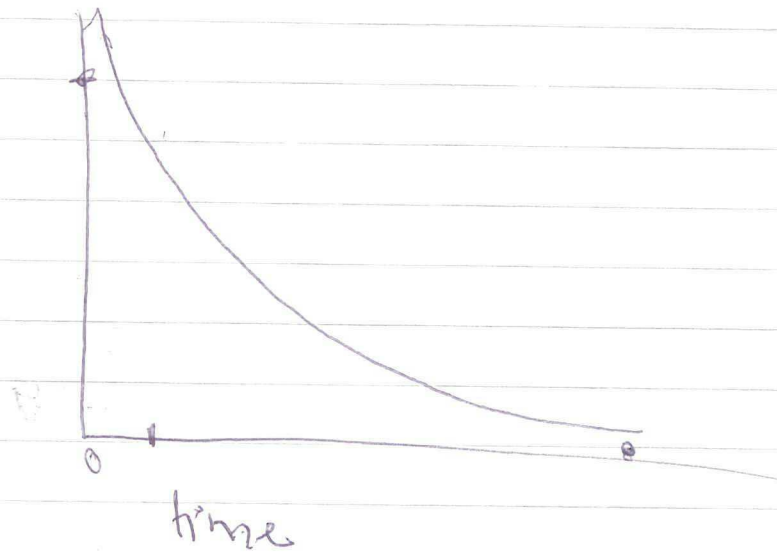
Single phase permeability experiment

height of sand 30 mm

Int Diameter of tube-glass

Wt of Sand
 Ht of water above sand)

Ht	Time	Ht	Time
cm	sec	cm	sec
45	75	45	75
35	63	35	65



4th Nov

Ht 1 75
 Ht 2 32.5 } 42.5 mm water column

Time 70 sec

2nd Nov → Ht of sand column 32.5 cm

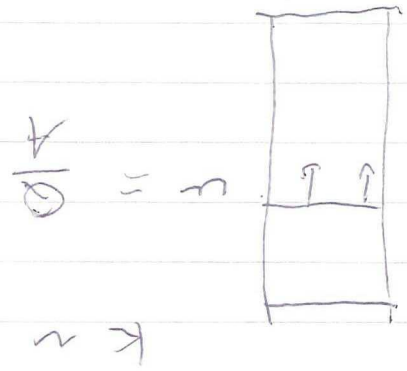
Ht of water	Time	Ht of water	Time	Ht	Time
cm	sec	cm	sec	cm	sec
80-32.5	90	80-32.5	95	80-33	87
75-32	85	75-32	110	75-32	107
65-32					

24th Nov

90-32 80 sec
~~90-32~~
 90-31.5 103 sec
 90-31.25 103 sec

28th Nov similar expt

68.5 32 2 cm below water



$$\frac{60}{100} = 0.6 \approx 0.5 \text{ cm} \approx 5 \times 10^{-3} \text{ m}$$

$$u = \frac{10^{-12}}{1000 \times 10^{-3}} \approx 10^{-5} \text{ m}$$

if $k = 1$ Darcy

$$u = k \frac{\Delta p}{\Delta x} = \eta$$

cm	sec
65	0
64.5	0.2
62.5	0.5
61	0.8
59	12
57.5	14
55	17.5
53.2	21.5
51	25
49.5	28
48	30
46	35
45	37
43	

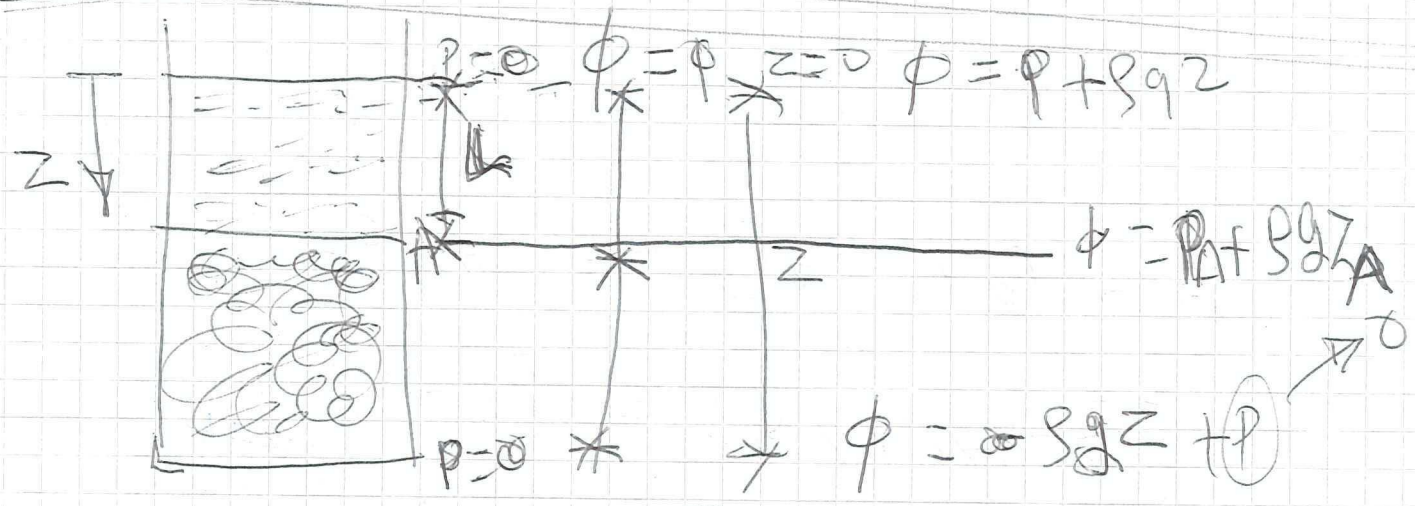
42	
<hr/>	48
	52
	60
35	62
33	72
32.5	75

Role-plays: 

- Topics
- Define a topic ①
- Debatable topic at the last ①
- Decision making questions ②

Report
Topic - Part 1
Answers - Part 2
conclusions →

Part 3: How did interview
open/closed connector/regulator,
friendly/angry 4-8 pages 45 minutes



$$\phi = sg(L_2 - U(t)) = \frac{d\phi}{dz} = sg$$

$$z = -(L_3 - L_2)$$

$$\phi = p + sg(L_3 - L_2)$$

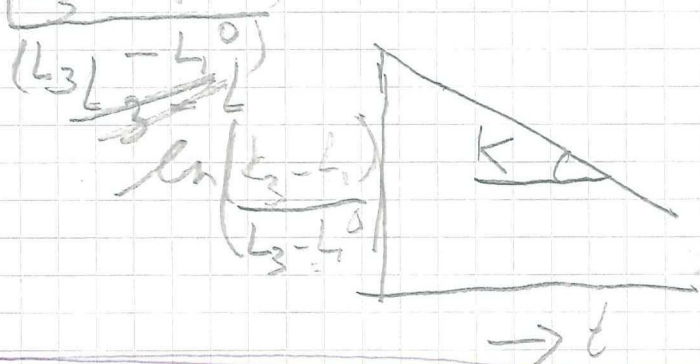
$$\phi = p + sg(L_3 - U(t))$$

$$\phi_3 = 0$$

$$\begin{aligned}\phi_2 &= \rho g (L_2 - L_1(t)) - \rho g (L_2 - L_3) \\ &= \rho g (L_3 - L_1(t))\end{aligned}$$

$$\begin{cases} \phi_3 - \phi_2 = \rho g (L_1(t) - L_3) \\ \phi_3 - \phi_2 = -\rho g L_3 + \rho g L_1(t) \end{cases}$$

$$\frac{dL_1}{L_3 - L_1(t)} = k dt$$

$$\ln \frac{(L_3 - L_1(t))}{(L_3 - L_1^0)} = -kt + c$$


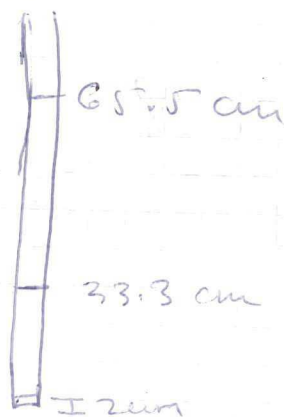
$$k = \frac{\epsilon^3}{150(1-\epsilon^2)} d_p^2$$

wt of coarse sand used in last exp. = 157 g

Task: loading of fine sand in the glass tube
 height of sand column 33 cm
 internal diameter of the glass tube 2 cm

2 cm below the water level

2 Dec 2011



Expt

$$\begin{array}{r}
 273.8 \text{ total wt} \\
 - 106.3 \text{ Pan wt} \\
 \hline
 167.5 \text{ wt of sand}
 \end{array}$$

2nd expt

2 Dec 2011

$L_{\text{sand}} = 33.5 \text{ cm}$

$L_{\text{air}} = 66.5$

17:00

Temp of water

$$\frac{55-53}{269-236} = \frac{58-55}{x-269}$$

$$\frac{2}{33} = \frac{3}{x-269}$$

$$\frac{2}{33} = \frac{3}{x-269}$$

$$49.5 = x - 269$$

$$\begin{array}{r}
 x = 269.0 \\
 + 49.5 \\
 \hline
 318.5
 \end{array}$$

6th Dec 2011



Demineralised

Expt with 0.5 wt% NaCl ⁱⁿ water

2000 ml of water with 10 gms of NaCl

fine sand ht 33.5 cm below water level

Water column 54.5

7th Dec 2011

Graduate program course

Teaching Session : →

A Active

8th Dec 2011

Expt to check if there are any loose particles

Sand column 34cm water column till 66 cm

fine sand, Demineralised water

time taken to decrease water column to the sand level
6 minutes 41 sec = 401 sec

Sample: — Demineralised water

— Product at the exit

11th Dec 2011

Expt to check if the tapping has an effect on permeability

Sulphuric acid cleaned sand

ht of sand column 21 cm

water column 35 cm

Repeat of 11th Dec 2011 with seven sieves
ht of sand 20.5 cm

14th Dec 2011 Expt with inertia effect

water column 48 cm

step 1: opening the valve to atmosphere

step 2: wait till water level drops till

32 cm note the time taken

2 min 53 sec

step 3: ~~Measure the time~~ close the

Valve when at 32 & measure

time & distance it has gone
32-30.5
after closing the valve

266
173

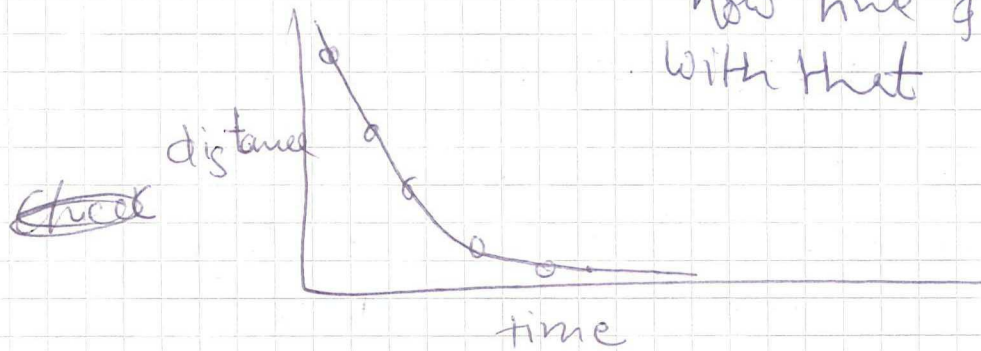
091 sec



Second Attempt water column 48 cm

① Valve open fill water reaches 32 cm

② Close the valve & find how time & distance it goes with that acceleration



checking file perm from ~~old~~ old Hans folder

Observation ~~leads to the fact that~~ is that

$$\text{Perm}_{\text{coarse}} = 1.9605 \times 10^{-11} \text{ Darcy} \quad \text{Perm}_{\text{coarse}} = 4.95 \times 10^{-10} \text{ Darcy}$$

~~Carman-Kozeny~~ Carman-Kozeny

$$d_{\text{part}} = \cancel{1.12} \text{ m} = 1.12 \times 10^{-3} \text{ m} \quad \text{Perm}_{\text{coarse}} = 4.72 \times 10^{-10} \text{ Darcy}$$

glasstube experiment

So that we do ^{not} need to use Panda lake correction factor. If we use, ~~Panda lake~~ we get ~~low~~ some deviation. Hence the glass tube expt are in accordance with ~~to~~ Carman-Kozeny ~~that~~ equation.

Same for fine sand ~~sed~~ $d = 0.38 \text{ mm} = 3.8 \times 10^{-4} \text{ m}$

$$\text{Perm}_{\text{fine}} = \cancel{1.75 \times 10^{-11} \text{ Darcy}} \quad 1.825 \times 10^{-10} \text{ Darcy}$$

Carman-Kozeny 182 Darcy

$$\text{Perm}_{\text{fine}}^{\text{glasstube}} = 5.6 \times 10^{-11} \text{ Darcy} = \boxed{\text{Factor of 3.25}} \quad \cancel{182} \text{ Darcy}$$

70 ± 15

Perm Results : Coarse sand $d \approx 1.4 \text{ mm}$
avg

$$\frac{\pi}{4} d^2 = A$$

Perm_{Coarse} Sandpack = $1.9 \text{ E-}11 \approx 19.60 \text{ Darcy}$

$$d = \sqrt{\frac{A \times 4}{\pi}}$$

$$d = 2 \sqrt{\frac{A}{\pi}}$$

Perm_{Coarse} Carmen Kozeny = $1.865 \text{ E-}9 \approx 1865.23 \text{ Darcy}$

$$d = 2 \sqrt{\frac{A}{\pi}}$$

Perm_{Coarse} glass tube = $4.72 \text{ E-}10 \approx 472 \text{ Darcy}$

factor of 3.95

$$A = \frac{\pi}{4} d^2$$

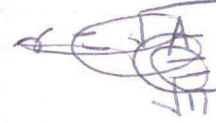
$$\pi r^2 = A$$

Final Correction

$$\text{dia} = 2 \sqrt{\left(\frac{\text{Area}}{\pi} \right)}$$

$$\frac{4A}{\pi} = d^2$$

$$d = 2 \sqrt{\frac{A}{\pi}}$$



Diameter of particles ~~d~~ $d_{\text{coarse}} = 1.12 \text{ mm}$ $d_{\text{grain fine}} = 0.38 \text{ mm}$

K_{glass}

For Coarse = 470 ± 50 Fine = 70 ± 15
Darcy Darcy

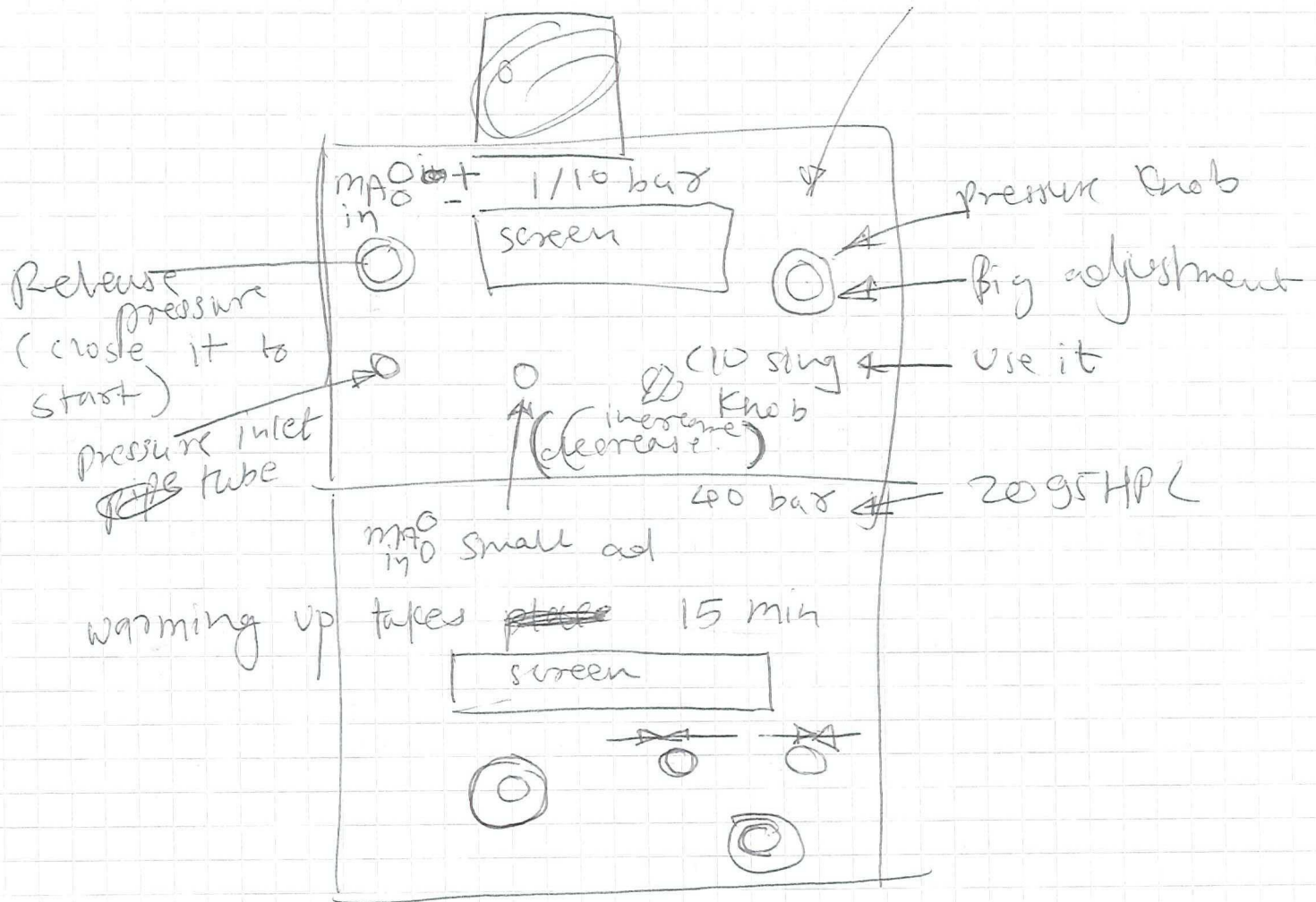
K_{CK} Coarse = 1193 Fine = 137
Darcy Darcy

$K_{\text{CK}} + PL$ Coarse = 1770 Fine = 173
Darcy Darcy

write down Calibration process of our manometers

Normal distribution of particle sizes

Pressure ~~manometer~~ calibrator 2095PC



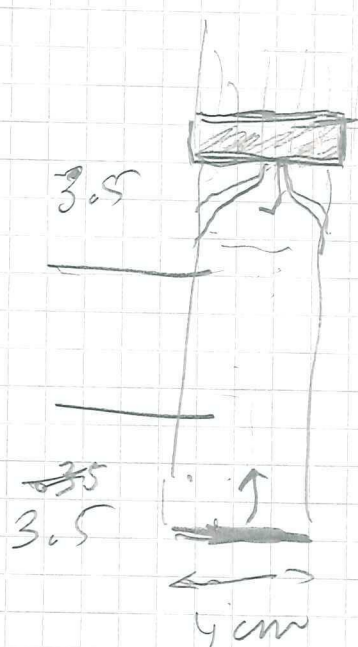
Both instruments have to be zeroed



$$\frac{\Delta \phi}{\Delta L}$$

$$= \frac{\mu u}{\bar{u}} + \beta p u^2$$

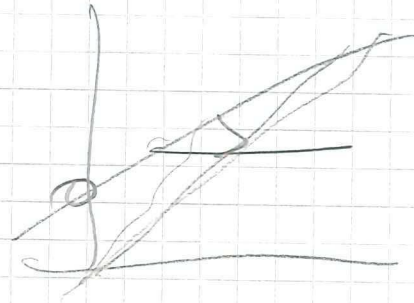
$p = 1 \text{ atm}$



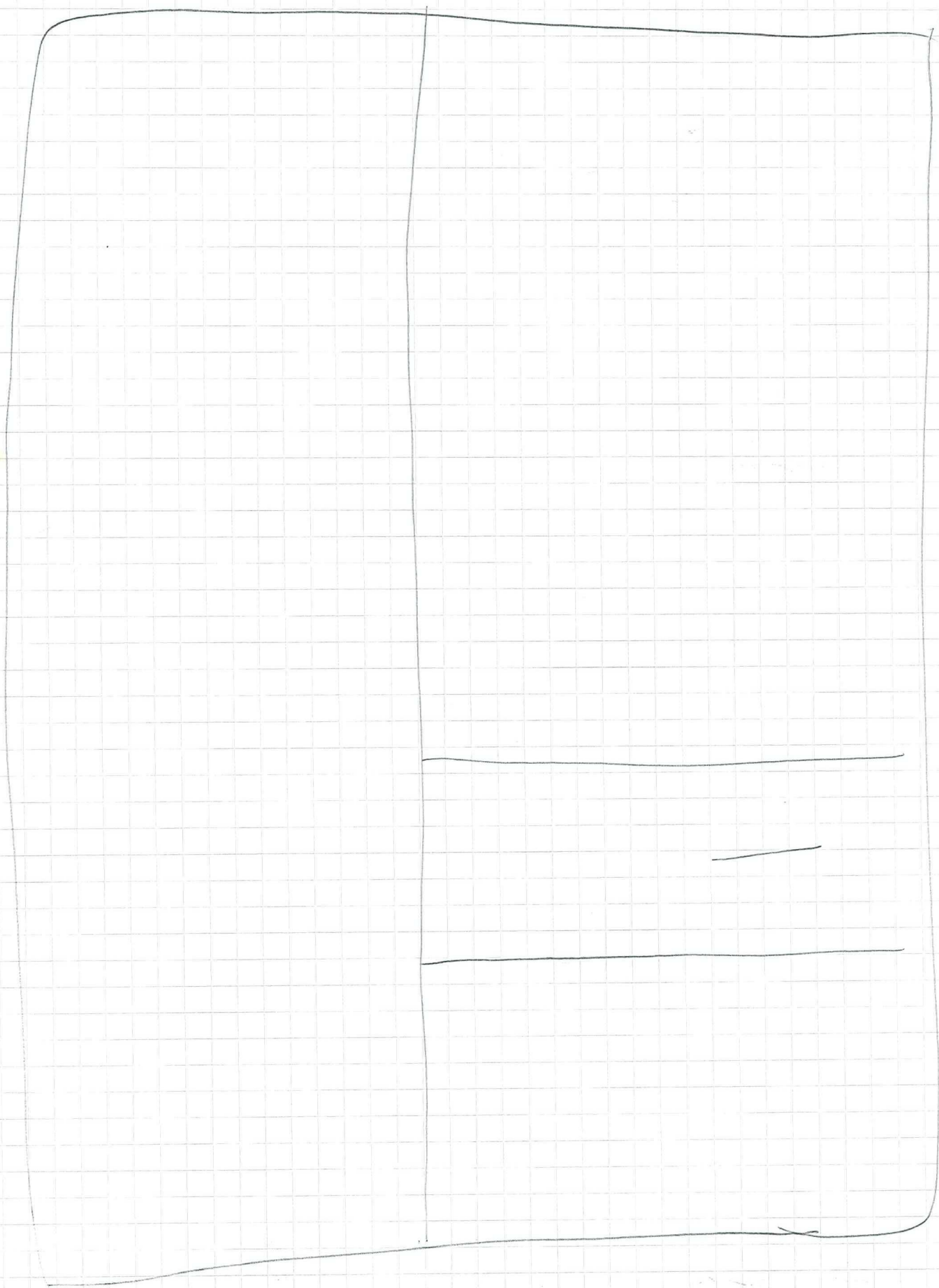
Date

slope
 $\Delta P / Q (\text{atm})$

brine
salt



2/3 3/5 5/8



Press zero to start

Connect Press-Calibrator to the plus side

Put some pressure

~~Applied Pressure in~~

~~measured Pressure~~

Applied bar	Measured bar	App	Measured	App	Measured
0	0.000	0.07	0.071	2.3	2.279
0.0000010	0.001	0.100	0.101	2.5019	2.479
+ 0.00024	0.002	0.15	0.151	2.7007	2.678
0.00051	0.002	0.1805	0.181	2.7513	2.728
0.001	0.002 0.003	0.200	0.201	2.9004	2.876
0.002	0.004	0.300	0.299	3.0009	2.976
0.003	0.005	0.502	0.501	3.0264	3.001
0.004	0.006	0.700	0.697		
0.005	0.007	0.9996	0.986		
0.007	0.009	1.0006	0.987		
0.008	0.010	1.2010	1.187		
0.010	0.012	1.3507	1.335		
0.0125	0.014	1.5005	1.484		
0.015	0.017	1.7004	1.683		
0.020	0.022	1.9003	1.881		
0.030	0.032	2.0003	1.980		
0.050	0.051	2.0003	2.179		

$$u = \frac{-\mu + \sqrt{\mu^2 + 4c\beta K\beta\mu}}{2\beta K\beta}$$

$$t = \frac{2a \ln(a + \sqrt{b + cy(t)})}{c} + \frac{2\sqrt{b + cy(t)}}{c}$$

$$\frac{69.5 - 69.5}{t} = \frac{-\mu + \sqrt{\mu^2 + 4c\beta K\beta\mu}}{2\beta K\beta}$$

Plot $L_1 - L_1(0)$ vs t

Eqn's

$$\textcircled{\otimes} = L_1 - L_1(0) = 0.0046 \ln(x) - 0.0058$$

$$\frac{\ln(x) L_1 - L_1(0)}{t} = \frac{L_1 - L_1(0)}{\ln(x)} = 0.0046$$

$$\frac{e^{L_1 - L_1(0)}}{x} = e^{0.0046}$$

20/01/2022

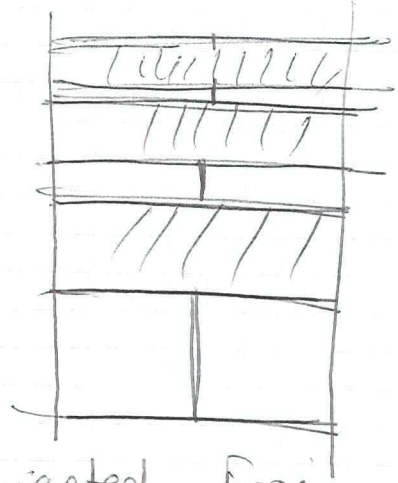
No

Silica fumed

0.014 M

Surface area 200 ± 25

Sigma-Aldrich



Accumulation of pore volume injected For first ~~exp~~ ash particle except (with 40 bars BP)

~~10 pore volume at a rate 5.6 ml/min~~

3 pore volume at a rate 0.9 ml/min

$$PV \text{ injected} = \frac{(Q_w) \cdot t}{0.38 \cdot A \cdot L}$$

3200 = t sec

$$B = PV = \frac{\cancel{0.38} \times 3200 \text{ m}^3 \times \cancel{s}}{0.38 \times 0.001256 \times 0.06 \text{ m}^3}$$

1 m = 100 cm

1 m³ = 10⁶ cm³ = 10⁶ ml

~~1 cc~~

1 cc = 1 ml

cm³ = m³

~~1 cm = 0.1 m~~

10 m³/s

$$\frac{\frac{\text{m}^3}{s} \times s}{\text{m}^2 \times \text{m}} =$$

Isoelectric points SiO_2 1.7-3.5 14/02/12

(pH at which a particular molecule or surface carries no net electrical charge)

that is why Krastev suggested to use pH 11 instead of pH 3

IEP of Alumina 7-11

(Monique Draijer)

nmr report

Silica \rightarrow high surface tension

Ash \rightarrow low surface tension

pH

pH

pH

nanoparticles

+

ADS

+

zeta potential

did I measure before the coating

Malvern

measure before

(before)

why

of ash

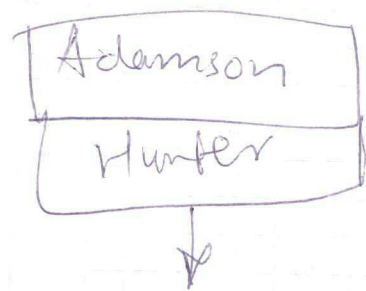
zeta potential values giving zero

0

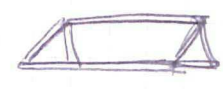
1, 2, 3, 4, 5, 6, 9, 11, 12, 15

16/02/2012

Zeta potential of blast furnace fly ash : \rightarrow
(Schneider)



Review of scientific instruments

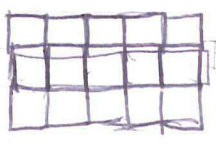


pump P-6000
Pharmacia Biotech
Inventorynummer 8702
Serial no. S6200158 GN 002300
made in Sweden
Code No. 18-4500-02

107
17/02/2011

$$36 \text{ ml/min} \downarrow \times 3 = 36 \times 6.0 = 2160 \text{ ml/hr}$$

If we can use 1 ml/hr 1 ml/min
~~45 ml/min~~



$$\frac{9 \times 9}{60} = 540 \text{ ml/hr}$$

3.6 ml/min 216 ml/hr

of highly purified water
pH at 25°C varies between 5-8

~~0-500 mbar~~
0-100 mbar

Bendheim's experiments

with Rouhi & Hans

16 17/02/2012

two-three experiments

- ① With Surfactant without particles
0.0375 W/W%
NaOH
pH 11
- ② ~~without~~ Surfactant, with particles
0.0375 W/W%
0.04 W/W%
pH 11
- ③ with particle
0.04 W/W%
pH 11
- ④ With Surfactant without particles
0.15 W/W%
- ⑤ without surfactant with particles
0.15 W/W%
0.04 W/W%
- ⑥ with particle
0.04 W/W%
- ⑦ permeability experiment ⑦

Cleaning by

- ① Water
- ② Ethanol
- ③ Water
- ④ CO_2

Parameters to check

- ① ΔP
- ② P_1 & P_2
- ③ Time
- ④ Temp
- ⑤ vol of water (Pore volume)
- ⑥ Particle check before & after flow
- ⑦ pH & Electrical conductivity before & after
- ⑧ Magnetic stirring

⑨

Buffer solutions : pH 11

Yellow core holder - Amin / Abbas

① Ben ~~we have to~~

① CO_2

② Water \rightarrow Permeability

③

④ Surfactant

surfactant + gas

Conductivity meter

Preparation of samples

For Monday

20/02/2012

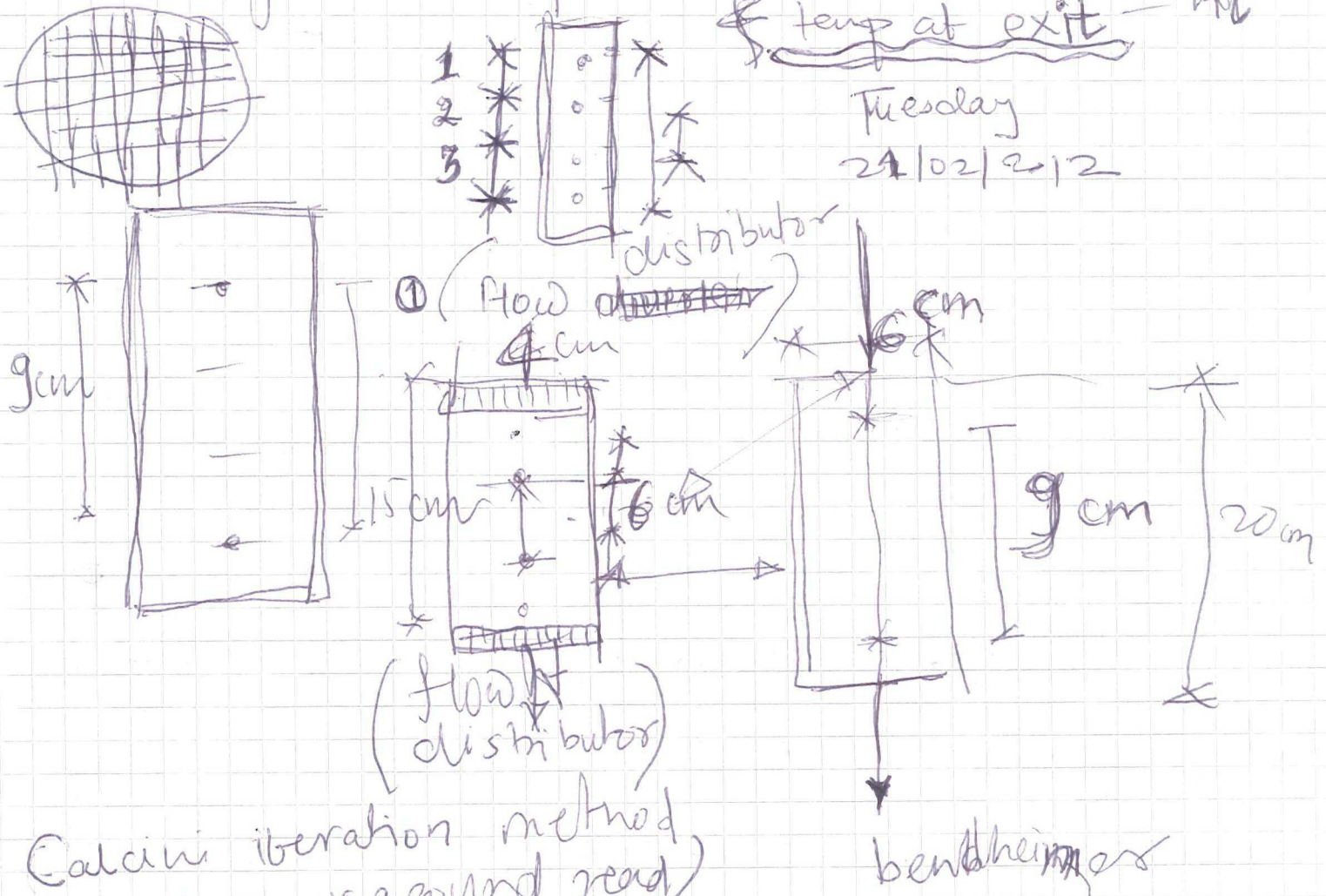
Binding core holder

Getting pH & Electrical Conductivity under (1) →

Putting back temperature ~~transducer~~ measurement & temp at exit - int

Tuesday

24/02/2012



Calcium iteration method
(Background read)

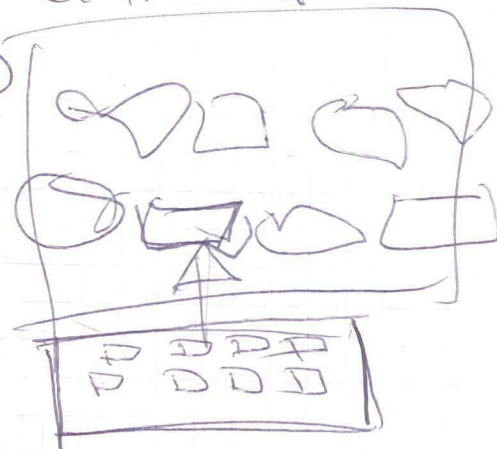
→ Abbas : check with the apparatus

Porosity measurement : \rightarrow

CO₂ flow & then water measurement
 Prof. Kreutzer (fine sand pack)

Hagroot : Gravity Drainage

$$\frac{Q}{A} = \frac{K}{\mu} \left(\frac{dP}{dL} \right)$$



Christian's thesis (Zeta potential studies)

Data box with more measurement point
 (verbetering van de system)

Kees van beek
 (Paul, Henk)

PH \rightarrow PEI
 1 x 16 \rightarrow 2 days \rightarrow Zeta potential \rightarrow 20, 18, 16 mV
 13 weeks

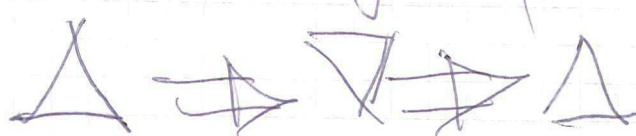
3 Expts \rightarrow 26 x 2 = 52 Days \approx 60 days
 + 13 weeks \approx 2 months

PH \rightarrow Buffer : Voegel \rightarrow 16 week + 15 months
 (pH of pref. Kraster measure)

pp. 830

Chemistry Complete

1 month \rightarrow 8 Expts



1

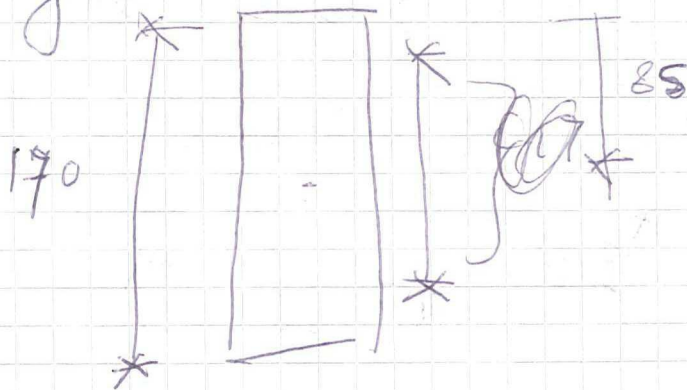
Write a experimental plan
write every experiment

Wednesday
22/02/2012
~~22/02/2012~~

Do every experiment as a final experiment with
great caution: →

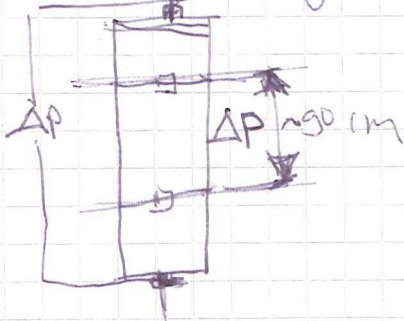
Check the injection pressures: →

Look for pump (anyhow we must have it from
somewhere)



Can prof. Krastev send new sample to carry experiment
200ml with 0.025 g/ml
(I have got 30 ml 0.025 g/ml pH 11) pH 11
I have 100 ml with 0.025 g/ml pH 7

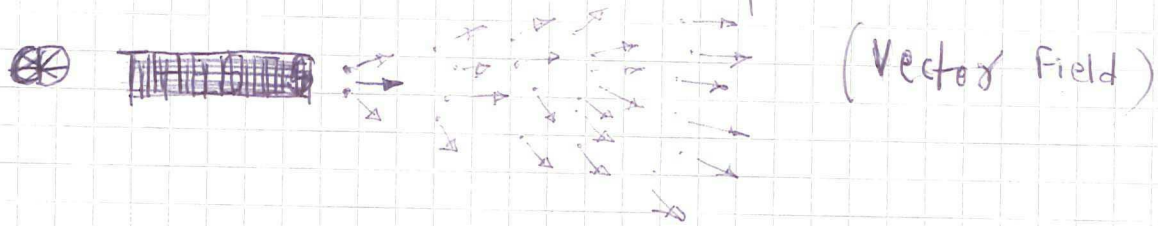
Gave the design to
New core design



Thursday
23/02/2012
Dick with
stuff core
holder we will have
Dick core holder
it ready by Monday.

The current core holes will be closed & core ~~holder~~ holder will be held two places.

1st Expt will be done under the supervision of Rouhi :->



pH & Electrical conductivity meter :->

744 pH ~~condu~~ meter found. Need to ask permission from

Yolanda & also to check about temp effect

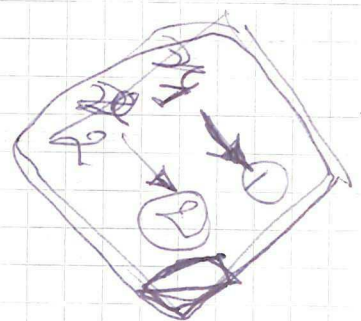
Talked with Hans about density meter, pH,
6:20pm I got the Density meter from the lab shown
by Hans. ~~need~~ I need to ask Negar to ~~ask~~ on
how to use it.

* Check with Abbas ~~tomorrow~~ about particle analyzer

* Send email to Rouhi, Hans about ~~the~~ pH meter

* Send ~~a~~ ad on various places (finally)

* ~~Rouhi~~ ~~Talked~~ Sent mail to Monique ~~and~~ Drijer about
the ~~relations~~ outcomes of the meeting.



* Talked to Hank about ~~APDT~~ ~~of~~ pump
He will take care Monday morning

Friday
24/02/2012
~~~~~

\* ~~Talk to~~ Talked to Abbas about Particle analyzer  
It measures  $\phi$  particles greater  $0.5 \mu m$  &  
that is bit of a problem.

\* Talk to Amin about Density meter calculation  
(Pursue Hame to use new setup than old one, old  
one looks kinda scary & lot of work).

\* Try to call this Pharmacia company.





## Particle size Analyzer

11:00 -

- \* Start the computer (Username : Admin Same Password)
- \* Start the program PAMAS (PMA) Program
- \* Go to measurement, select new, save the file in a place you want **D**: Userdata : Rahul
- \* Fill set up ~~the~~ things  $\begin{matrix} 10 & 10, 10, 10 \\ \text{Pre-run} & \text{Measurement} \end{matrix} = 40 \text{ ml}$   
Rinse (DD water)
- \* stay no of runs : 3 You can also save the setup in a location & retrieve every time, you need
- \* Diameters : you can select ~~between~~ from 0.5  $\mu\text{m}$
- if sample is diluted you can write that down here in new measurement
- \* ~~wait~~ Wait for some time and press start  
You need to be careful to put some ~~ma~~ breaker at the exhaust  
(The sample is 10 ml & the ~~data~~ results are calculated in terms of 100 ml) : Cumulative distribution
- \* After the test (1, 2, 3) : Rinse button will lit. ~~to put~~ Put the Rinsing liquid (DD water) & Press Rinse
- \* Save the results in ~~Result~~ your folder
- \* You can also print it in PDF & Save
- Tried to create dot based system than comma's

Try to have presentation for the group / Invite Zitha  
pH measurement / Etc.

Rosser

overheard from Zitha

Hans

Rouhi

(Measurements has to be between  
300 mbar — 2700 mbar for 0–3000 mbar  
Pressure transducer)

otherwise we need to put error bar

Use data smoothing

Fluid property sensor : → Netherlands : Distributor

(Carol Haller) Talk to  
Carol about

(Injection - Exhaust)

~~Help~~ Advice from Amin Use different manometers  
in parallel

\* check with Hans or anybody else about  
materials characterisation

\* Check the presentation with Hans : →

\* Talk to Hans about the two manometer setup

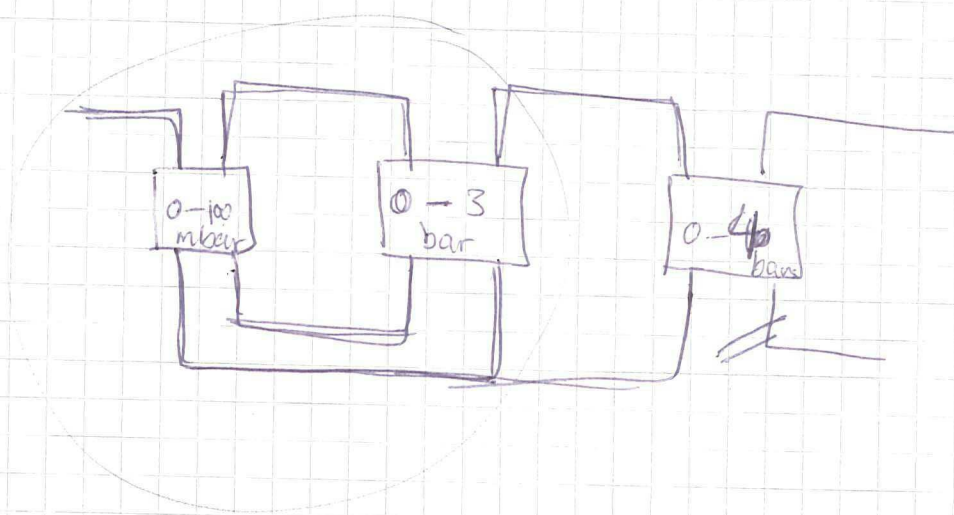
\* Density measurement : Anton Paar ~~was~~

First blow the air through the machine & then ~~put~~  
put syringe in the ~~system~~ <sup>place</sup>. Keep the syringe in  
(with your solution) ~~lets to~~

the place & push start button. It takes a couple of  
minutes to get the results. Blow the air afterwards

(before any use of the instrument)





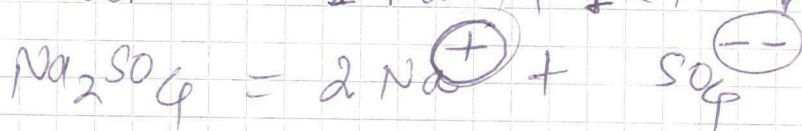
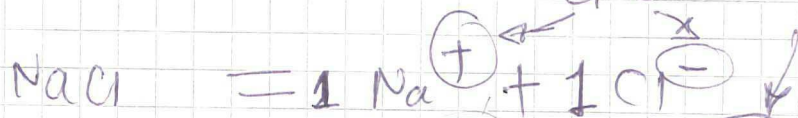
Read Chapter 4 Colloidal Interactions & flocculation

Is there any way we can measure those things like ionic strength in one of our experiments? →

$$I = \frac{1}{2} \sum_{i=1}^n c_i z_i^2$$

$c_i$  = molar concentration of ion ( $\text{mol-dm}^{-3}$ )  $z_i$

$z_i$  = Charge no. of that ion



0.050 mol/dm<sup>3</sup> in Na<sub>2</sub>SO<sub>4</sub> solution is

$$\begin{aligned} I &= \frac{1}{2} \left( 2(1)^2 \times 0.050 + 0.050 \times (-2)^2 \right) \\ &= \frac{1}{2} (2 \times 0.050 + 0.050 \times 4) = \frac{1}{2} (0.1 + 0.2) \\ &= \frac{0.3}{2} = 0.15 \text{ mol-dm}^{-3} \end{aligned}$$

Saturday 25/02/2012

11:20 Worked for one hour to find the problem of shear ~~thick~~ thinning & shear thickening.

The case 0.0375 shows ~~a decrease~~ increase in <sup>v</sup> viscosity which is basically different than any other cases studied (e.g. 0.15 and also earlier 0.075 with 40 BP). All other cases suggest decrease in app viscosity as the total velocity increases.

( It seems that <sup>for</sup> at 0.0375 increase in velocity does not ~~result~~ result in viscosity change. Viscosity affects more at high concentrations than in low concentrations (0.075, 0.15) (0.0375) surfactant foam flow. )

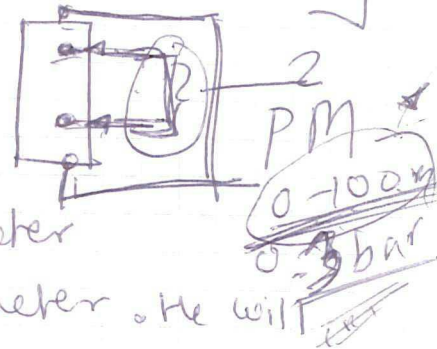
### Conclusion

• If prof. Zitha asks about accuracy (his say ~~that~~ 300 300 mbar - 2700 mbar for 0-3 bar PolT), tell him about the measurement ~~about~~ we did as well as ~~to~~ manufacturers sign on the Pressure transducer



Monday 22-02-2012

Asked Dick about the core, He said it will be ready by tomorrow. The design is same



Now to search Henk about pressure manometer

9:45: Talked to Henk about Pressure manometer. He will

Come back to talk to me.

Also @ pump: Found the glass tube on ~~glass~~ <sup>cylinder</sup> GE Health care

Product code ~~18-4699-0~~ 18-4699-01

154 Euros

Discussion with Henk:  $\rightarrow \frac{500 \times 0.05\%}{100 \times 0.05} = \frac{25}{100} = 0.25 \text{ mbar}$

0-1 bar  
0-50 mbar

(Discuss about Rouhi @ the computer system)

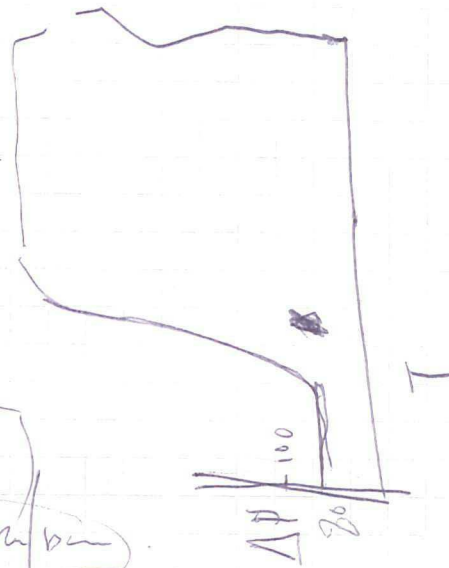
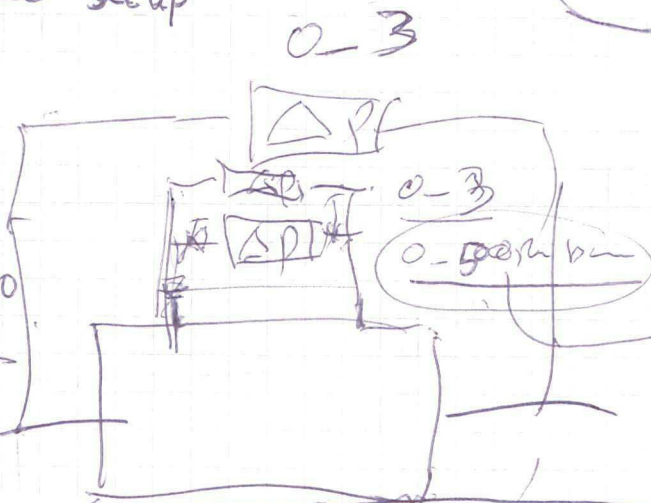
1700 Euro New  $\rightarrow$

0-3 bar

Search for new setup

$\Delta P$  DT

C-26B40



0-1 bar  
0-50 mbar

Talk to Karel about ~~meter~~ <sup>fluid property sensor</sup> studies

\* Henk has applied for two manometer for glass cylinder





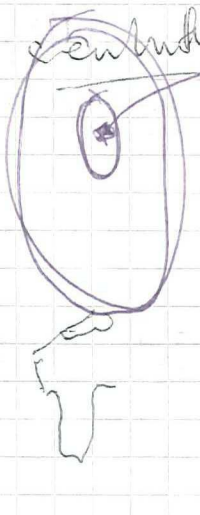
~~Pump~~ Talked to Henk to change the Pdt manometer finally 0-100 mbar & 0-3 bar are ordered.

15:15 ~~Giving~~ \* drying the fine sand from previous experiment

Hans meeting

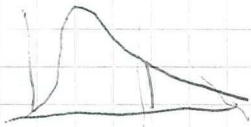
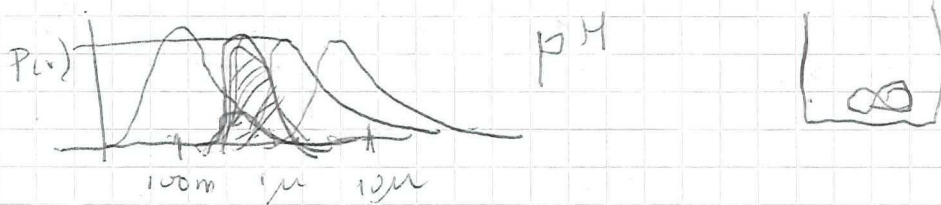
28/02/2012

Light scattering techniques:   $pH = 3$   
 Particle size distribution

  $6\pi\eta v = \frac{4\pi}{3} v^3 \rho g$

$$v = \frac{2}{3} \frac{v^2 \rho g}{\eta} \Rightarrow \frac{2}{3} \frac{10^{-14} \cdot 10^3 \cdot 10}{10^{-3}} \Rightarrow \frac{2}{3} 10^{-7} \text{ m/s} \approx \frac{2}{3} 10^{-2} \text{ m/day}$$



$$g = \omega^2 r = 4\pi v^2 v$$



~~pH testing~~

Particle size Analyzer

Effect of pH on the solution

(1-12) Different pH  (particles + 0.0325 AOS)  
 vogels  Deposition

# Dependence of agglomeration pH

(sed)

\* Geert van der Kraan Thursday (on centrifuge techniques).

\* Karl-Heinz Wolf for particle element analysis

\* Acoustic, ultrasound, laser : Ask Kassel

\* Lyon van Paasen :  $\rightarrow$  about nanoparticles

$$10^{-4} \text{ kg/m}^3$$

Coulter counter

$$\phi \rho_{H_2O} + (1-\phi) \rho_{part} = \rho$$

pH versus PSD

$$\textcircled{1} 1000 + (1-\phi) 2600 \frac{\text{kg}}{\text{m}^3} = \rho$$

Optical analysis

$$(\rho_{part} - \rho_{H_2O}) \phi = \rho_{part} - \rho$$

Geert.

$$\phi = \frac{\rho_{part} - \rho_{sol}}{\rho_{part} - \rho_{H_2O}}$$

Microscope

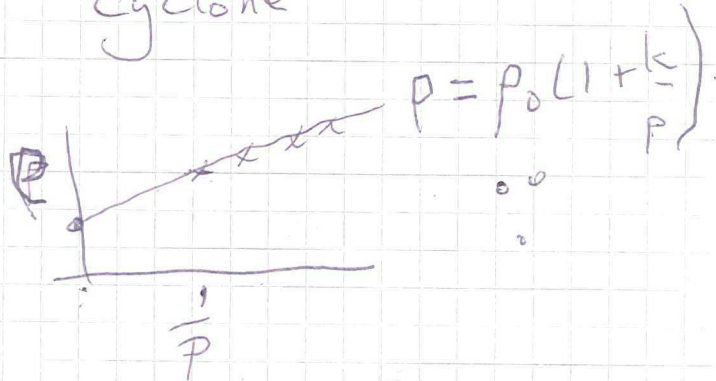
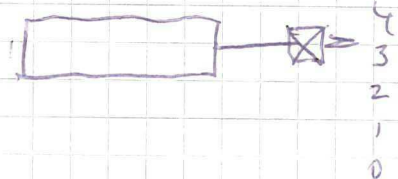
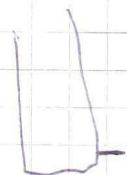
Leon Paasen

$$\Delta \phi = \frac{\Delta \rho_{sol}}{\rho_{part} - \rho_{H_2O}} = \frac{10^{-4}}{1600 \frac{\text{kg}}{\text{m}^3}}$$

halimond tube

$$\Delta \phi = 10^{-4} \frac{\rho_{part} - \rho_{H_2O}}{\rho_{part} - \rho_{H_2O}}$$

cyclone





29/02/2012  
Preparing the coarse sand pack to calculate coarse sand pack permeability & checking the output

⊗ Check Google Calendar, ~~Notes~~, tasks, Evernotes for ~~everything~~ other things.

wt of the sandpack with packed at both ends (while no nuts at four openings = 1481.0g and no screws

\* Dick Delivered the Benelheimer sandstone with bores and it is ready for connection

worked all day with Henk & Kees van Beek @ Friday 3/02/2012 computer system. wrote few pages @ how to work with it.

Saturday : Read Nguyen's thesis 3/02/2012

Sunday : Sent mail to Ronhi & Hans @ proposed experiment 4/02/2012

5/02/2012 Monday fixing the stuff pump computer system etc.

1 MPa = 10 bar

Calculation @ how much gas is needed

Ask Ellen @ double distilled water

Preparation of samples ( 0.0375 w/w% AOs )  
First



Tuesday 06/03/2012

\* Spent the morning on the instruction from Yolanda @ pH 744 meter & ET WTW conductivity meter : 2:18 PM

3:53 PM Run a demo test to check the things & took an output. Things required to change in the output : →

1. Date/Time : in the format "March 2, 2012"
2. Time : Remove the decimals
3. Counter : Remove the counter
4. Remove . Chan001, Chan002
5. Time : Remove the time column from the end of the column. Make it ~~look like~~ work to start measuring <sup>the time</sup> when ~~the~~ start recording

find PdF program in the computer system  
Monday 12/03/2012 : Yolanda pH of acid  
Tuesday 06/03/2012

Made correction in MP3 program 12:15

First coarse sand testing

1:24 Flushing CO<sub>2</sub> for 2 minutes PDT reading 15 mbar

Calculation of flow rates

1:33 PDT reading shows 0

Experiment with increase in pressure rate

Wt of 1000 ml glass bottle (without cap) = 501.63 g

After putting the suction tube = 538.64 g

System tared

~~System~~ weight of the water 792.14g

\* Checking connections

Measured value : 0.000bar

Datafile setup Test 2012-03-13-028

(Permeability test with coarse sand)

Recording started 2:00 pm 15 min wait and then start the expt.

~~Pressure~~ Flow rates 50, 100, 150, 200, 250  
for 30 minutes

Initial Record fluctuate @ around -2 to +2mbar due to Sensitivity of the instrument.

Fluid  
Next 50 ml/hr is started. There is some fluctuation because of the first time flooding of sandpack (You can see the water at the outer side of the glass sand pack reaching from lower end of (plastic)

The sandpack to the upper end. So it takes time to Flood whole system without the back pressure (Currently the back pressure -0.048 bar) 2:43PM

Two pictures are taken to make some studies

water flow pressure 0.4 MPa  $\approx$  4 bar

Going to run till 3:30 (that 90 min) while it



Floods all the system

2:55 PM : Water at exit observed

3:35 PM : Flow rate changed to  $100 \text{ ml/hr} = \frac{100}{60} = 1.6 \frac{\text{ml}}{\text{min}}$

4:10 PM :  $150 \text{ ml/hr}$

There is a need to have a back pressure otherwise our system cannot work against the results are bit ~~slow~~ sloppy.

We need to arrange back pressure (At least 1 bar?)

Pressure is -ve at  $150 \text{ ml/hr}$   $4.8 \text{ ml/min}$  We have to do another measurement

Abandoning the expt because with increase in flow rate,  $\text{PdT}$  does not increase.

\* Issues to solve  $\rightarrow$  Back pressure (1 bar)

$$1 \text{ ft/day} \quad \frac{30 \text{ cm}}{24 \times 60 \text{ min}} = \frac{1}{48} \frac{\text{cm}}{\text{min}} = \frac{0.01 \text{ m}}{48 \text{ min}}$$

$$\Rightarrow \frac{0.01 \text{ m}}{48 \times 60 \text{ sec}} = \frac{0.01}{2880} = 3.4722 \times 10^{-6} \text{ m/s}$$

Stopping the experiment 4:55 PM but continue Recording the data.

①



# Calibration of P1 & P2 pressure manometers

Friday  
2:47 PM

~~The one~~

A

The one written on wire

Calibration meter 2095 HPC (40 bar)

66 P2 "

P2 →

| Applied (bar)              | Measured (bar)             | Applied (bar) | Measured (bar) |
|----------------------------|----------------------------|---------------|----------------|
| 0                          | 0                          | 5.430         | 5.395          |
| <del>0.544</del><br>-0.004 | <del>0.544</del><br>-0.007 | 5.670         | 5.640          |
|                            |                            | 5.823         | 5.789          |
| 0.540                      | 0.499                      | 6.183         | 6.150          |
| 0.802                      | 0.791                      | 6.458         | 6.418          |
|                            |                            | 6.760         | 6.726          |
| 0.924                      | 0.913                      | 7.025         | 6.985          |
| 1.375                      | 1.365                      | 7.197         | 7.157          |
| 1.755                      | 1.740                      | 7.544         | 7.500          |
|                            |                            | 7.988         | 7.944          |
| 2.170                      | 2.154                      | 8.460         | 8.413          |
| 2.717                      | 2.696                      | 8.782         | 8.730          |
| 3.090                      | 3.067                      | 9.162         | 9.112          |
| 3.415                      | 3.393                      | 9.450         | 9.377          |
| 3.948                      | 3.919                      | 9.608         | 9.556          |
| 4.163                      | 4.136                      | 9.950         | 9.893          |
| 4.903                      | 4.870                      | 10.395        | 10.341         |

|                |               |                   |        |
|----------------|---------------|-------------------|--------|
| 10.628         | 10.570        | 19.918            | 19.807 |
| 10.905         | 10.847        | 20.358            | 20.245 |
| 11.207         | 11.145        | 20.960            | 20.839 |
| 11.694         | 11.633        | 21.610            | 21.486 |
| 12.145         | 12.078        | 22.1055           | 22.026 |
| 12.515         | 12.446        | 23.100            | 22.961 |
| 13.000         | 12.930        | 23.545            | 23.403 |
| 13.435         | 13.362        | 24.260            | 24.105 |
| 13.950         | 13.878        | 25.000            | 24.842 |
| 14.485         | 14.408        | 26.000            | 25.835 |
| 14.656         | 14.576        | 27.000            | 26.827 |
| <u>15.1000</u> | <u>15.019</u> | 28.000            | 27.820 |
| 15.499         | 15.415        | 29.046            | 28.851 |
| 15.903         | 15.809        | 30.000            | 29.792 |
| 15.980         | 15.899        | 31.120            | 30.910 |
| 16.585         | 16.492        | <del>31.120</del> |        |
|                |               | 32.009            | 31.793 |
| 17.000         | 16.903        | 33.205            | 32.972 |
| 17.325         | 17.228        | 34.109            | 33.872 |
| 17.690         | 17.593        | 35.040            | 34.795 |
| 18.130         | 18.028        | 36.180            | 35.923 |
| 18.660         | 18.550        | 37.017            | 36.758 |
| 19.220         | 19.113        | 38.030            | 37.761 |
| 19.634         | 19.324        |                   |        |



M Pin

| Applied | Measured | Applied | Measured                | Applied                                                             | Measured |
|---------|----------|---------|-------------------------|---------------------------------------------------------------------|----------|
| -0.004  | -0.008   | 7.647   | 7.5901 <sup>Appl.</sup> | 17.230                                                              | 17.130   |
| 0.100   | 0.083    | 7.867   | 7.809                   | 17.650                                                              | 17.550   |
| 0.300   | 0.3      | 8.208   | 8.150                   | 18.050                                                              | 17.943   |
| 0.860   | 0.832    | 8.590   | 8.525                   | 18.483                                                              | 18.375   |
| 1.070   | 1.042    | 9.000   | 8.938                   | 18.845                                                              | 17.740   |
| 1.319   | 1.289    | 9.385   | 9.312                   | 19.870                                                              | 19.749   |
| 1.683   | 1.648    | 9.735   | 9.661                   | 20.017                                                              | 19.896   |
| 1.770   | 1.735    | 10.270  | 10.203                  | 20.500                                                              | 20.380   |
| 1.987   | 1.952    | 10.815  | 10.746                  | 21.030                                                              | 20.901   |
| 2.315   | 2.280    | 11.203  | 11.130                  | 21.420                                                              | 21.287   |
| 2.522   | 2.487    | 11.628  | 11.555                  | 22.070                                                              | 21.933   |
| 2.703   | 2.666    | 12.007  | 11.934                  | 22.600                                                              | 22.458   |
| 3.062   | 3.022    | 12.380  | 12.302                  | 23.050                                                              | 23.901   |
| 3.384   | 3.342    | 13.026  | 12.941                  | 23.480                                                              | 23.250   |
| 3.812   | 3.772    | 13.320  | 13.234                  | 23.420                                                              | 23.268   |
| 4.450   | 4.405    | 13.700  | 13.614                  | 24.065                                                              | 23.906   |
| 4.830   | 4.787    | 14.140  | 14.057                  | 24.705                                                              | 24.545   |
| 5.266   | 5.215    | 14.800  | 14.708                  | 25.110                                                              | 24.948   |
| 5.694   | 5.645    | 15.370  | 15.280                  | 26.000                                                              | 25.830   |
| 6.020   | 5.973    | 15.768  | 15.673                  | Further info in computer<br>excel sheet<br>on <del>lab</del> lab PC |          |
| 6.609   | 6.557    | 16.315  | 16.219                  |                                                                     |          |
| 7.137   | 7.083    | 16.645  | 16.518                  |                                                                     |          |
| 7.378   | 7.322    |         |                         |                                                                     |          |

spent Monday on connecting system 19/03/2012



Conducting ~~first~~ <sup>second</sup> experiment on coarse sand with  
Back pressure 1 bar

Tuesday  
20/03/2012

Measurements  $P_{d1}$ ,  $P_{d2}$ ,  $P_1$ ,  $P_2$   
Mass Balance, Temperature, time

Plan is to check the ~~permeability~~ permeability.

Test 2012-03-20-030, 031, 032, 033

Expt started ~~at~~ @ 11:00

Rmp pushes at  
@ ~ 4 bar the  
liquid

| Flow rate | $P_{dT}$<br>mbar | Time  |
|-----------|------------------|-------|
| 50        | 1.27             | 12:37 |
| 100       | 1.36             | 13:39 |
| 150       | 1.407            | 14:40 |
| 200       | 1.45             | 14:54 |

$$\frac{Q}{A} = \frac{K}{\mu} \frac{\Delta P}{\Delta L}$$

$$\frac{K}{\mu} = 9.5 \times 10^{-6} \times$$

2041.7 - 2116.667

$$\frac{\Delta P}{\Delta L} = \frac{9.5 \times 10^{-6}}{A} \times 2041.7$$

$$\frac{imp}{n} = \frac{1 \times 10^{-6} \text{ m}^3}{3600 \text{ s}} = Y = A\alpha + B$$

$$A = \frac{K}{\mu}$$

~~Q =~~

$$\frac{Q}{A} = \frac{K}{\mu} \frac{\Delta P}{\Delta L}$$

$$\frac{K}{\mu} = Q$$

1 cm =  $10^{-2}$  m  
1 cm<sup>3</sup> =  $10^{-6}$  m<sup>3</sup>

$$1 \text{ mbar} = 1 \times 10^{-6} \frac{\text{N}}{\text{mm}^2}$$

$$1 \text{ mm}^2 = 10^{-6} \text{ m}^2$$

$$1 \text{ mbar} = 1 \times 10^2 \text{ N/m}^2$$

Please calculate the porosity of new core ~~by~~  
how much cc? by the same methods  
used early

Weight of the core with ends closed 01:23 pm

See eemote on mobile 1897.6 gm

with water 1914.0 gm

Wednesday

21/03/2012

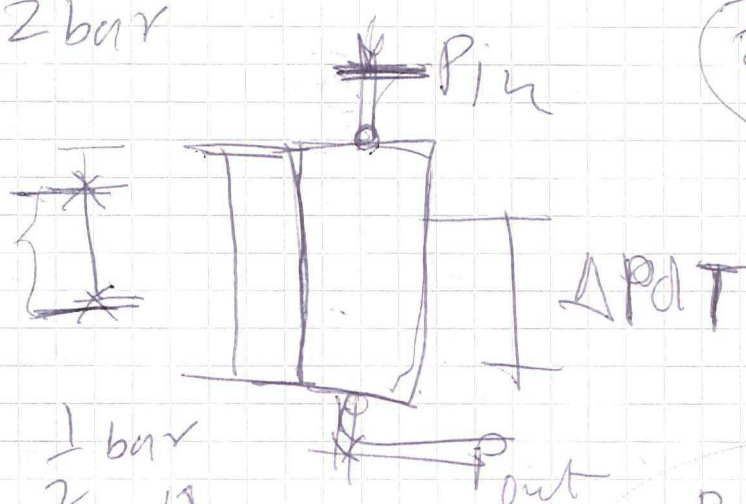
By putting the nuts on weigh machine = 1952.4 gm &   
 Conducting ~~core~~ permeability test on Bentheimer   
 Core (3.00 pm)

CO<sub>2</sub> is flown (3.6 ml/min) throughout the system   
 for 5 minutes

Pressure

Flowing water through ~~flow~~ meters to make it 0   
 (Disconnect the core from the setup & connect   
 the inlet direct to pressure manometer)

2 bar



$$\left( \frac{2}{3} P_{in} - P_{out} \right)$$

$$2 - \frac{1}{2} \text{ bar} = 1.5 \text{ bars}$$

$$\Delta P \approx 0.1 \text{ bar}$$

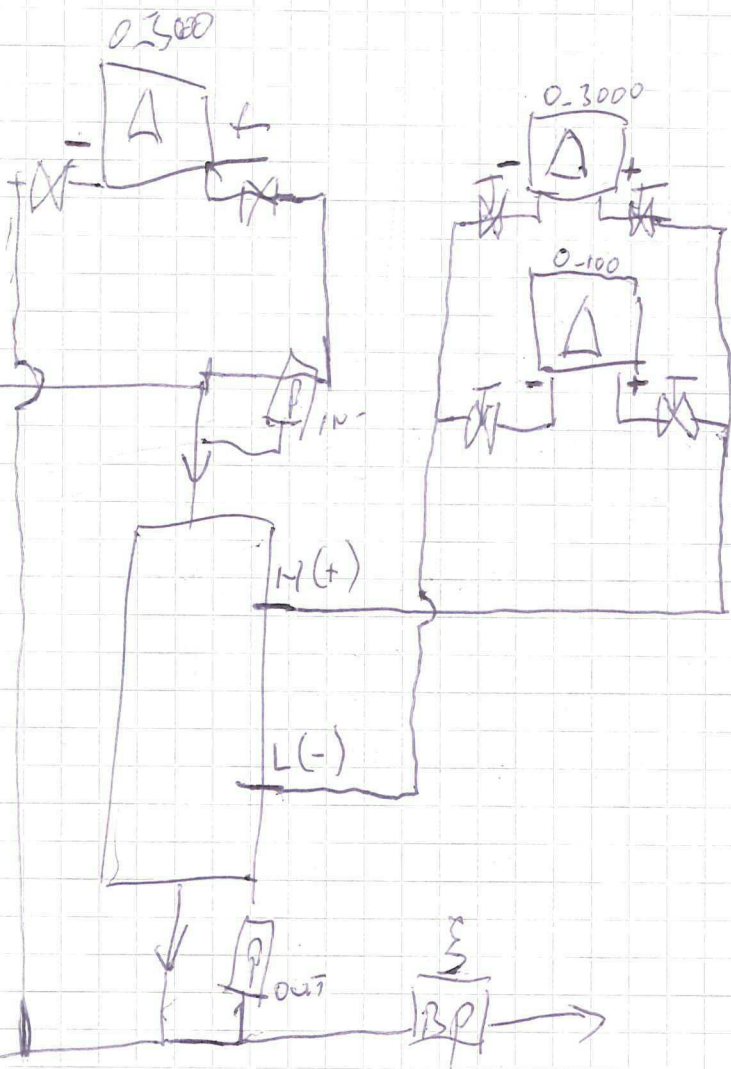
$$\left. \begin{array}{l} P_{in} \approx 11 \\ P_{out} \approx 10 \end{array} \right\} \begin{array}{l} 10\% \text{ due} \\ \text{to exp} \end{array}$$

high volume expansion problem Talk to Rouhi

So high back pressure



1. Permeability except with Bendheim 22/03/2011
- \* Pump is not pushing the water
  - \* The line was in air so it should work now



- ① 7:30 Flushed the  $\text{CO}_2$  from the system  
Applied back pressure ~~water~~ 1 bar

$$\Delta P_{dt} = -36$$

Test 2012\_03\_22\_037

- ② Pushing water through core ~~for~~ while  
pressure manometer is disconnected 16:00

- ③ Pushing water through <sup>only</sup> pressure manometer to make  
~~while core is disconnected~~ manometer with water



The first time you try to push the water in Bendheimer ~~it~~ ~~the~~  $P_1$  &  $P_2$  increases until  $P_2$  reaches Back pressure level

Dimensions of the core

Pelt length = 9 cm

Outside height = 21 cm

① Diameter = 5 cm

$P_{in}$  &  $P_{out}$  had

wrong offset so cannot take the data granted.

⑤ Stopping the inflow so that we can fill pressure manometer with water

⑥ Now ~~the~~ everything is connected in the system and water is flown to take out the gas from pressure manometer lines 17:52

⑦ Waiting to come back the pressure to 0

(A)

23/03/2012

Starting permeability experiment : →

PdT = -34.00 try anyway

8:20

Pressure diff increases &amp; then decreases

8:30

showing the Gas ~~out~~ going out  
(air)We will measure the pressure difference & for  
the flowrate when pressure difference line is  
horizontal.

|           | mbar<br>Pd T1 | mbar<br>Pd T2 | bar<br>P1 | bar<br>P2 | g<br>m  | See       |
|-----------|---------------|---------------|-----------|-----------|---------|-----------|
| 50 ml/hr  | 3.1           | 4.6           | 1.287     | 1.274     | 386.010 | 9:10      |
| 0 ml/hr   | 0.4           | 1.4           | 1.26      | 1.25      | -       | 8:25 0200 |
| 100 ml/hr | 6.4           | 8.0           | 1.263     | 1.250     | 328.04  | 9:43      |
| 150 ml/hr | 9.7           | 11.2          | 1.251     | 1.23      | 236.50  | 10:23     |
| 200 ml/hr | 12.7          | 14.2          | 1.250     | 1.225     | 117.80  | 10:59     |
| 250 ml/hr | 16.02         | 17.2          |           |           |         |           |

(measure the electrical conductivity before & after  
it pass  
Next experiment with pH 3 water

|           | Pd T1<br>mbar | Pd T2<br>mbar | P1<br>bar | P2<br>bar | m<br>gm | Time<br>Sec |
|-----------|---------------|---------------|-----------|-----------|---------|-------------|
| 0 ml/hr   | 0.1           | 1.3           | 0.0       | 0.0       | 456.5   | 600         |
| 50 ml/hr  | 2.9           | 4.5           | 1.22      | 1.21      | 418.2   | 12:30       |
| 100 ml/hr | 6.2           | 7.8           | 1.22      | 1.21      | 367.8   | 13:01       |
| 150 ml/hr | 9.3           | 10.8          | 1.22      | 1.20      | 282.84  | 13:35       |
| 200 ml/hr | 12.4          | 13.9          | 1.22      | 1.19      | 173.350 | 14:09       |
| 250 ml/hr | 15.4          | 16.8          | 1.21      | 1.17      | 34.46   | 14:43       |

26/03/2012  
Monday

Switched to next log book

Measuring the ~~data~~ data  
Surface tension  
pH & electrical  
conductivity



Friday 23/03/2012

① 1<sup>st</sup> Experiment with Bentheimer core  
double distilled (boiled water) ~~at~~ of pH 3  
Perm measured is 1.83 Darcy

② 2<sup>nd</sup> Experiment with Bentheimer core  
double distilled (boiled water) of pH 3  
~~Perm~~ <sup>Perm</sup> measured is 2 Darcy

Monday 26-03-2012

Surface tension measurement of double distilled water (pH 3) inlet & outlet from previous experiment 2

|                       | inlet            | Outlet           |
|-----------------------|------------------|------------------|
| $pH$ at $20^{\circ}C$ | 2.84, 2.86, 2.87 | 3.94, 3.93, 3.93 |

Surface tension at  $20^{\circ}C$  69.217 std. dev. 0.099

Electrical conductivity at  $20^{\circ}C$  470  $\mu S/cm$  0.499  $\mu S/cm$

Making solution (0.0375 w/w%. with pH 3) 15:30 time

100 ml of ~~0.3~~ 0.3 w/w% + 100 ml of double distilled water  
= 0.15 w/w% @ 200 ml + 200 ml double dist.  
= 0.075 w/w% 400 ml + 400 ml of dd  
= 0.0375 w/w% of 800 ml

So add 100 ml of ~~0.3~~ 0.3 w/w% & 700 ml of dd to get 800 ml of 0.0375 w/w%.

Tuesday 27-03-2012

8:15 Preparing the pH 3 solution

Taking out 10 ml from the solution

pH of 0.0375 w/w% <sup>Acid</sup> double distilled water is 5.64

HCl 0.1M = 9.3 - 4.7 = 4.6 ml

pH = 2.97 / 3.07

managing Stand still

Flow rate calculation

$$1 \text{ cm} = 1 \times 10^{-2} \text{ m}$$

$$1 \text{ cm}^3 = 1 \times 10^{-6} \text{ m}^3$$

Liquid : Designed velocity  $2.4 \text{E}-05 \text{ m/s}$

$2.4 \text{E}-05 \times \text{Area of the sandpack}^{\text{core}} = \text{Flow rate}$

$$\frac{\text{m}}{\text{s}} \times \text{m}^2 \quad 2.4 \text{E}-05 \times 0.001963 = 4.7 \text{E}-08 \quad \text{m}^3/\text{s}$$

\* wrong (0.001256 for 4cm diameter core)

$$1 \text{ m} = 100 \text{ cm}$$

$$1 \text{ m}^3 = (100)^3 \text{ cm}^3 = 1 \times 10^6 \text{ cm}^3 = 1 \text{E}06$$

$$= 4.7 \text{E}-08 \frac{\text{cm}^3}{\text{s}} \frac{\text{m}^3}{\text{s}^3} \text{ hr}$$

Multiplying by 3600 to  
convert in hrs

$$= 4.7112 \times 10^{-2} \times 3600$$

$$= 169.6 \text{ ml/hr}$$

$$\approx 170 \text{ ml/hr}$$

Gas flow : Designed velocity  $4.8 \text{E}-05 \text{ m/s}$

Similar to liquid ~~hence~~  $4.8 \text{E}-05 \times 0.001963$   
 $= 9.4224 \text{E}-08 \frac{\text{m}^3}{\text{s}}$

$$\approx 9.4224 \text{E}-08 \text{ cm}^3/\text{s}$$

Multiplying by 60 to convert in min

$$= 9.4224 \text{E}-08 \times 60$$

$$= 5.65 \text{ ml/min}$$

$$= 5.65 \text{ cc/min} = 3.39 \text{E}-04 \frac{\text{m}^3}{\text{hr}}$$

$$1 \text{ l} = 1000 \text{ cc} \quad 1 \text{ ml} = 1 \text{ cc}$$

Gas flow pipe is attached and made sure that there  
is a gas flow

Back pressure is maintained at 3 bar

Use 1st 100 ml to keep flow going at 170 ml/hr  
Before injection of gas

Mass balance : 822.560



Experiment started on 11:00

100ml sol<sup>n</sup> is pushed through ~~10~~ with 170 ml/hr rate  
 PdTI is stopped at 100.17 mbar // Gas is applied  
~~during~~ after 100ml at 11:48.

13:00 the pressure is 2500 mbar and our crossing  
 limit is 3000 mbar (!close very close!)

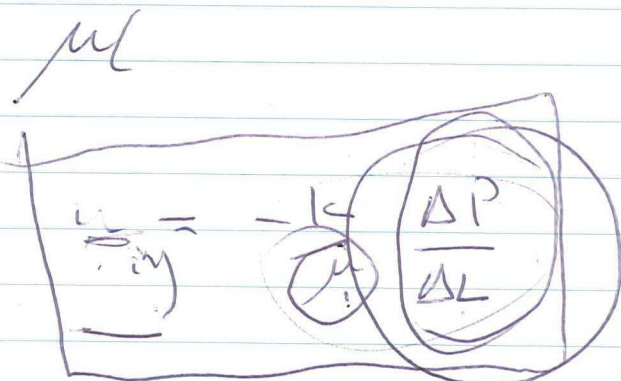
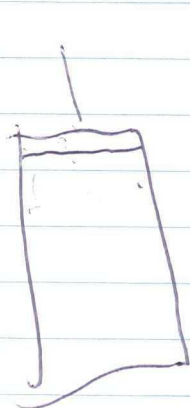
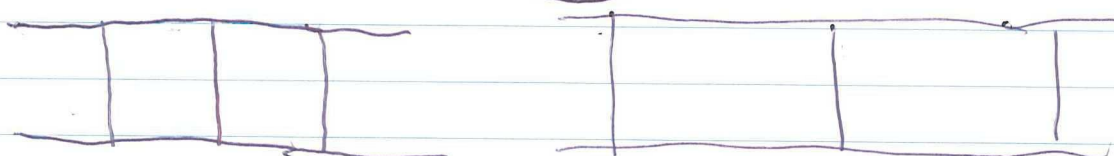
Pressure difference is stabilized at 2090 mbar & water used is  
 Gas flow is stopped ~~at~~ when 200ml water remaining till 200

$$\frac{d(pu)}{dx} = \text{const} \cdot 0 \quad pu = \text{const}$$

$$\frac{d}{dx} \left( \frac{M \cdot p}{RT} \cdot \frac{k \cdot \frac{dp}{dx}}{\mu} \right) = 0$$

$$\frac{M}{2RT} \cdot \frac{k}{\mu} \frac{dp^2}{dx} = \text{const} = pu$$

$$pu = \frac{M}{2RT} \cdot \frac{k}{\mu} \frac{p_1^2 - p_2^2}{L}$$



$$u = -\frac{k}{\mu} \frac{dp}{dx}$$



Elham's paper, viscosity studies

$$\frac{\partial(nS_g)}{\partial t} + \dots = R_{in} - R_{out}$$

$$\Rightarrow \mu = \mu(n)$$

① ~~Particle~~ <sup>Foam</sup> viscosity vs Bubble size

② Pressure expansion ~~at~~ the effect of back pressure

running only water for remaining 100 ml & then stop with measurement

Wednesday 28/03/2012

|        | Surface Tension (20°C) | Std. dev.  | EC (20°C)      | pH (20°C) |
|--------|------------------------|------------|----------------|-----------|
| inlet  | 28.673 mN/m            | 0.071 mN/m | 325 $\mu$ S/cm | 3.10      |
| Outlet | 27.803 mN/m            | 0.047 mN/m | 228 $\mu$ S/cm | 3.65      |

Afternoon

Passing 50 ml Ethanol at 50 ml/hr with 1 bar BP

Passing 100 ml double distilled water 50 ml/hr with 1 bar BP

Removing the bubbles from previous expt by opening & ~~lines~~ (gas) incoming lines to PDT1

230 ml to 180 ml

Study of Ideal gas law  $PV = nRT$

slpm: standard liters per minute

3.6 NCC l/min normal CC l/min  $T = 20^\circ$   $P = 1.01$  Atmospheric

Darcy's law

$$u = \frac{k}{\mu} \frac{dp}{dx}$$

$$m = \rho V$$

mass equation

4

$$PV = nRT$$

number of moles  
of the  
substance

$$P \cdot \frac{k}{\mu} \frac{dp}{dx} = nRT$$

$$\text{Ideal gas equation } n = \frac{m}{M} \frac{\text{mass}}{\text{molar mass}}$$

$$P \cdot \frac{k}{\mu} \frac{dp}{dx} = \frac{m}{M} RT$$

Volume

$$P \cdot \frac{k}{\mu} \frac{dp}{dx} = \frac{\rho V}{M} RT$$

$$P \cdot \frac{k}{\mu} \cdot dp = \frac{\rho V}{M} RT \cdot dx$$

$$\left[ \frac{P^2 k}{2 \mu} \right]_{P_2}^{P_1} = \frac{\rho V}{M} RT x$$

$$V = \frac{k}{\mu} \cdot \frac{P_1^2 - P_2^2}{2x} \cdot \frac{M}{RT}$$

$$\mu = \frac{k}{V} \cdot \frac{P_1^2 - P_2^2}{2x} \cdot \frac{M}{RT}$$

# I know permeability, velocity at inlet,  $P_1, P_2$   
molar mass of the substance (if you consider  
foam as gas)



Thursday 29<sup>th</sup> March 2012

8:45 Boiled the dd water (waiting to cool down)

9:20 ~~Preparation~~ Preparation for weighing dd water 495 ml

11:30 Reading Elham's paper

13:15 Preparation of pH3 dd water

pH = 6.14

300 rpm,

4 ml of 0.1 M HCl

2.83

14:00 Meeting with Hans

$$\lambda \frac{\partial^2 T}{\partial x^2} = a$$

$$\frac{dT}{dx} = 0 \text{ at } x = \frac{1}{2}$$

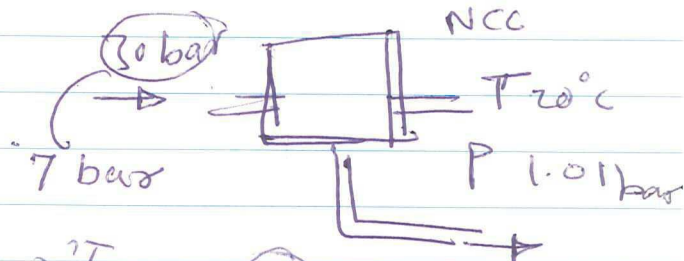
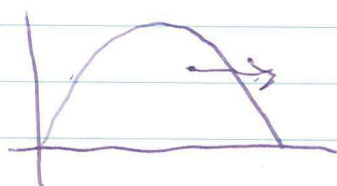
$$\bar{T} = ax^2 + bx + c$$

$$x = 0 \quad \bar{T} = 0$$

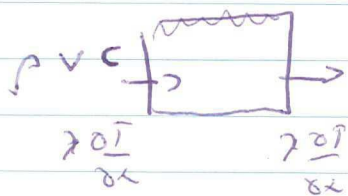
$$x = 1 \quad \bar{T} = 0$$

$$\bar{T} = \bar{T}_0$$

$$c = 0$$



$$\underbrace{(\rho c)_v}_{\text{liquid pump}} \frac{\partial T}{\partial x} = \lambda \frac{\partial^2 T}{\partial x^2} + \textcircled{a}$$



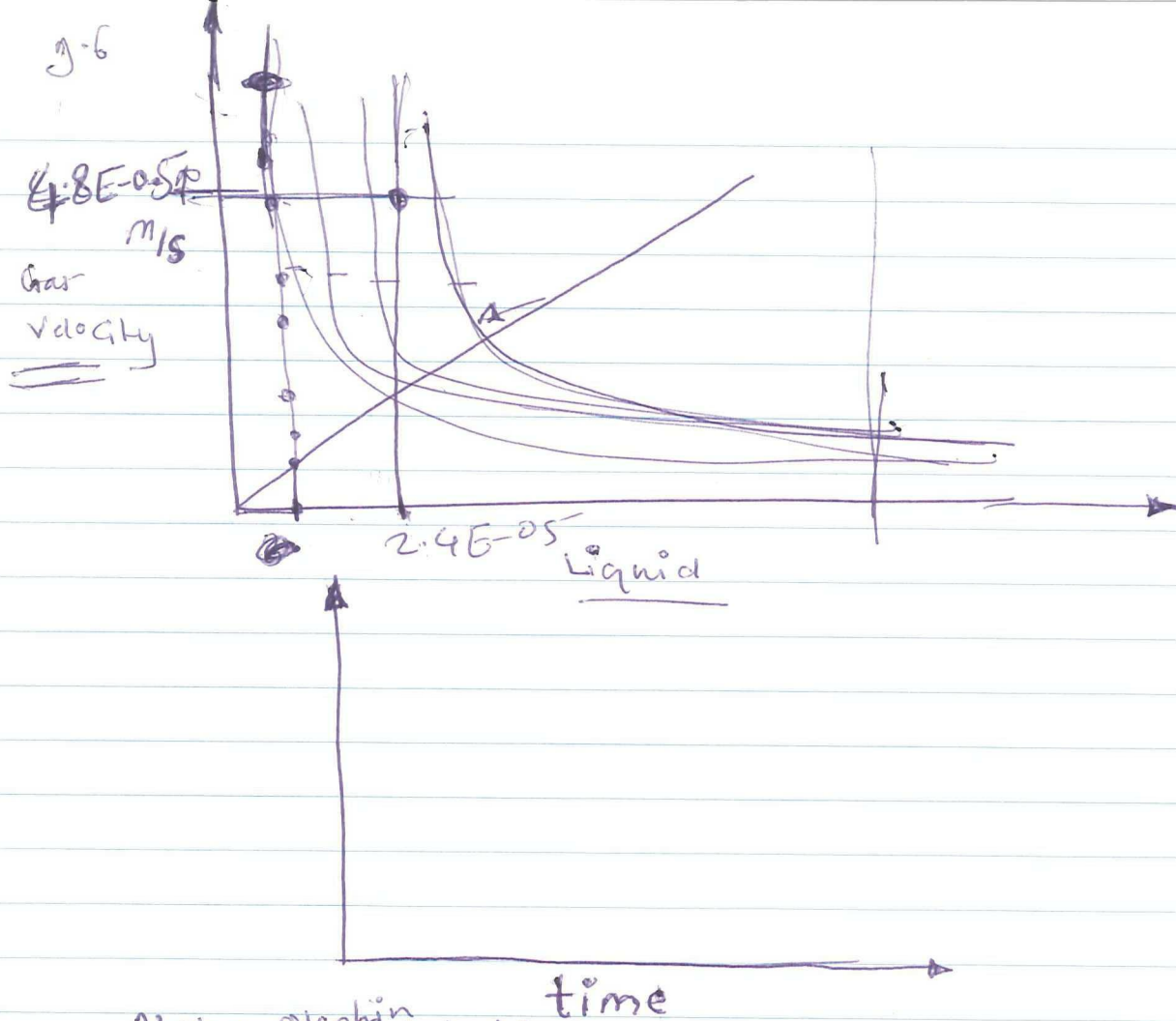
incompressible

liquid pump  $\Rightarrow$  Volume/time  $\leftarrow$

Gas flow meter  $\Rightarrow$  Mass/time  $\leftarrow$

1. Set up 2. Photograph

3. Pressure difference vs total superficial velocity



Alpha Olephin Sulphate  
(AOS)  
surfactant  
properties  
(surface tension expt)  
anionic  
(viscosity chart)

Sand Properties

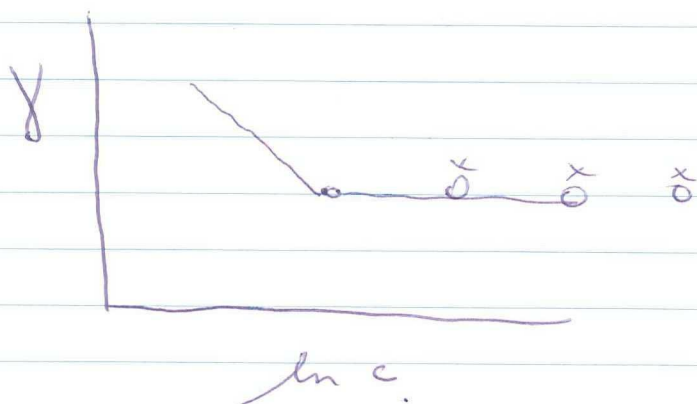
water - Gas expansion 6 bar - 3 bar

Things to do

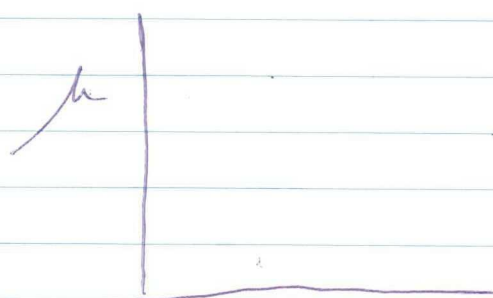
1. Six ~~slides~~ slides about the work
2. Two ~~slides~~ slides about AP vs ~~to~~ X (Unconsolidated) of Bentheimer
3. Volume compression effect
4. Kirchhoff transformation /
5. Sand properties / surfactant properties / Viscosity / EC & pH
6. Reference : Authors







Reserve plot.



$$\mu = \mu_0 \left( 1 + \frac{5}{2} \phi \right)$$

volume fraction.

Darcy law  
 Mass equation  
 Ideal gas equation

$\frac{Q}{A} = \frac{K}{\eta} \cdot \frac{dp}{dx}$

$m = S \cdot V = C$

flow rate  
 Velocity  
 moles of substance

$$PV = nRT$$

$$S \cdot V = \text{mass flux}$$

$$\eta = \frac{m}{M}$$

mass of your substance  
 molar mass

$PV = \frac{m}{M} RT$

volume

$$S_1 V_1 = S_2 V_2$$

$$P = \frac{m}{VM} RT$$

$$S \cdot \frac{Q}{A} = \frac{SK}{\eta} \cdot \frac{dp}{dx}$$

$$P = \frac{M \cdot p}{M} RT$$

$$S \cdot \frac{Q}{A} dx = \frac{SK}{\eta} \cdot \frac{dp}{dP} P^2$$

$$M \cdot P = RT$$

$$S \cdot \frac{Q}{A} dx = \frac{K}{\eta} \cdot \frac{M}{2RT}$$

$$\frac{\Delta P^2}{\Delta x} = \rho u \frac{\mu}{K} \frac{2RT}{M}$$

$$\frac{m}{g}$$

$$u = \frac{K \mu}{m}$$

$$S = \frac{kg}{m^3}$$

$$g =$$

$$m$$

$$PV = nZRT$$

$$\rho u = \frac{K}{\mu} \rho \frac{dP}{dx}$$

$$\rho = \frac{MP}{ZRT}$$

$$\left( m(P) = \int_{P_{ref}}^P \frac{1}{\mu} \frac{MP}{ZRT} / ( ) \right)$$

Kirchhoff transformation

$$\frac{dm(P)}{dx} = \frac{MP}{ZRT} \frac{dP}{dx}$$

$$\rho u = \frac{K}{\mu} \frac{dm}{dx}$$

$$\frac{\Delta m}{\Delta x} = \rho u$$

pH 3

— highly +ve

pH 11 — highly -ve

IEP

pure media -ve charged

$$m(P) = \int_{P_{ref}}^P \left[ \frac{MP}{\mu ZRT} / \left( \frac{MP_{ref}}{\mu_{ref} Z_{ref} RT} \right) \right] dP$$

$$p_u = -k \frac{dm(P)}{dx} \quad \times \quad \cancel{E} \quad \cancel{\chi}$$

$$p_u =$$

$$\frac{d}{d\lambda} \int_{u(\lambda)}^{v(\lambda)} f(x, \lambda) dx = \text{Leibniz's rule}$$

$$= \int_{u(\lambda)}^{v(\lambda)} \frac{\partial f}{\partial \lambda} dx + F(v, \lambda) \frac{dv}{d\lambda} - f(u, \lambda) \frac{du}{d\lambda}$$



$$p_u = -k \frac{1}{\mu} \frac{MP}{2RT} \frac{dP}{dx} \quad x = d_{\text{can}}$$

$$p_u = -k \frac{\Delta m}{\Delta L} x$$

$$\frac{\Delta P}{\Delta L}$$

17:23 Permeability expt

Test 2012\_03\_27\_041 Thursday  
29th March

Back pressure 1 bar,  $P_{dT1} = 0.4$  mbar  $P_{dT2} = -0.5$  mbar

Started pumping at 17:38 at (50 ml/hr)

| $P_{dT1}$ | $P_{dT2}$ | $P1$ | $P2$ | Mass   | Flow rate | Time  |
|-----------|-----------|------|------|--------|-----------|-------|
| 10.2      | 9.6       | 1.21 | 1.18 | 445.45 | 50        | 17:38 |
| 20.2      | 19.9      | 1.23 | 1.19 | 354.1  | 100       | 18:26 |
| 27.9      | 27.5      | 1.25 | 1.19 | 241.0  | 150       | 19:00 |
|           |           |      |      |        |           | 19:46 |

(Something went wrong, the core is not cleaned properly)

Friday 30th March 2012

8:45 Measurement of pH, EC &  $\sigma_s$  of Inlet & outlet of 2nd per  
at 21°C

|        | Surface tension           | EC      | pH (21°C) |
|--------|---------------------------|---------|-----------|
| Inlet  | 67.375 mN/m std dev 0.167 | 176 326 | 2.93      |
| Outlet | 31.793 mN/m std dev 0.457 | 176     | 3.22      |

Calculation of particle concentration in ~~eg~~ water

pH 3 sample from Krastev 12.5 g / 250 ml

so 1 g / 20 ml  $\Rightarrow$  0.1 g / 2 ml  $\Rightarrow$  0.05 g / ml

in case of 100 ml 5 gms 5% solution

so to prepare 0.04 w/w%. we have to dilute the sample by  $\longrightarrow$

5 gm per 100 ml so ~~25~~ + 100 ml

~~5~~ gms in 200 ml (2.5 ~~5%~~) + 200 ml

5 gm in 400 ml (1.25 %) + 400 ml

5 gm in 800 ml 0.625 % + 800 ml

5 gm in 1600 ml 0.3125 % of 1600 ml

~~Suppose we take 10 ml of this~~

~~0.04 g / 100 ml of the solution~~

0.05 g / ml \* 0.5 g in 10 ml

~~0.5 g in 10 ml + 10 ml DD = 0.5 g in 20 ml ~~0.05~~~~

~~0.05 g in 1 ml + 1 ml~~

10 ml soln would contain 0.5 gms

800 ml of 0.04 w/w% solution should contain

0.04 per 100 ml so 0.4 g per 1000 ml

0.32 g per 800 ml

0.05 g / ml so  $\frac{0.32 \text{ g}}{0.05} = \frac{32}{5} = 6.4 \text{ ml of Krastev's solution}$

$$\begin{array}{r} 800.0 \\ - 6.4 \\ \hline 793.6 \end{array}$$

6.4 ml of Krastev's solution & 793.6 ml of DD (pH 3) to make 0.04 w/w% of ash solution

To calculate 793.6 DD pH 3 = 789.6<sup>ml</sup> DD + 4 ml of 0.1 HCl

$\uparrow$   
So take 789.6 ml at

the start



Measuring the sample ~~DD~~ DD = 789.6 ml 13:40  
Adding 0.1M HCl to make dd of pH3 13:50  
Starting pH 5.79 2.83 Adding 4 ml 0.1 HCl

Preparing expt with ash particles 15:00

mass balance is put on downside (outlet) because of the need to use stirrer at the inlet (keeping the ~~in inlet~~ ash particles afloat in the dispersion (300 rpm)

The Saturated soln from previous experiment (DD pH3) is kept in the lines. Test2012\_03\_30\_042

ash particles are added as per the calculations

1. Reading started 15:57 waiting 10 min before starting to pump dispersion at 170 ml/hr rate ( $2.4E-05$  m/s)
2. Pump started at 170 ml/hr ~~at~~ 16:08, waiting till 100 ml gets pushed in the system that is 70 ml at the inlet reading (Assuming 20 ml in the core & 10 ml in the line).
3. pdTI = 14.5 mbar at 170 ml/hr or  $2.4E-05$  m/s
4. pdTI = 13.5 mbar, started pushing gas at 5.65 ml/min at 16:49 after 90 ~~ml~~ ml is collected at the exit  
~~5. no difference in the pdTI~~
5. Valve was still closed at 100 ml soln
6. Valve was opened at 126 ml & at 16:55 time
7. There is no mixing of gas & water. ~~At~~ At the outlet there is alternate ~~form~~ of flow of water & gas resulting in the fluctuation of pressure difference (Noted 17:11)
8. Opened the connection where ~~is the~~ gas & water mix. The measurement gone away because ~~it is~~ of the opening waiting to stabilise (18:08)
9. Mass balance replaced to continue the storage 19:13  
After total addition of 600 ml (100 ml from now)  
stopping the gas
- 10.



$$u = \frac{k}{\mu} P_x \quad k = \frac{\mu u}{P_x}$$

- ① Make the colors of same as lines in ~~paragrap~~ the graph  
photo of previous apparatus
- ② Put the names in the figure  
Put ~~the~~ (it) Back on the presentation
- ③ Prepare the final graph with pressure difference instead of app. viscosity  
Colors of the bars has to be changed
- ④ make changes in the table as well
- ⑤ Check the reference of Espinoza 2010

⑥ ~~viscosity~~ viscosity →

Strong foam / weak foam

We get strong foam by addition of Ash particles

2 April 2012

Morning spent on correcting the presentation now measuring the ~~st~~ S.T., EC, & pH of Inlet & Outlet of the particle solution. 13:45

|                            |                               |                            |        |
|----------------------------|-------------------------------|----------------------------|--------|
| EC outlet                  | 114.8 $\mu\text{S}/\text{cm}$ | (clear)                    | } 20°C |
| EC <del>outlet</del> inlet | 93.6 $\mu\text{S}/\text{cm}$  | ( <del>clear</del> turbid) |        |

Surface tension at 22°C

|        |             |                 |
|--------|-------------|-----------------|
| Inlet  | 62.066 mN/m | Std. dev. 0.193 |
| Outlet | 58.078 mN/m | Std. dev. 0.414 |

pH testing

|        |      |         |
|--------|------|---------|
| Inlet  | 3.93 | at 20°C |
| Outlet | 3.82 | at 20°C |

3 April 2012

Morning spent on shifting the things to above floor

14:00 Preparing sample for next <sup>(3<sup>rd</sup>)</sup> permeability ~~result~~  
Expt for tomorrow

Weighing 495 ml of

wt of 1000ml bottle without blue cap is 501.86 g

adding 4 ml of 0.1 HCl

pH of solution before adding HCl 5.7

pH after adding " " 2.95 / 2.98

Passing 50 ml of Ethanol for cleaning at 50 ml/hr with  
1 bar BP.

Pumping stopped at 4:04 pm

4 April 2012

7:15 ~~Passing~~  $\text{CO}_2$  for 5 minutes

7:25 Pumping ~~200~~ 100 ml water ~~to~~ at 50 ml/hr to rinse the  
core 495-395 ml

8:15 Trying to get rid of bubbles

9:00 415 ml water PDT1 show: 0.1 mbar PdT -0.2 mbar  
Starting the expt.

| Time  | PdT1 | PdT2 | P1   | P2   | mass    | ml/hr |
|-------|------|------|------|------|---------|-------|
| 9:28  | 3.7  | 3.7  | 1.26 | 1.27 | 386.020 | 50    |
| 10:03 | 6.7  | 6.8  | 1.27 | 1.25 | 329.090 | 100   |
| 10:35 | 10.0 | 10.1 | 1.27 | 1.24 | 251.120 | 150   |
| 11:02 | 13.3 | 13.2 | 1.27 | 1.24 | 159.040 | 200   |
| 11:26 | 16.6 | 16.5 | 1.28 | 1.23 | 61.00   | 250   |

water remaining in inlet 61.5 ml

~~###~~

S.T. Inlet 70.367 mN/m Std. dev. 0.072

S.T. Outlet 30.466 mN/m Std. dev. 0.144 20°C

EC - 270  $\mu\text{S}/\text{cm}$  Inlet 20°C

129  $\mu\text{S}/\text{cm}$  Outlet

pH 3.06 ~~0~~ Inlet 20°C

3.48 Outlet



## preparation of AOS + Ash mix

Ash particle

~~400 ml of 0.08~~

400 ml of 0.08 w/w% solution should contain

0.08 g per 100 ml so 0.8 gm per 1000 ml

0.32 gm 400 ml

So like previous situation, we need to add 6.4 ml of Kraster's solution to make 400 ml of 0.08 w/w% ①

400 ml = 393.6<sup>ml</sup> water

+ 6.4 ml Kraster's solution

~~AOS~~ AOS solution

100 ml of 0.3 w/w% + 100 ml DD

= 200 ml 0.15 w/w% + 200 ml DD

= 400 ml 0.075 w/w%

so 100 ml 0.3 w/w% + 300 ml DD

= 400 ml 0.075 w/w%

prepare 800 ml of solution & then take 5 ml away to add 5 ml of 0.1 M HCl

pH = 2.92

800 ml soln contains

~~800~~ 7.0 ml of 0.1 M HCl

6.5 ml of Kraster's solution (5%)

100.0 ml of AOS 0.3 w/w%

113.5 ~~ml~~ & rest distilled water (boiled)

$$\begin{array}{r} 800.0 \\ - 113.5 \\ \hline 686.5 \end{array}$$

Tomorrow change the BP to 3 & attach gas flow meter  
stir the ~~mix~~ ~~better~~ mix at higher degree



April 5 Thursday

Test 2012\_03-30-046

- Everything got prepared like said last time

1. 8:24 starting the reading for 10 min before pushing the gas at 170 ml/hr

2. PdT stabilised 11.5 mbar for 170 ml/hr

3. After 100 ml on the downside gas started injecting

4. Highest value measured was 3292, 3303, 3322

3359, 3341, 3353, 3375, 3384, 3392, 3404, 3416, 3435, 3452, 3495, 3518, 3485, 3525, 3533, 3550, 3557, 3560, 3594, 3613, 3634, 3636, 3650, 3675, 3674, 3684, 3701, 3717, 3720, 3735, 3753, 3779, 3784, 3831, 3840, 3826, 3828, 3840, 3833, 3835, 3834, 3832, 3842, 3848, 3872, 3843, 3839, 3847, 3856, 3870, 3894, 3906, 3902, 3897, 3886, 3872, 3871, 3859, 3852, 3849, 3848, 3827, 3819, 3794, 3780, 3762, 3755, 3750, 3734, 3713, 3688, 3677, 3655, 3630, 3611, 3591, 3585, 3566, 3564, 3560, 3555, 3530, 3548, 3493, 3469, 3470, 3415, 3395, 3375, 3250, 3229, 3219, 3174, 3134, 3119, 3115, 3112, 3110, 3100, 3124, 3126, 3110, 3274, 3376, 3385, 3418, 3439, 3505, 3532, 3533, 3541, 3528, 3562, 3549, 3547, 3547, 3551, 3528, 3529, 3538, 3509, 3491, 3435, 3414, 3402, 3379, 3366, 3361, 3338, 3324, 3317, 3302, 3297, 3290, 3273, 3267, 3262, 3242, 3227, 3217, 3198, 3186, 3178, 3149, 3132, 3119, 3089, 3062, 3041, 3017, 3000, 2981, 2959, 2948, 2940, 2937, 2929, 2925, —

— 3333, 3329, 3320, 3325, 3319, 3266, 3242, 3220, 3207, 3196, 3182, 3170, 3. (Remove the third hump occurred because of closing & opening the valve) 3092, 3087, 3083, 3079, 3065, 3053, 3049, 3051, 3035, 3029, 3025, 3003 (Replace 3012.7 with above numbers)

CASK Henk to increase the  $\Delta PdT_2$  to 0.4 bar in next experiment) \*Does not work

- 3015, 3027, 3034, 3057, 3069, 3079, 3085, 3072, 3074, 3067, 3073, 3084, 3082, 3101, 3120, 3123-3359, — 3396, 3403, 3386, 3350, 3267-3089, 3057, 3037, 3026, 3022,

There is a ~~leak~~ leak again in the pump

(Remove the pump just after the dip

Remove the dip as it is caused by closing the gas valve (dip is entering in the gas line so we have to remove it)

22880

Remove the next hump 2988

There is a problem with gas valve

Gas pressure tends to get more than 7 bar  
the liquid starts to pump itself in the  
gas line. Remove another hump of 2890 or  
something or try to get ~~away~~ around  
reading of around 2600 mbar

(The pressure from gas has to be more than  
~~2600~~ 7 bar otherwise everytime Pin exceeds  
7 bar liquid is trying to get inside the ~~data~~  
gas line

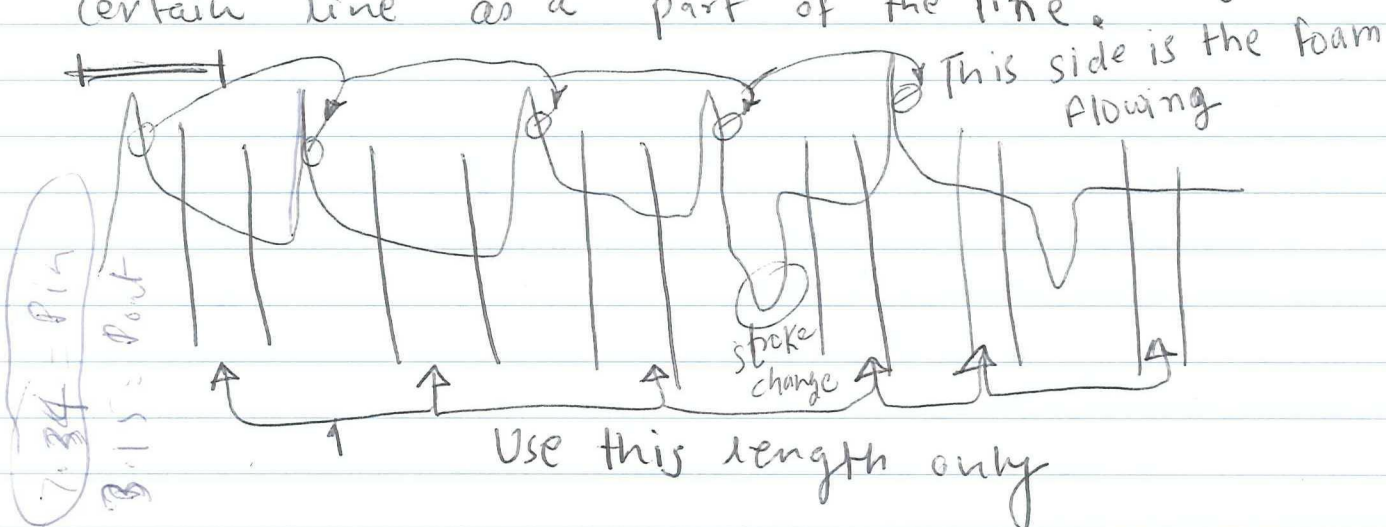
changing the heater after 420 ml

Remove the dips ~~with~~ because there is no gas  
flow & we opened the valve so that the  
the liquid expanded

|      |      |               |       |
|------|------|---------------|-------|
| Pin  | Pout | Gas flow      | Pd T2 |
| 7.45 | 3.17 | varying (1-5) | 2392  |

11:34 The gas flow is now higher than what we  
adjusted it is fluctuating (along the line).

The fluctuations has to be normalised along  
certain line as a part of the line.



or use the data when gas flow is running  
that way we can predict better ~~make changes~~ & it is  
more honest. But do not ~~make changes~~ in time, mass, ~~at~~  
~~values~~

7 bar  
gas  
line



(2600 mbar)

clean the pump & measure the ash particles weight that is lost.

System looks most stable at 2380 noted at 11:50 with P1 7:36, P2 3:16

12:25 ~~Wait~~ Waiting till the inlet ~~gas~~ remain 150 ml & then closing the gas valve for good

There is no point of pushing particles which are not ~~stable~~ colloiddally stable.

12:35 - mass balance 236-24 PdT 2540 mbar  
stopped the gas flow

Now flowing the ~~det~~ fluid for 100 ml  
Stopped at 13:00

170ml  
85ml  
half

Tuesday ~~is~~ ~~At~~ next week permeability expt: →

Discussion with Hans 14:00

① ~~Sober~~ High volume effect

~~30 bar~~ Sober Back pressure in the order of 100 bar

② literature : @ effect of Back pressure

$$F = ma$$

Barbara Thuss

$$6\pi\eta rv = \left(\frac{4\pi}{3} r^3\right) \rho g$$

$$v = \frac{2}{9} \frac{r^2 \Delta \rho g}{\eta}$$



$$\begin{aligned} r &= 0.1 \mu m \\ \Delta \rho &= 1000 \text{ kg/m}^3 \\ g &= 10 \\ \eta &= 10^{-3} \end{aligned}$$

$$\frac{2}{9} \frac{10^{-12} \times 10^3 \times 10}{10^{-3}}$$

$$\frac{2}{9} 10^{-5} \approx$$



\* Discussion with Rohi Particles + Back pressure



~~Discussion~~ Try to understand the readings

15:00 st. EC & pH testing  
EC of dd water is  $1.4 \mu\text{S}/\text{cm}$

| Surface tension ( $22^\circ\text{C}$ ) |                    | EC ( $20^\circ\text{C}$ )   | pH ( $20^\circ\text{C}$ ) |
|----------------------------------------|--------------------|-----------------------------|---------------------------|
| Inlet                                  | 25.691 sddw. 0.154 | 324 $\mu\text{S}/\text{cm}$ | 3.17                      |
| Outlet                                 | 29.040 sddw. 0.052 | 208 $\mu\text{S}/\text{cm}$ | 3.71                      |

6th April 2012 At library working on the writing

Make outlet only with two decimal places except

Pin & Pout

Remove : Time (at the end of the chapter), then & Counter,

Smooth out the data using FFT from origin software

1. Processed file Test2012\_04\_046.xlsx & 045.xlsx

2. Noted down the S.T., EC, & pH of the samples

3. search literature for Back pressure

// Next time try to get a computer inside the  
silence section // for Word 2010

(plan)  
find things to measure (kinematic viscosity) & it  
nanoparticle size measurement  
I have it so we need to measure it  
straight way  
(next week)

Prepare article with silica results :->

15:06 Read Zhang (2011) paper

Now checking what is dynamic surface tension  
(Papers from Rouhi, Pacelli, Nguyen etc.)

15:53: Jürgen came for a coffee

17:00 Going home & calling families & joining doc book

7<sup>th</sup> April 2012

Reading about relative permeability from Abaci paper  
~~I know~~

$$S = \frac{V_F}{V_P}$$

$V_F$  = Volume of fluid

$V_P$  = ~~Volume~~ total pore volume  
↑

(need to check accurately)

8<sup>th</sup> April 2012

12:00 read Du-Navy paper

~~Feb~~ 13:56 Made corrections in the graphs & put things (EC, ST, & pH values) in permeability experiment. On ~~Tuesday~~ adding this data to Experiment 2012 ~~Spring~~ document.

9<sup>th</sup> April 2012

Reading Apaydin thesis (13:35)

Try to find any <sup>foam</sup> model which ~~we~~ can use to simulate our case of experiments.

10<sup>th</sup> April 2012

Working on cleaning the pump

9:00

Still busy with correction

10:00 // DD water

flowed

13:20 flowing 50 ml Ethanol ~~and~~ <sup>CO<sub>2</sub> & then</sup>

14:38 Flowing Ethanol, shifting to <sup>CO<sub>2</sub> & then</sup> water & during the time will work out with gas separation.

15:10 CO<sub>2</sub> is flowing & now pushing DD water (100 ml)

16:30 Water is flowing through a sand pack & ~~making~~ as there is no sign of bubbles in the lines.

17:30 Stopping the flow tomorrow 4<sup>th</sup> permeability experiment

11<sup>th</sup> April 2012

Preparing solution for permeability test

8:45

pH ~~water~~ = 5.74

Adding 0.1M HCl  
(4 ml)

2:53



9:20 Starting to record the data

9:25 No Gas so stopped recording

9:45 ~~No Started~~ Installed Nitrogen gas cylinder  
& so started recording

Test 2012.04.11\_048 (2)

~~Flow~~

~~Pin~~ ~~Flow~~

| ml/hr | Pat1 | Pat2 | Pin  | Pout | m1     | m2     | Time  |
|-------|------|------|------|------|--------|--------|-------|
| 50    | 3.4  | 3.4  | 0.14 | 0.13 | 478.1  | 22     | 10:32 |
| 100   | 6.6  | 6.7  | 0.15 | 0.12 | 416.3  | 83.24  | 11:08 |
| 150   | 9.9  | 10.1 | 0.15 | 0.12 | 330.13 | 168.95 | 11:43 |
| 200   | 13.1 | 13.2 | 0.16 | 0.11 | 220.10 | 278.56 | 11:16 |
| 250   | 16.4 | 16.3 | 0.17 | 0.12 | 85.95  | 412.78 | 12:49 |

12:50 Expt stopped

| Surface tension (20°C) |                                         | EC (20°C) $\mu\text{S}/\text{cm}$ | pH (20°C) |
|------------------------|-----------------------------------------|-----------------------------------|-----------|
| Inlet                  | <del>59.171</del> 70.317 std dev. 0.087 | 333                               | 2.95      |
| Outlet                 | 59.171 std dev. 0.370                   | 145                               | 3.50      |

12th April 2012

Cleaned the lab place @ 9:40

measured 1st permeability inlet water EE 470  $\mu\text{S}/\text{cm}$   
made a presentation for tomorrow ~~with~~ EU-India.  
on 12:30

Correction in the report 16:00

Bentheimer Perm from literature  
Nguyen & Zitha (2007) 1010 mD 22.1 %  
Kaimaie 2006 1397 mD 22 %  
Waggoner 1. 21 %



Question to Rouhi

theoretical

1. ~~How to~~ How to calculate ~~theoretical~~ permeability of Bentheimer core? (Particle size)

13th April 2012

9-1:30 Meeting EU-India program, presentation

3:30 meeting with Rouhi

- issues
1. Bentheimer result, further expt, plans
  2. Comparison with Unconsolidated sand
  3. Change of back pressure //
  4. Change of Arh particles with other
  5. Problem in the ~~clinging~~ sedimentation
  6. Nanoparticle analyzer, DMA viscosimeter
  7. Advice over paper publication from previous work //
  8. Possibilities over funding (equipment)

SPE ChanHu Tulsa TOR conference

Micromodel paper to Mirza

mhamadmira@aquario@~~udel~~.students.tudelf.nl

rio\_banzai@yahoo.com

goss  
rishi  
SPE

\* Plot it different way

Meeting with Hans

Recommended Repeat

→ Nano-particles

→ pH 11

→ Surfactant concentration

→ Repeat of pH 3

→ Velocity → Reduction of velocity

→ Back pressure

Surfactant  
Reduction

f

Change in pH 11


Ajay's number 0659163416

Monday 16<sup>th</sup> 2012

Helping Ajay 10:00  
Electrical conductivity writings 11:00  
Reading diffusion of particle pp. 235. Landau Fluid mechanics

short note on the  
collected SPE papers & told by Rouhi 14:00  
Correction in the graph 16:00

Tuesday 17<sup>th</sup> April 2012

9:00 Correction in the graph done (10:30)  
11:00 Information about Anton Paar cannot find anything  
online (check with lab what ~~differs~~ they have  
there) for Maryam). 

(Also Parelli)

\* Ask technicians if they know where we can measure  
particles size & distribution

\* On go to micro CT scan people

Can't we guess from ST, pH & EC or do the  
experiment (finally with particle size analyzer)

Particle size analysis with ~~experiment~~ nanoparticles  
scheduled on ~~2~~ next Wednesday.

We cannot measure the particle size once it is dried  
Particle concentration ~~has to be measured by using~~  
is bit difficult to measure (we can do it  
by ~~dry~~ drying a sample in oven).

~~Try to~~ Tried to download the Casimir Autobiography  
but couldnot manage from Scribd.com 12:58

Wrote few variables that ~~change~~ would affect (for  
DOE studies)

Regression ~~statistical~~ statistical relationship between  
random variables. (independent & dependant)



1:24 Reading "Identification of Objects" from Khurgin book // about crude oil extraction

Ask Hans if he wants me to do regression analysis on each permeability experiment //

15:00 Made analysis of first permeability test  
Talk to Hans about the Origin software analysis.

Calculate the area under the curve

Question to Hans What does the area under the curve tells us? At least mathematically? 15:40

← calculated the std dev. function of the line, error for 1<sup>st</sup> perm)  
Checking various functions in Origin 15:50 Basically peak viewer.

Sent various email to people regarding housing 16:30

Can we believe that input and output are related by a linear differential equation. Or should the model represent transformation of input function  $x(t)$  to  $y(t)$  output function. 17:30

Wednesday 18<sup>th</sup> April 2012

Reading "Identification of objects" from Khurgin book

66 "Probability distribution of a random variable"

"conditional probability"

Ask Hans about this thing called conditional probability & check if we could use it.

10:41 Sent mail to Jon about 22 May talk

11:08 Read something about Kolmogorov

check the page 118 to see the plotting of input parameter to output parameter

A new model must be constructed based on some "Qualitative physical considerations"



Regression :-

Joint probability distribution

$$y = M(\eta | \xi = x) = \varphi(x) \text{ regression equation}$$

Continuous functions  $\Rightarrow$

Weierstrass theorem about approximation of continuous functions of polynomials.

"every continuous function defined on a closed interval  $[a, b]$  can be uniformly approximated as closely as desired by a polynomial function."

•

13:30 Preparation of AOS sample for tomorrow expt.

100 ml of 0.3% AOS & 700 ml DD water (Boiled)

200 ml = 5 ml thrown away = 795 ml total

Boiled the water for next expts

14:47 preparation of pH

Current pH 5.99      pH 3.03 after adding  
~~3.5 ml~~      5.5 ml

weighing machine measures 836.55 g, needs to be adjusted tomorrow before expts

Task for tomorrow ① Balance ② Flow of nitrogen  
③ Back pressure

15:30 - 16:10  $\Rightarrow$  Jurjen Koffie

16:30 writing EU-India progress report

17:38 EU-India progress report is written

Ask Hans to correct/add/subtract

Thursday 10 April 2012

Thursday 20<sup>th</sup> April

Started 9:00 ~~to~~ flushed the ~~water~~ in the  
intake line to get rid of bubbles.

checked Nitrogen gas line (it is working)

•

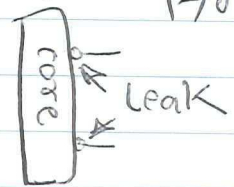
waiting to get pressure stable

No back pressure was applied. so starting again after applying back pressure 3 bar.

Test 2012\_04\_19\_050 (1)

The pressure difference (PdTI) is stabilising at  $\frac{10 \text{ mbar}}{170 \text{ ml/hr}}$

Stopped again because leakage was detected



Test 2012-04-19\_051 Running again 10:32

Check the Pin-Point of other experiments

Just ~~realized~~ realized that Back pressure was not 3 bar, so  
Again started with Test 2012\_04\_19\_052

System is stabilised ~~doing~~ on ~~10:11.5~~ 11.5

| Pin  | Pout | PdTI | PdTI2 | Mass  | ml/hr | Time  |
|------|------|------|-------|-------|-------|-------|
| 3.22 | 3.15 | 11.5 | 11.5  | 37.22 | 170   | 11:01 |
| 3.13 | 3.12 | 11.6 | 11.6  | 92    | 170   | 11:21 |

Pushing the gas 11:24

Remove the first Peak

Bit of screw up while going to the pick. Back pressure was stopped & then again started so that showed on the Pin. Point & PdTI correction has to be done for these 10 or 20 points

Going very fast to 3000

3071, 3104, 3163, 3217, 3263, 3354,  
3478, 3578, 3109, 3134, 3158, 3204, 3220,  
3228, 3326, 3383, 3397, 3435, 3440, 3477,  
3496, 3535, 3541, 3580, 3586, 3582, 3601, 3597,  
3699, 3724, 3750, 3826, 3856, 3835, 3831, 3898,  
3890, 3870, 3866, 3824, 3773, 3743, 3699, 3612,  
3608, 3589, 3696, 3777, 3627, 3502, 3488,  
3469, 3464, 3453, 3420, 3383, 3338, 3602,  
3582, 3526, 3413, 3345, 3305, 3205,



3250, 3357, 3412, 3482, 3356, 3305, 3283,  
 3243, 3227, 3213, 3185, 3168, 3138, 3146, 3169,  
 3260, 3313, 3329, 3246, 3156, 3146, 3133, 3109,  
 3046, 3039, 3027, 3011, 3013, 3014, 3198,  
 3326, ————— 3120, 3091

Take the  $P_{LT}$  points which are after one point of  
 Gas flow measurement-

There is a relation we can draw <sup>between</sup> ~~for~~ the permeability  
 & pressure difference

Pore volume should // cumulative //

Average the gas flow rate to 5.65 ml/min

Plot  $P_1$  &  $P_2$  graphs to figure out the problems

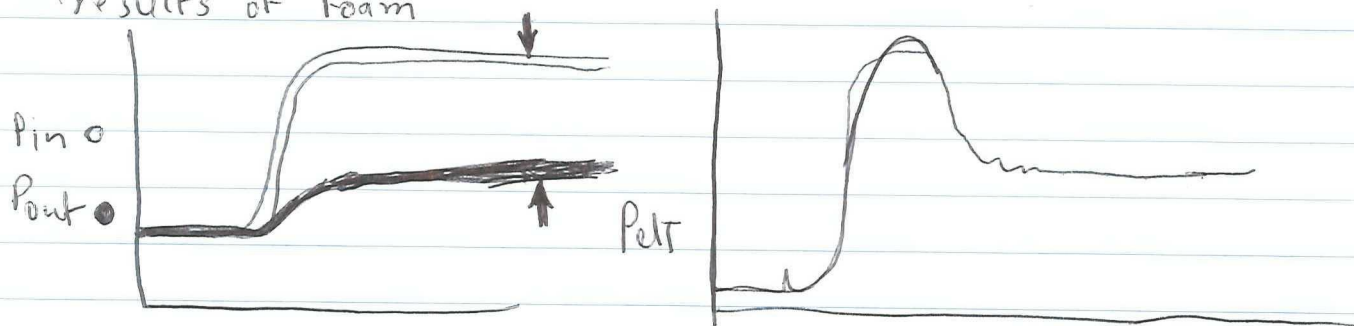
The problem is that  $P_{out}$  is also increasing

Calendar on Saturday : looking at  $P_{in}$  &  $P_{out}$  of  
 Foam experiments

First thing to do is to remove the points which  
 does not have 5.65 ml/min gas flow rate.

Calendar clean the gas flow meter next morning

You need to check something with back pressure or  
 more precisely  $P_{out}$  (Perhaps it is leaking or  
 something, it has to be compared with previous  
 results of foam)



Foam propagation through porous  
 media



In principle Pout should always remain stable  
< Check with back pressure valve

Remove points below 1900 mbar

Very erratic, needs lots of correction during processing

Stopping the ~~the~~ experiment, ∴ reading, liquid flow,  
Gas flow

No 100 ml liquid was flown during  
this experiment in the final

Doing correction in the excel sheets

- ① Removing points where there is no gas flow or  
too high flow (above 5.00)
- ② ~~the~~ Adjusted the mass balance ~~exp~~ weights
- ③ Change in ~~Pd~~ PdT2  
i. change in highest values

768-905

689-757

Good fit

- ④ Change in Pin Point 400 onwards ~~0.5 bar~~ less

⑤ 20.04 ~~33469.51~~  
14.95 31538.89

( 17.82 3.996 )  
( 22.16 4.176 )

11.23 - 12.25



13.02 3.583

17.82 3.996

14.96 3.099

Remove some points around 23.16 3.607 fault  
Should 4.00

~~2~~

15.85 - 24693

26.73 - 22491



15.82 - onwards

Friday 20th April 2012

|        | measuring s.t. |                 | pH                   | EC (S)     |
|--------|----------------|-----------------|----------------------|------------|
| inlet  | 27.774 mN/m    | Std. dev. 0.120 | <del>2.85</del> 3.16 | 83.0 (325) |
| outlet | 28.831 mN/m    | Std. dev. 0.047 | 3.95                 | 44.1       |

outlet should show some variation because it was not averaged (some water lost due to misplacing)

The onset ~~of~~ of foam generation is faster if there is no full saturation of water in core.  
Though it hardly affects the stabilising value.

let us wait till ~~pot~~ mix experiment & then make necessary adjustments in the plots

1:32 worked an hour on the graphs

1:47 Passing 100 ml ethanol 50 ml/hr  
so two hours almost till 3:47 ≈ 16:00

Then CO<sub>2</sub> flushing for ~~an hour~~ five minutes & then water

Tensiometer KSV sigma 701

15:00 Helping Ajay for gravity setup expts.

16:30 DD water is put inside so ~~can~~ Monday morning  
flushing with CO<sub>2</sub> & water flooding

How excel or origin fit a line? By the method of least squares? or just passing the line touching the points thereby ~~getting~~ getting  $\beta_1 + \beta_2 x$

$$(\text{Std error})^2 = \frac{(\text{Std. dev})^2}{\text{no of samples}}$$

17:00  
Printed pages of Origin lab of read std error

QSS Sxx Syy Sxy etc.



Method of least squares works on the principle of fitting the data with a line where RSS (residual sum of squares,  $\sum_{i=1}^n (y_i - \bar{y})^2$  would be minimum)

A residual is difference between the actual value of the dependent variable & the value predicted by model.

$$r_i = y_i - f(x_i, \beta)$$

info about Central limit theorem

Saturday 21<sup>st</sup> April 2012

~~Made~~ started making presentation for 22<sup>nd</sup> May  
Need to figure out to connect S.T, viscosity, pH & EC results to Foam Flow results.

~~Ca~~

Monday 23<sup>rd</sup> April 2012

Start pumping water 8:45 am, but first 5 min Flushing of ~~Ca~~  $\text{CO}_2$ . Instead of flushing 100 ml we will flush 200 ml to ensure complete cleanliness of the core.

10:01 Helping Ajay with gravity setup

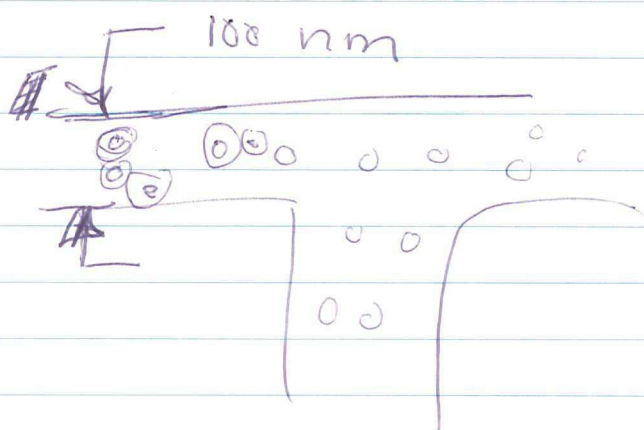
14:00 meeting with Hans : Discussion points

1. Results on permeability, foam, error analysis
2. Preparation for the next experiment
  - i. Back pressure, ii. Velocity, iii. Another core
3. Faculty talk 22<sup>nd</sup> May
- 4.

Calculation for Debye length  
Oversbeck

Centrifuge  $\rightarrow$  Sedimentation rate

Box-Behnken designs





Tuesday 24<sup>th</sup> April 2012

Changing pH of PD water for permeability expt.  
pH = 2.97

Starting the expt 11:20

Pressure is increasing till 1 bar (BP) test2012\_04\_24\_056  
(should increase), Bit of a problem

maintaining 1 bar. So starting again 12:00

| P <sub>in</sub> | P <sub>out</sub> | PAT <sub>1</sub> | PAT <sub>2</sub> | ml/hr | Time  |
|-----------------|------------------|------------------|------------------|-------|-------|
| 1.17            | 1.15             | 4.0              | 4.1              | 50    | 12:25 |
| 1.16            | 1.13             | 6.6              | 6.7              | 100   | 12:48 |
| 1.14            | 1.12             | 9.8              | 9.9              | 150   | 13:30 |
| 1.14            | 1.12             | 12.2             | 12.9             | 200   | 13:56 |

Wednesday 25<sup>th</sup> April 2012

Correction in the report 10:10

Sent mail to Rouhi & Hans 11:00

Preparation for the Latex @ workshop 13:30

LATEX WORKSHOP : →

<http://ecie.vutp.tudelft.nl/pslatex>

Not able to make ~~any~~ any output  
because compiler is not present on  
most of the computers

16:00 testing from previous 5<sup>th</sup> perm expt

| P            | pH   | ET <sub>0</sub> | EC (μs/cm) |
|--------------|------|-----------------|------------|
| Outlet Inlet | 2.98 | 70.185 (0.067)  | 387        |
| Inlet outlet | 3.47 | 55.812 (0.286)  | 186.7      |

This is because of extra cleaning ml  
passed through the core.

Thursday 26<sup>th</sup> April 2012

|                                  |               |               |
|----------------------------------|---------------|---------------|
| Double distilled water           | 686.5 ml      | 411.9         |
| 0.1M HCl                         | 7.0 ml        | 4.2 ml        |
| <del>6</del> Krastev's soln (5%) | 6.5 ml        | 3.9 ml        |
| Aos soln (3%)                    | 100.0 ml      | 60 ml         |
|                                  | <u>800 ml</u> | <u>480 ml</u> |

pH of DD + 0.1M HCl + Aos = 2.98  
411.9 4.1 60

Adding 3.9 ml of Krastev's soln.  
using solvent change in the pump to change the  
soln from DD to Aos + Ash mix

(soln)  
Waiting till it occupies the cylinder in the pump at a  
50 ml/hr

Started ~~the~~ reading program 10:15, going to start  
the pushing single phase flow in 5 minutes

MPS program not responding so starting again

Started pumping soln at a rate of 170 ml/hr 10:25  
Now waiting to 100 ml ~~soln~~ pushed out & then  
Starting the gas flow.

Stabilisation values 170 ml/hr 11.3 mbar  
Pushing the gas 11:05

12:30 There is a lack of solution so put 10 ml from  
Aos-Ash mix from 5<sup>th</sup> April in

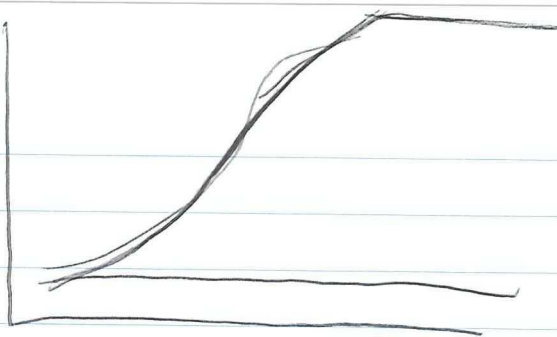
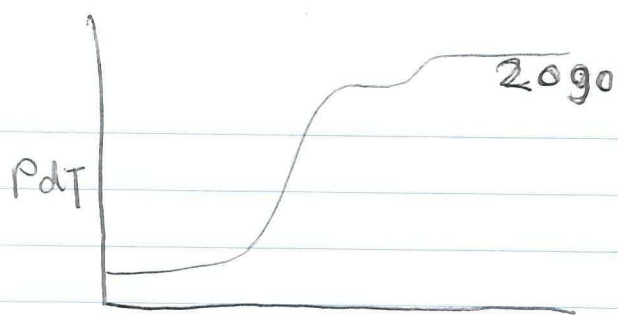
~~At~~ 12:45 Removed exhaust (400 ml) & put 80 ml inlet  
to make it run for another possible hour <sup>Water</sup>

12:54 Put 20 ml Aos from 20<sup>th</sup> April inlet to make up  
For ~~the~~ the less Aos water put in earlier

13:42 PdT2 ~~still~~ moving around 1720, bit low  
for Aos-Ash mix (last time it was around 1900  
mbar)

check the P1 & P2 of other expt as well

13:50 PdT1 & P1 keeps on increasing

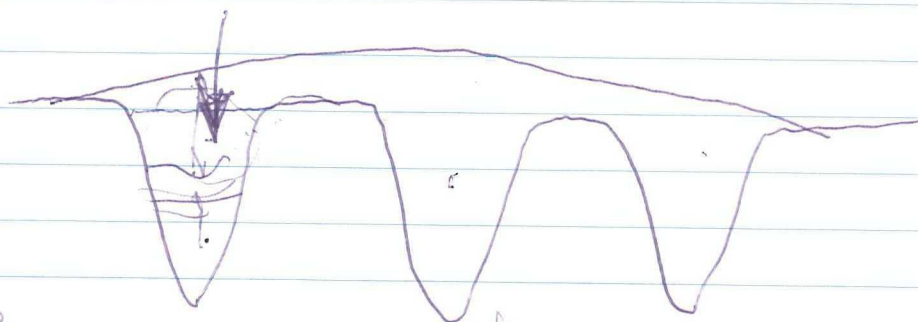


~~14:54~~ 14:18 stopped due to lack of ~~working~~ liquid but the sample has reached the equilibrium PdT

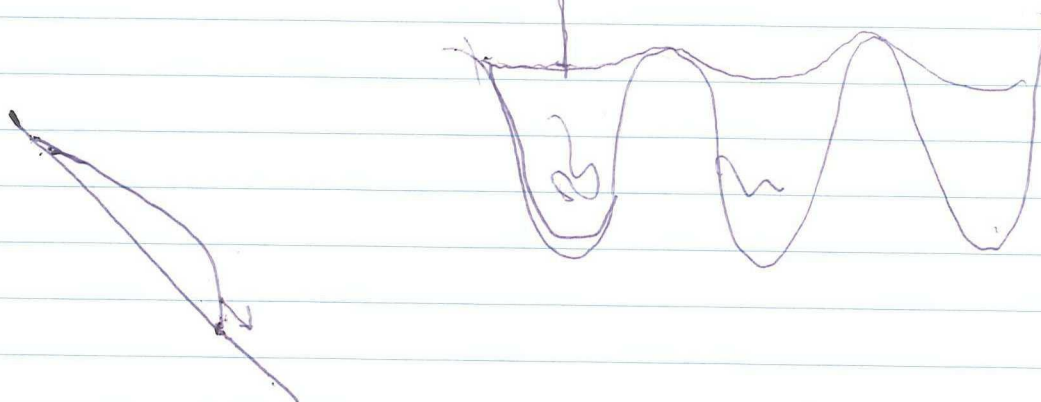
3:30 ~~Evening 1~~ Evening meeting with Hans

$$y = ax + b + N(0, \sigma)$$

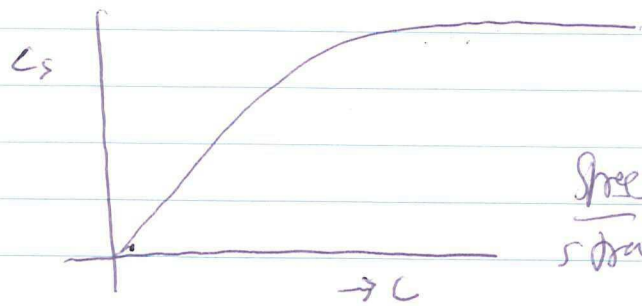
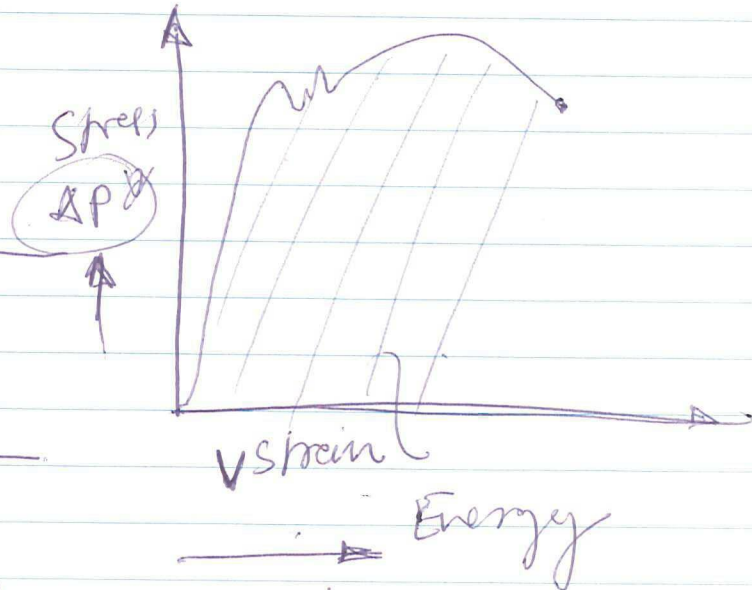
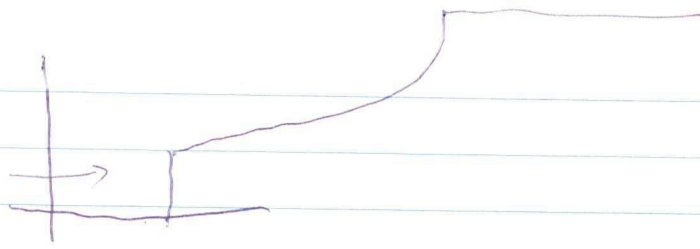
$$4.87 \pm 0.035$$



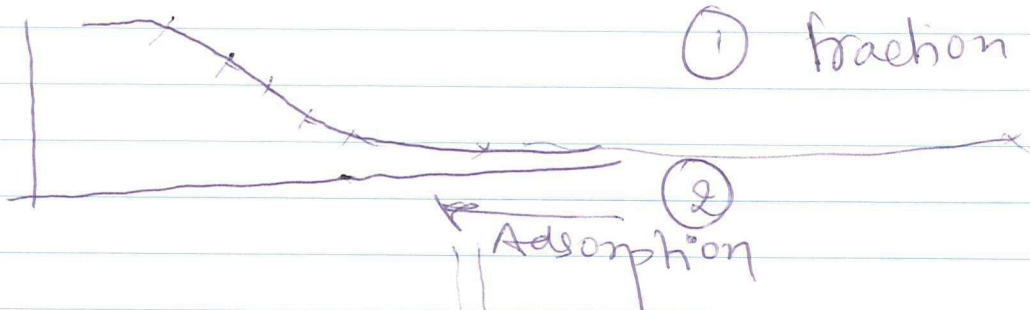
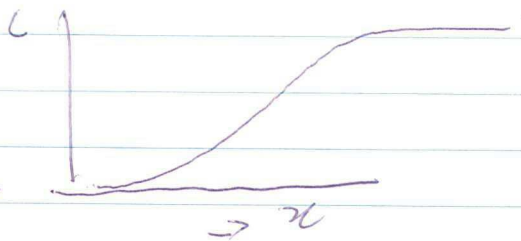
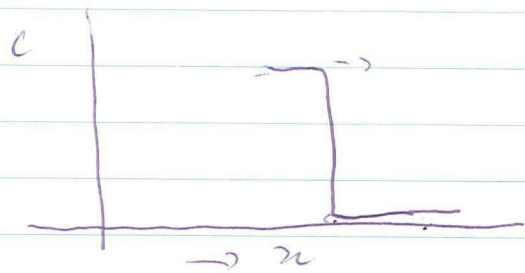
4000 Å







$$\frac{\text{stress}}{\text{strain}} = \text{modulus}$$

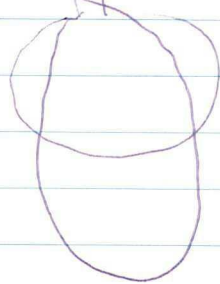


① fraction collector

② Adsorption

① literature about the concentration

Effect of initial conditions on the AOS-Ash



- ① flush with water for one day & then do the expt
- ② flush with surfactant sol<sup>n</sup> for one day & then do the expt.
- ③ fraction collector

Friday 27<sup>th</sup> Apr 2012

8:40 Visit by shell personal

Cleaning by ethanol 100 ml

- ① Starting the pump & use solvent change
- ② Shifting <sup>to</sup> 50 ml/hr Ethanol pushing ~~100 ml~~
- ③ Passed 80 ~~ml~~ ml Ethanol (Stopped the ~~pump~~ flow at 11:10)

Corrections in the presentation: → 13:00

~~Reading~~ SPE-15336-MS paper

- \* shear rate : what shear rate in our condition  
change in shear rate due to change in injection rate
- \* Use of nanoparticles increase foam viscosity by  
1.5 to 2.5 times
- \* With increasing nanoparticle conc the normalized  
mixture viscosity increased & relative mobility  
decreased.

< what is Breakthrough curve? OTC-21212  
Zhang on nanoparticles > (in our case or not?)

3:30 meeting with Zooki & Hans

1. Next ~~batch~~ Current expt. Discussion

Q.

2. Next batch of expts (velocity, back pressure, pt of surf)

3. Supplementary Experiments : Particle size analysis,  
viscosity,

Charge on the ash particles pH 3

Pore volume

Constant pressure ~~fluid~~ conditions

Wet core  $\square$

$2.4 \times 10^{-5} \text{ ml/s}$   
Water

$4.8 \times 10^{-5} \text{ ml/s}$

$\leftarrow \boxed{66.67\%} \rightarrow$

Foam quality  $\rightarrow$

Rate  $\square$

- ① Clean it properly (Ethan)
- ② ~~water (24 hrs)~~ AOS
- ③ AOS

① Rate

② Adsorption

① Clean it properly

② ~~water~~ water (24 hrs)

③ AOS Expt

- ① AOS +
- ② AOS + Ash

Bulk foam expt

$\boxed{\text{SPE 154285}}$

- ① Contact Simjoo & check about the best results
- ② Ask guys about

③

No

Slower flow rate  
Larger Back pressure



① Preparation

② flow rate

③ Particle detection

$\boxed{\text{Foam scanning tests}}$



28<sup>th</sup> Apr 2012

12:30 Analysis of the expts done

~~mob~~  $\frac{\Delta P/L}{Q/A} = \text{Darcy law}$

$$\frac{Q}{A} = \frac{K}{\mu} \cdot \frac{\Delta P}{L}$$

$$\frac{\mu}{K} = \frac{\Delta P \cdot A}{L \cdot Q}$$

$$\mu = K \frac{\Delta P}{L} \cdot \frac{A}{Q}$$

mobility reduction factor =  $\frac{(\Delta P/L / Q/A)_F}{(\Delta P/L / Q/A)_W}$  ?

Going home 15:00

29<sup>th</sup> Apr 2012

3:00 Reading from the book of Khurgin

1<sup>st</sup> May 2012

9:45 Flushed (O<sub>2</sub> 10 min)

10:00 Started Water 50 ml/hr (bubbles had to be removed this time)

11:30 output S.T. AOS-Ash mix pH 3 at 22°C  
28.872 mN/m 0.132 Std. dev.

EC 225  $\mu S/cm$

pH ~~4.02~~ 4.02

15:00 Read paper: SPE 154285

2<sup>nd</sup> May 2012

To prepare 0.3 w/w% AOS soln

~~7.67 g~~ 7.67 g 992.33 g  
AOS Water

A sample has been prepared waiting till 11:30 to start the AOS Expt.

11:30 Stopping the water inlet

100 ml 0.3 AOS + 700 ml DD water

& then 5 ml thrown away so total 795 ml + 5.5 ml  
pH = 3.03

solvent change ~~is~~ enforced

② Back pressure huge gas

③ mass balances are ~~to~~ zeroed

④ Opened the program

Lunch 12:21

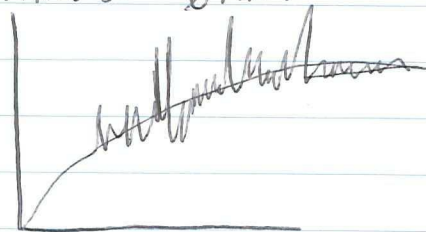
Starting the expt pushing the water at 170 ml/h  
till we get 100 ml in the outlet Beaker

PdTI stabilised at 11.1

2:32 Foam propagation : ~~ir~~ erratic flow  
Separate water & bubble flow

In my opinion the core is damaged Or there is  
no proper mixing of Gas & Surfactant mixture. One  
guess is AOS soln is less concentrated, hence not  
able to form foam immediately.

find statistical recipe to minimise error



Or just remove the measurement points

3058, 3075, 3054, 3041, 3054, 3114, 3150, 3164, 3163,  
3144, 3159, 3168, 3172, 3199, 3189, 3189, 3208, 3217,  
3214, 3238, 3285, 3267, 3272, 3241, 3231, 3237,  
3294, 3292, 3277, 3294, 3295, 3287, 3279, 3307,  
3258, 3229, 3162, 3167, 3172, 3174, 3181, 3172,  
3073, 3048, 3002,

Removing points with gas value lower than ~~5.00~~ <sup>5 ml/min</sup>

3 May 2012 Thursday

11:00 Helped Ajay with permeability expt

12:00 EC, ~~PH~~ pH & S.T. EC

Inlet 1 3.12 31.196 SH. 0.217 71.6

Outlet 151.2 4.2 28.682 SH. 0.106 30.5

(0.499 l/cm)

(0.100 l/cm)



3:00 Analysis of the Test 57 & comparison with previous AOS Expt.  
 5:00 Abstract writing

Meeting with Hans

Evening 2-3:00

1. ~~2007~~ 2007 paper

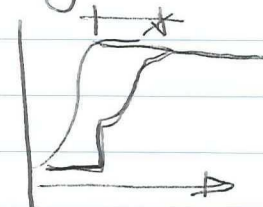
Drainage / Imbibition

(ASK Mohammad Simjoo)

Wettability

↓  
Foam

Foam generation in big pores



Porters with Bill Rossen  
 on the ~~report~~ Foam Book.  
 from

Read Bill's ~~work~~ work

SPE Journal, March 1998

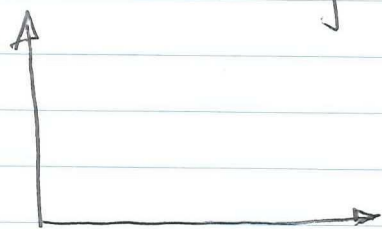
Capillary pressure fluctuation

what is the difference between interstitial velocity & Darcy Velocity?

$$\frac{A \cancel{u} t}{A \cancel{L} \phi} = \frac{\cancel{V} t}{\cancel{L}}$$

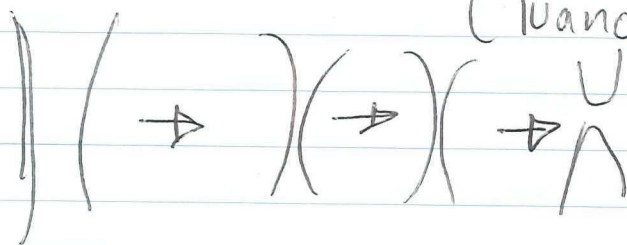
check the formulae: checked (it is ok)

Foam mobility in heterogeneous porous media: Kovscek



Mechanical properties

Joosten: Advance in foam  
 Ivanov



et al

① low flow rate & low surfactant concentration

② Confirm only duplicated expts with

③ unconsolidated sand pack



~~Give another color to Bentheimer~~

Give velocities  $7.2 \text{ E-}05 \text{ m/s}$  name "c"

4th May 2012

Sent mail to Jon @ 22nd May talk 10:20

Sent mail to ING @ Credit card problem 11:40

Preparation ~~with~~ For a meeting with Mohammad 13:40

\* Showing him Velocity vs Pressure drop variation results

\* About the parameters (Bentheimer & Back pressure 20 bar etc.)

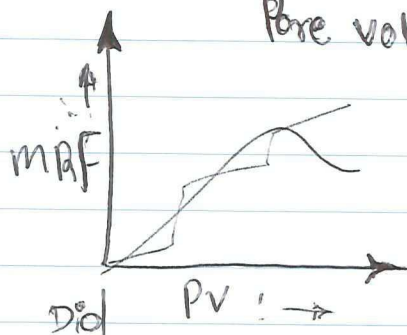
\* Results & discussion in case of mobility reduction

Factor

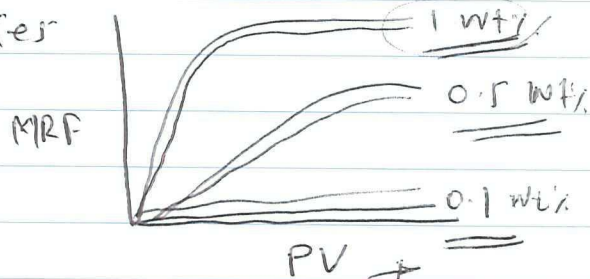
$$\text{MAR} = \frac{\Delta P_{\text{foam}}}{\Delta P_{\text{water}}} \left| \begin{array}{l} 7.2 \text{ E-}05 \text{ m/s} \\ \text{same } 2.4 \text{ E-}05 \text{ m/s} \end{array} \right. \quad (7.2 \text{ E-}05 \text{ m/s})$$

at the same superficial velocity & How to calculate this? Because what I did or usually do is use  $u = 2.4 \text{ E-}05 \text{ m/s}$  & then inject gas at a rate (e.g.  $4.8 \text{ E-}05 \text{ m/s}$ ) so I cannot AP at the same  $u$

Pore volume of Bentheimer is  $40 \pm 2$



\* ~~Did~~ Simgo ~~did~~ conduct experiments with increase in surfactant conc? Ter

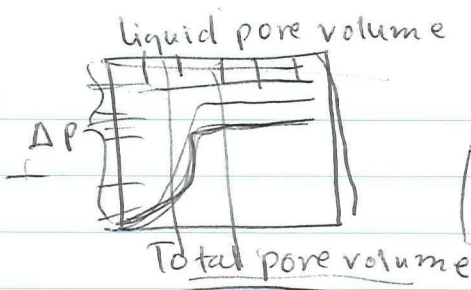


Viscosity vs relative permeability effects

< Studies on the saturation analysis >

(next page)

How to draw



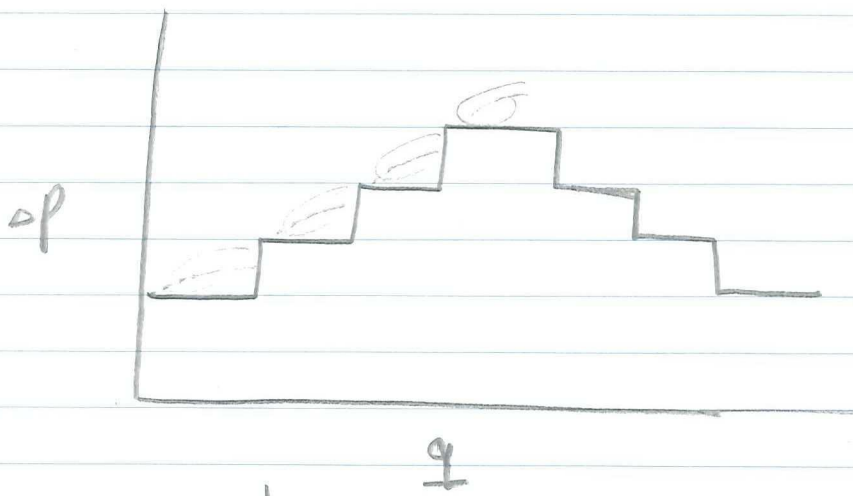
SPE 45043

pp. 16

MATLAB 8

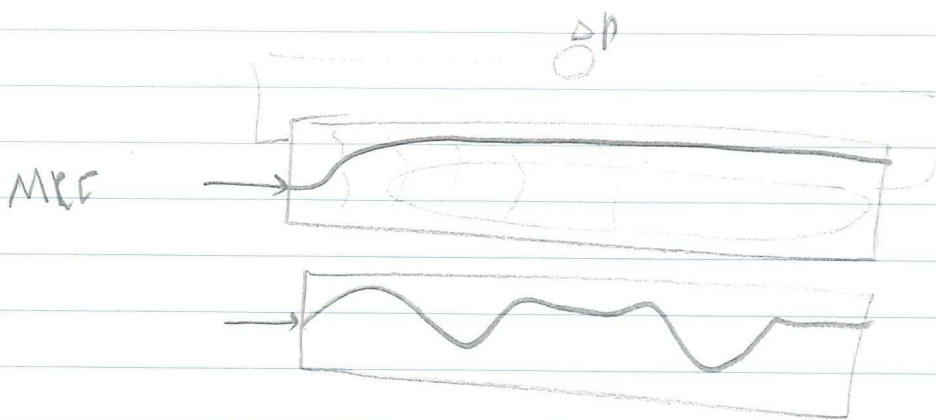
with back pressure

without back pressure



BP = 25, 30

assigning → Secondary axis



Notes on Simjoo meeting

Calculate ~~MRF~~ MRF by  $\frac{\Delta P_{\text{foam}}}{\Delta P_{\text{water}}}$  | u ← same (Get  $\Delta P_{\text{water}}$  vs u from perm exp.)

Use excel for plotting secondary axis to get  $\gamma_1$  (check the shear plot the ~~plots~~ graphs in  $\gamma_1$  total rather than only ~~stable~~ steady state part)



If the expansion is not much then the effect can be ignored & we can still use Darcy's law for calculation of viscosity

5<sup>th</sup> May 2012

Louise's Birthday!

Looking back to older foam results and putting them in summary section

\* Mixbrine 17 Feb 2011 expt is one with ~~a~~ change in the flow rates ~~of~~ during foam flow. Not many expts done ~~at~~ like this. In fact this might be the only one.

6<sup>th</sup> May 2012 Sunday

Worked three hours on the search for expts from earlier year 8 (2011) — Mostly the period Jan-June ~~2006~~ 14-18:00 Hockey match ~~video~~ video making

7<sup>th</sup> May 2012 Monday

\* Cleaning the ~~pump~~ (I don't think about Monique!)  
10:00 Pushing 150 ml <sup>system</sup> of Ethanol through the system (70me)

11:00 Stopping pushing of ethanol & replacing it with water // ~~Re~~ filled the pump with ~~the~~ DD water

12:30 Pushed the <sup>CO2</sup> gas for 5 min & now pushing DD water at a rate 50 ml/hr

15:30 stopped the water flow & total 150 ml water is flown. Tomorrow expt with AOS

Just noticed that the diameter of the Benthamer is ~~3.4~~ 4 cm rather than 5 cm as we took it. This may result in correcting all the calculations ~~for~~ now. :C



8<sup>th</sup> May 2012 Tuesday

Preparation of AOS 0.0375 w/w %.

9:00 100 ml of AOS 0.3 w/w % & 700 ml of DD water  
Test 2012-05-08-058

Now adding HCl to make it 3

Initial pH 6.23  
3.01

after addition of 6.5 ml of  
0.1 HCl

10:10 Pushed AOS soln in ~~water~~ the pump, raised back pressure to 3 bar, ~~raised~~ ~~water~~ checking if it is 0 mbar at PdT1 & PdT2, checked the gas line (It is OK)

Check the relation between Back pressure & PdT. Because if BP is fluctuating or less value than ~~designed~~ designed (3 bar), Variation in the PdT values occurs.

Started pumping AOS at 10:30

System is stabilised at ~~11.5~~ 11.5 mbar

Pushing gas at 11:10

11:32 ~~No gas~~ still not ~~for~~ foam produced

11:55 Then increase <sup>rate</sup> in foam flow is not much

12:10 PdT is dropped to 55 after reaching 75  
No idea why this happens but it was observed in previous case as well

Check on "Breakthrough curve in case of foam"

13:16 The foam PdT curve keeps on increasing as predicted.

At  $m_2 = 600$  gm change the Outlet breaker  
PdT is stabilized at  $\sim 2300$  mbar

Remark: One of few no problem expts

A hand-drawn graph showing the variation of gas flow rate ( $A$ ) versus time. The vertical axis is labeled  $A$  and Gas Flow, and the horizontal axis is labeled time. The graph shows a series of oscillations around a horizontal line, with a peak labeled  $x$ .

Wednesday

12:00 lunch with Jürgen

14:30 Pushing ethanol again for ~~2 hrs~~ 1 hr

16:13 water boiled / Took the picture of sandpack

PH

S.T.

spel. clv

Inlet

3.07

30-934

~~Step 2~~ 0.219

Outlet

3.72

29. 830

0 066

Need to recalibrate EC device as it is not giving the good result.

Working on the analysis of the AOS / 15:00  $\Rightarrow$

Presentation / 16:40

Saving the data: 17:55

Meeting with Hans 9:00 at  
Westplantseon 136

- ① Initial foam
- ② Theoretical conductivity (Moore w.J. physical chemistry)
- ③ continuous electrical conductance measurement (Einstein formula)
- ④ Karel Heller continuous measurement
- ⑤ Phreeqc / Geochemistry }
  - Green : Solution
  - Blue : Input file

To calculate theoretical pH

add picture from NMI about particles in test tube

Debye-Hückel formula for expts: → wikipedia

Siemens/cm

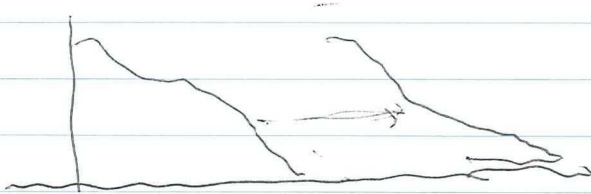
\* liquid chromatography

\* Onset of foam formation

$$\partial_t c + v \partial_x c = 0$$

$$c = \underline{c(x-vt)} \quad ; \quad c = c(\eta) \quad c' = \frac{dc}{d\eta}$$

$$-v c' + v c' = 0$$



$$\partial_t c + \partial_t c_s + v \partial_x c = 0$$

$$c_s = k c$$

$$\partial_t c + k \partial_t c + v \partial_x c = 0$$

$$(1+k) \partial_t c + v \partial_x c = 0$$

$$c = c(x, t)$$

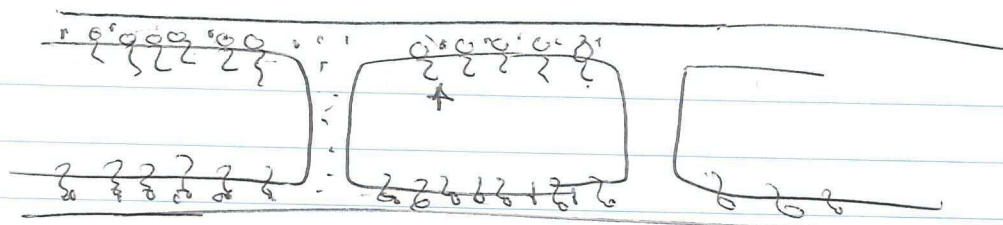
$$dc = \frac{\partial c}{\partial x} dx + \frac{\partial c}{\partial t} dt =$$

$$\left( \frac{\partial x}{\partial t} \right)_c = - \frac{\partial c / \partial t}{\partial c / \partial x}$$

minus are rule

$$\left( \frac{\partial x}{\partial t} \right)_c = \frac{v}{1+k} \quad \text{Finding } k$$





## Surfactant concentration - Maragoni effect

- \* Surfactant & particles
- \* Measuring things at outlet
- \* Mirza: → bubble density

11th May 2012 Friday

flushed the core with  $\text{CO}_2$  (5 min) 9:00  
 started flowing water at a rate of 50 ml/hr 9:30  
 Stopping the flow of water at 11:30

Preparation of the sample for permeability test  
 DD water (boiled) 4.96 ml pH 6.21  
 0.1 M HCl 4.1 ml pH 2.98 / 3.00 } 20°C  
 Preparation of the sample 12:00

Starting the experiment 3:30

| ml/hr | P <sub>in</sub> | P <sub>out</sub> | Pd T1 | Pd T2 | Time        | Temp |
|-------|-----------------|------------------|-------|-------|-------------|------|
| 50    | 1.31            | 1.30             | 3.6   | 3.3   | 4:00 - 4:34 | 19   |
| 100   | 1.28            | 1.27             | 6.5   | 6.3   | 4:34 - 5:07 | 19   |
| 150   | 1.26            | 1.25             | 9.6   | 9.4   | 5:07 - 5:41 | 19.4 |
| 200   | 1.30            | 1.26             | 12.3  | 12.2  | 5:41 - 6:15 | 18.7 |
| 250   | 1.31            | 1.26             | 15.1  | 15.0  | 6:15 - 6:50 | 18.5 |

~~12th~~

12th May 2012 Saturday

Correction for 5 cm to 4 cm

expts: → it does not seem right in case of permeability

Changed 59, 48, 41, 38, 39

Because if the Bentheimer is 4 cm, ~~and it~~ sandpack would be smaller than 4 cm? (it looks smaller at least)

14<sup>th</sup> May 2012 Monday

- 10:00 - 11:00 Read some part of Khurgin book  
11:30 - Talked to Elham about meeting  
12:30 - 15:30 Read Elham's paper on Foam generation at the entrance region  
(Notes are made on the papers)  
15:30 - 17:00 Presentation preparation & sent to Rouhi & Hans

15<sup>th</sup> May 2012 Tuesday

- 10:00 Talked to Dick about ~~core~~, He is very busy  
11:00 Talked to Yolanda about EC calibration problem. Unfortunately Alma suffered Yolanda's disappointment due to vic of EC meter for organic things  
13:00 - 15:00 Reading Elham's paper  
15:00 - 17:00 Presentation correction

16<sup>th</sup> May 2012 Wednesday

- 9:00 - 10:30 ~~Re~~ Correction ppt, emailing, Bank transfer etc.  
10:30 - 12:30 Reading Elham's paper of traveling wave  
1:30 - 2:30 ~~an~~ Analysis of conclusions from the paper

Top Points of discussion with Elham

- \* Types of models: LE, Pop-bal
- really fast  $\uparrow$  FF methods (always connected) time dependent
- \* (Is there any model to directly connect with our case)

\* What is shock front

\* Is there any software to prepare (simulation) demo of the model

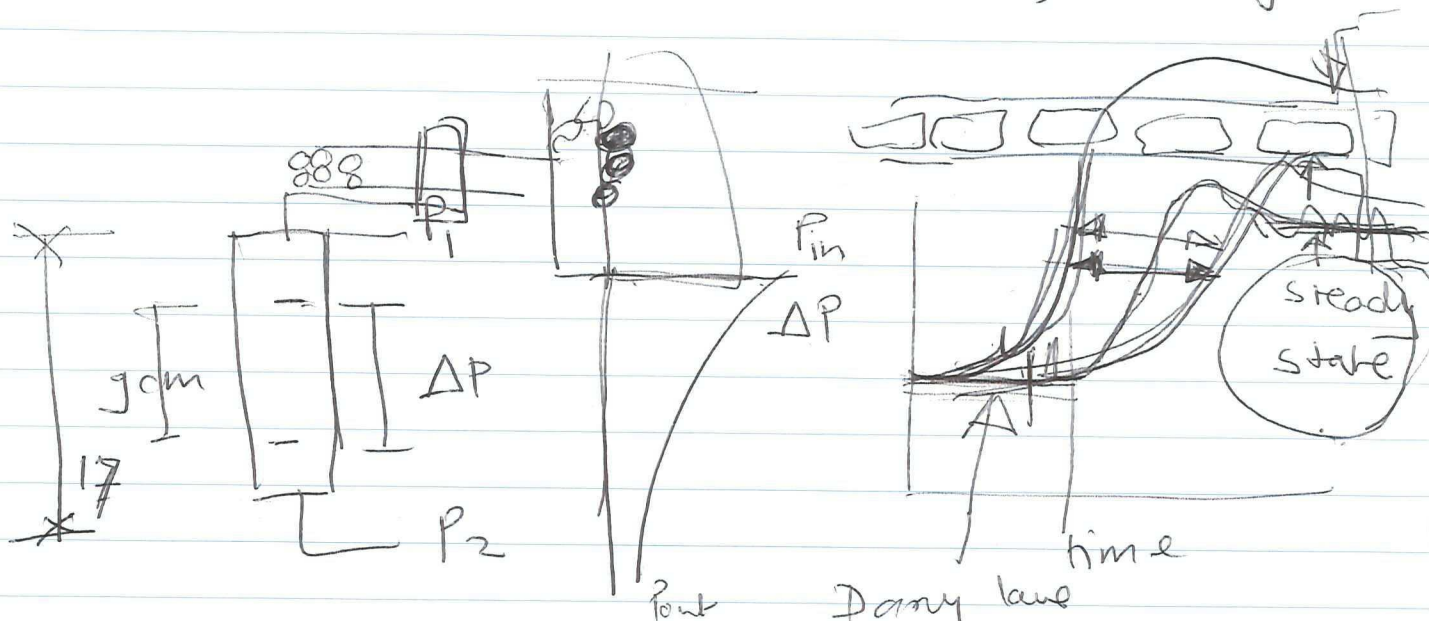


\* ~~Both~~ Egn<sup>to</sup> satisfy boundary conditions  
 { for our case of pre-generation }

\* when to use  $\frac{\partial}{\partial x}$  (partial) &  $\frac{d}{dx}$  (Ordinary)

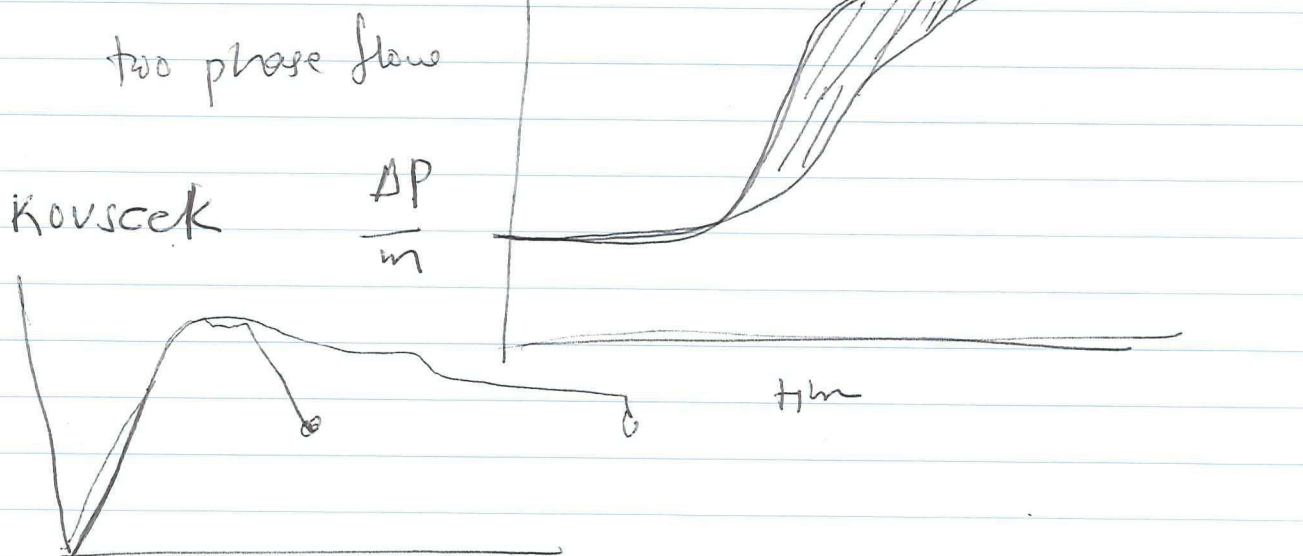
\* Elham has ~~eq~~ ~~condi~~ eqn's for conditions such as no foam & Steady state foam but what about transition zone.

\* Discuss the terms foam kinetics & Foam dynamics



Darcy law

$$\frac{Q}{A} = \frac{K}{\mu} \cdot \frac{\Delta P}{L}$$





try to ~~find~~ write things for local equilibrium  $v_g = v_c$  by Fractional Flow theory

So  $y = Ax_1 + x_2 + x_3$

Friday 18<sup>th</sup> May 2012

study of surfactants at library : — 10:00

Gibbs isotherm  $-d\gamma = \Gamma_1 d\mu_1 + \Gamma_2 d\mu_2$

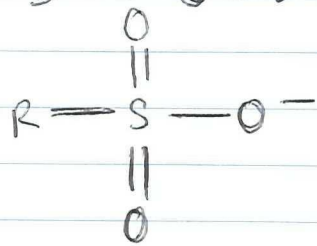
It relates changes in concentration of a component in contact with a surface with changes in the surface tension

$\gamma$  Surface tension

$\Gamma_1, \Gamma_2$  surface excess of component 1, 2  
 $\mu_1, \mu_2$  concentration of component 1, 2

Anionic : based on permanent anions

A Sulfonate is a salt of sulfonic acid



Cationic : CTAB  $\rightarrow$  Permanently charged quaternary ammonium cation

CTAB:  $\rightarrow$  cetyl trimethyl ammonium bromide

Marangoni effect: mass transfer along an interface between two fluids due to surface tension gradient.

Gibbs law :  $\rightarrow r = - \frac{1}{RT} \frac{d\gamma}{d \ln(c/c^\ominus)}$

$$dG^\sigma = -S^\sigma dT + \gamma dA + \sum_j \mu_j dn_j^\sigma$$

$$\sigma = \frac{1}{r N_A}$$

Read diffusion of particles through liquid

$$v = \frac{F}{f} \quad f = 6\pi\eta a$$

velocity  $\uparrow$   $f \propto$  friction factor  $\uparrow$  radius  $\uparrow$  viscosity (?)

$$\Delta x = \sqrt{6D\Delta t}$$

$$D = \frac{k_B T}{f}$$

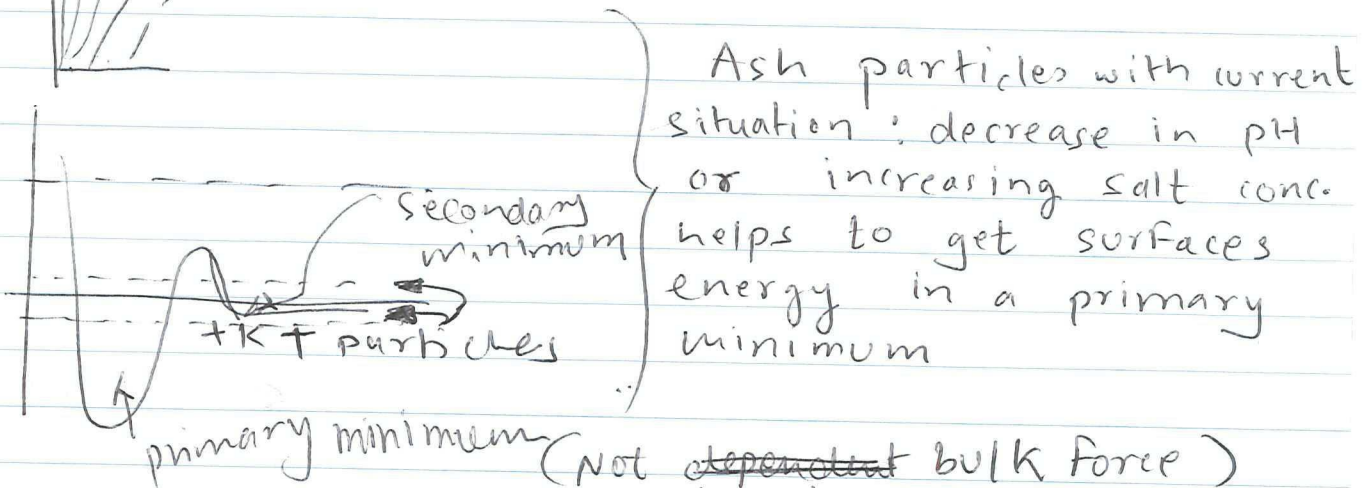
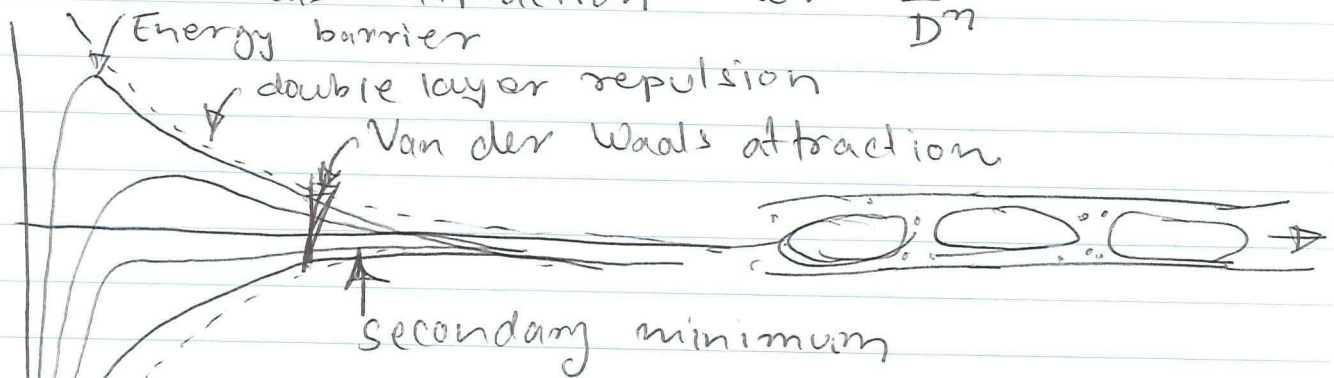
$$k_B = 1.38 \times 10^{-23} \text{ J/K}$$

$$J_D = -D \nabla c \quad \text{Fick's law}$$

diffusion coefficient  $\uparrow$  (gradient concentration)

\* DLVO theory : Van der Waals & double layer forces acting together

Van der Waals attraction  $\propto -\frac{1}{D^n}$



Ash particles with current situation : decrease in pH or increasing salt conc. helps to get surfaces energy in a primary minimum

(not dependent bulk force)

Short distant interaction forces

solvation forces, DLVO forces, & Van der Waals forces



19<sup>th</sup> May 2012 Saturday

worked on the low force Sandpacks conditions (there is something wrong in these data sets: ~~Calculation~~ application of total velocity to  $\rho L T$  is wrong)

20<sup>th</sup> May 2012 Sunday

- Worked Pressure gradient vs total velocity plot
- Worked on S.T. & EC for Beutheimer case
- make notes on zeta potential
- In total made changes in the PPT

21<sup>st</sup> May 2012 Monday

- Preparation for ~~tomorrow~~ tomorrow 10:00
- Problem with stomach 13:00 - 15:00
- Preparation of presentation 15:00 - 18:30

22<sup>nd</sup> May 2012 Tuesday Talk

- Preparation of the power point 10:00 - 12:00
- Presentation 12:00 - 14:00
- Jürgen Köpf 15:00
- Correction in the foam flow experiment 2012
- Hockey 17:00 →

23<sup>rd</sup> May 2012 Wednesday

Correction in the graphs: Morning  
Samples from prof. Krastev: → 0.05 g/ml

|        |                                           |                            |        |
|--------|-------------------------------------------|----------------------------|--------|
| pH 3   | Concentration: → <del>12.5 g/250 ml</del> | March 2012                 | 250 ml |
| pH 11  | conc. 0.025 g/ml                          | 27 July 2011               | 30 ml  |
| pH 7   | conc. 0.025 g/ml                          | 27 <sup>th</sup> July 2011 | 100 ml |
| pH 7.5 | conc. 0.025 g/ml                          | 10 <sup>th</sup> July 2011 | 100 ml |

PEI Stabilizer

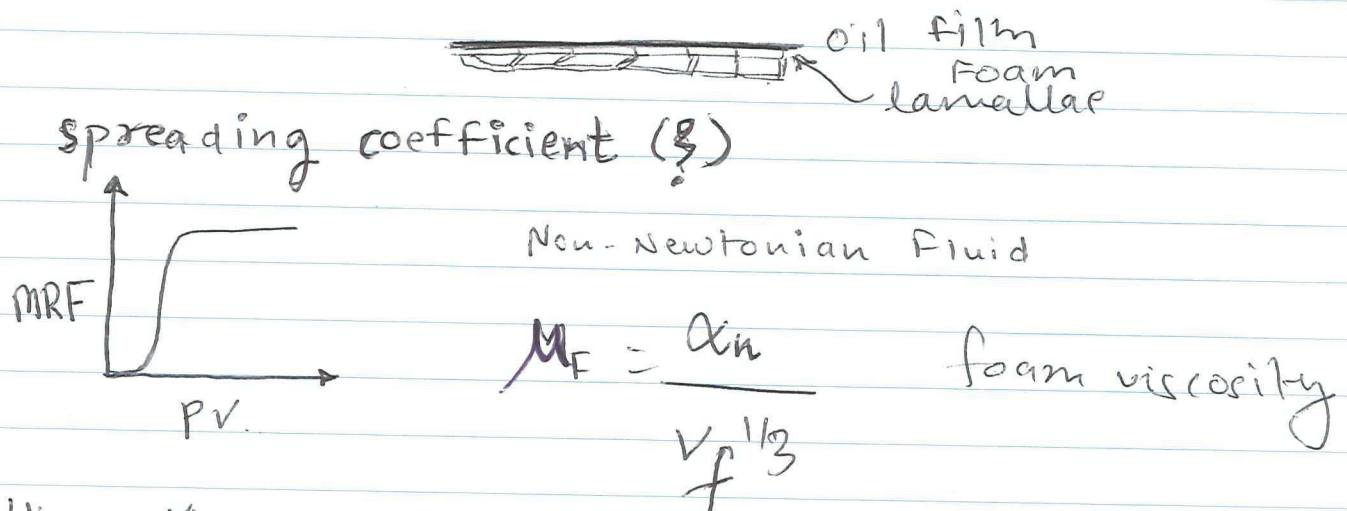


24<sup>th</sup> May 2012 Thursday

9:00 Talk by M. Simjoo : Immiscible foam for Enhancing Oil Recovery

Bulk foam study experiment  
Ostwald ripening :  $\rightarrow$  size :  $\rightarrow$  smaller bubbles will diffuse into larger bubbles

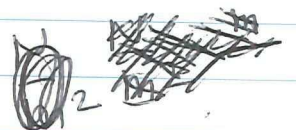
oil - thin film interaction



Hirasaki Model

Dimensional Analysis

$$\frac{NS}{m^2}$$



14:00 working excel sheet of all the foam experiments

15:00 ~~break~~ coffee with Torjen

16:00 printing ~~some~~ the summary of foam expt ~~graphs~~

Points to be discussed with Hams

1. pH 3 expt
2. Summary of foam expt
3. ~~New set up~~ of The experiments with affluents
4. possible writing of conference paper

① Continuous is a big issue  
(Electrical conductivity meter)

② Karel Heller : → 1902

③ fraction collector : →

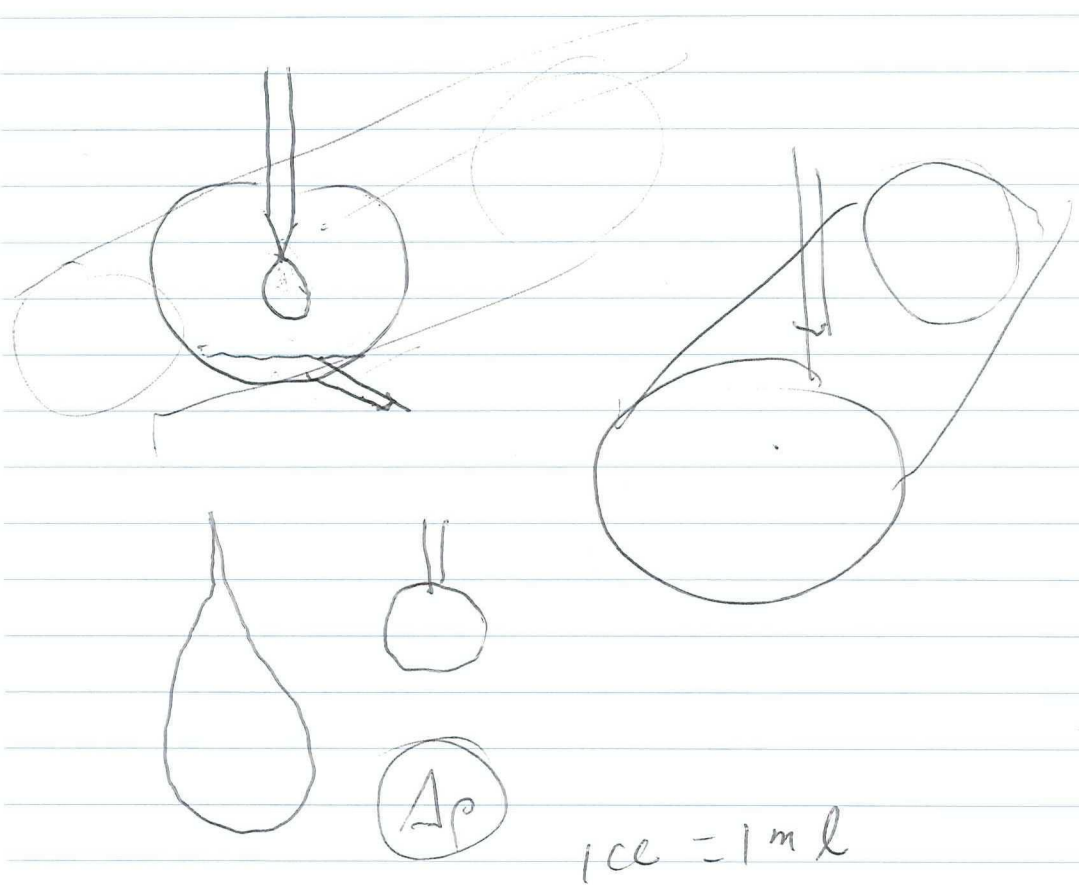
④ ~~Segregate~~ ④ Segregation  
⑤

Abbas →

Talk to Suzanne Kortland @about

(electrical conductivity meter)

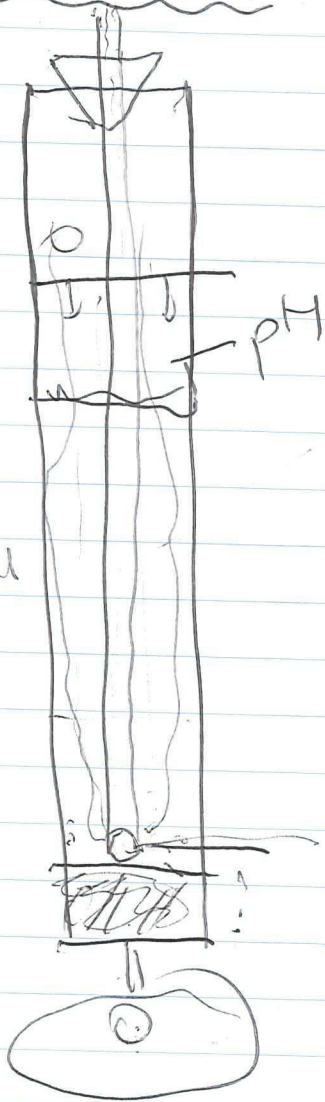
continuous  
surface tension measurements : →



2g/ice 2g/ml 0.04 g/ml → 2%.

1.002  
1.002502

photo multiplier ?



Experimental set up

$$\omega^4$$

$$6\pi\eta r v = \frac{4\pi}{3} r^3 \rho g$$

$$v = \frac{2}{9} \frac{r^2 \rho g}{\eta}$$

$$r = 1 \mu m$$

$$\frac{2 \cdot 10^{-12} \times 1000 \times 10}{9 \cdot 10^{-3}}$$

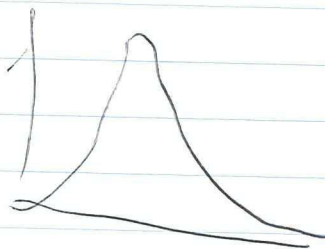
$$\frac{2 \cdot 10^{-5} m}{9}$$

$$\sim 3 \times 10^{-6} m/s$$

$$3 \times 10^{-6} cm/s$$

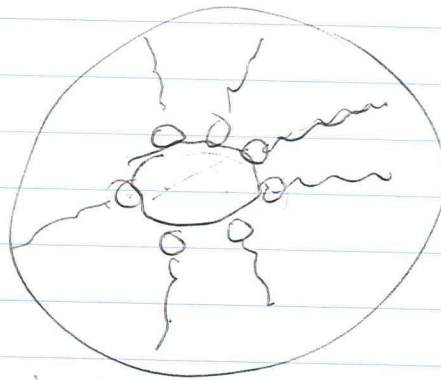
$$3 \times 10^{-10} cm/s$$

$$u = \frac{k}{\mu} \delta p g$$



NH3

E



Hesselin-k



Refractometer index : →

Fraction collector : → Indian guy



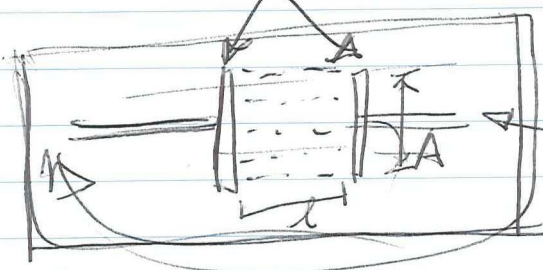
\* Monte Carlo approximation : →

25<sup>th</sup> May 2012

Friday

meeting with Monique Drijver 9:30 - 10:30

Gold plated electrodes



Talk with  
Karel Heller

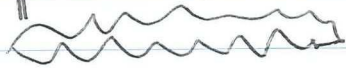
Wires

(AC)

$$R = \frac{l}{A}$$

Meeting with Hans & Rouhi about experiments

~~PH~~ pH 1 to 12



① pH 3 → pH = 5.8 →

② pH 1

③ pH 2

④ pH 12

(0.04 w/w %)

In small bottles →  
centrifuge  
&

then  
Refractive Index



At what pH particles are optimal

Alma: // Refractometer

Tuesday 29th May 2012

① Refractometer : → Discussed with Yolanda about the use of refractometer, In essence you need to put the sample (druppel: drop) in the cavity of refractometer & note down the temp before hand of your sample. Refractive index goes to four decimal.

Measurement

~~pH of 3~~ pH 3: → solution is actually 11.26 pH  
all at 20°C measurement

March pH 3 solution ~~actual~~ : 11.26

27.7.2011 pH 11 soln 10:49

27.7.2011 pH 7 soln 10:40 53

March 2012 pH 11 soln 11:47

Pilot check of up of Inlet AOS 2nd May : 14:00  
1.3314 Temp ~~22.9~~ 22.9°C uvr

should check double distilled water first : →  
then with AOS & Ash particle compositions  
(centrifuged or not centrifuged)

or  
② Designed experiments } Change pH of sample &  
measure the refractive index  
of each sample  
(centrifuge?)

How the refractometer can be used  
for checking effect of Ash particles  
checked with Electro. conductivity meter with Karel

(?)  
Mitigation of liquefaction of saturated sand  
using biogas - Jiam Chu

Bacteria produced gas : →



Wednesday 30th May 2012

Refractive Index : —

10:30 March 2012 soln pH 11.26 Temp 23°C

tried to measure the refractive index: very hazy  
Cannot distinguish between light & dark regions  
which is ~~poor~~ must for measurement

do  
Should <sup>do</sup> the experiment with variable pH

The idea is to take the sample in small  
beaker (0.04 %) & try to see how <sup>can</sup> these  
particles ~~could~~ form ~~the~~ colloidal formations?

Refractive Index of AOS outlet @ 2nd May  
1.3311 Temp 22.5°C

Try to find the plastic small tubes & centrifuge

Ash only inlet 1.3295 (Bit Hazy)  
30th March

Thursday 31st May 2012

\* Talked to Hams ~~for~~ the evening

Refractive Index before Centrifugation  
Refractive Index after Centrifugation

Measuring inlet of 5th permeability 26th April  
1.3309 1.3311 1.33105 Temp 22.5°C

Inlet of 2nd permeability 29th March  
1.3312, 1.3313, 1.3314 Temp 23°C  
(AOS)

Inlet of 1st foam ext 26th March Temp 23°C  
1.3314, 1.3314, 1.3312

Outlet of AOS-Ash mix ~~26th April~~ 5th April Temp 23°C

1.3312, 1.3310, 1.3310



outlet of AOS-Ash mix 26<sup>th</sup> April

~~1.331~~ 1.331, 1.331, 1.3314

Friday 1<sup>st</sup> June 2012

Points for the meeting with Hans & Rouhi

\* Design of experiments with PHS

\* Change the dates in document which we discussed last week & present it to H&R

\* Refractive Index  $\left[ \begin{array}{l} \text{without & with particles} \\ \text{No } \text{ } \text{change in} \\ \text{Refractive index} \end{array} \right.$

centrifugation after discussing these results

Van 't Hoff's law : relationship between osmotic pressure to the mass concentration  $c$  of dispersed material by

$$\frac{\pi}{RT} = \frac{c}{M} (1 + B_2 c + \dots)$$

Molar mass  $M = N_A M_p$   $\leftarrow$  Particle mass

$\uparrow$  Avagadro's number  $6.0 \times 10^{23}$

$$B_2 = 4 \frac{V_p}{M_p}$$

3 nm particle would after a second diffuse to a distance of approximately 20  $\mu\text{m}$  (700x of its size!)

$$\Delta r \approx \sqrt{6D\Delta t} \quad D = \frac{k_B T}{f}$$

$f = 6\pi\eta a$   $\leftarrow$  radius of particles

$\uparrow$  (viscosity of liquid)  
 $\uparrow$  Height

Sedimentation eqn'  $c(z) = c(z_0) \exp \left\{ - \frac{g V_p \Delta \rho}{k_B T} (z - z_0) \right\}$

$\uparrow$  Conc.  $\uparrow$  Particle V.  $\uparrow$  Density diff  $\uparrow$  Temp  $\uparrow$  Boltzmann's Con.

Standard visible light spectrometer

Transmission factor  $T = \exp \{ -(K + \tau) d \}$  Absorption factor  
 For not too dense systems  $\tau = cS$   $\uparrow$   $\uparrow$  turbidity length of optical path

Scattering cross section  $S \propto \left[ \frac{n^2 - 1}{n^2 + 2} \right]^2 V_p^2$   
 (for small & dense particles)

for larger particles  $S \propto$  complex function of wavelength, scattering angle, refractive index, & particle size (Mie theory)

$$S \propto \phi V_p = \phi a^3$$

(Turbidity of the colloidal suspension of given volume fraction is directly proportional to the product of volume fraction & particle vol hence to particle size cubed.)

② Particle velocity meter

① old fashioned spectrometer  $\uparrow$  Photo

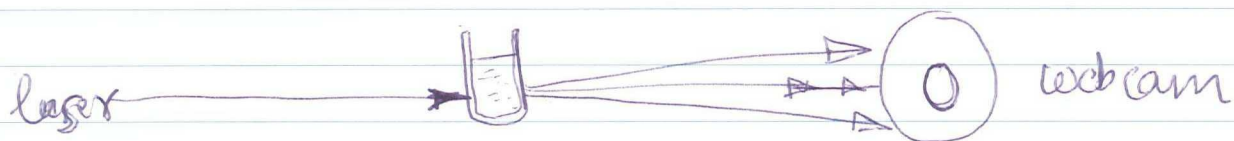
③ ~~Silicon~~ Infrared camera

④ Water

⑤ Check the particle stability

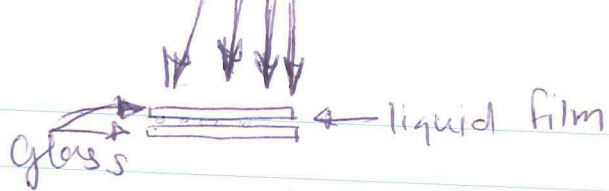
⑥ Particle counter :  $\rightarrow$

~~HEL~~ HELDS  $\rightarrow$  Laser diffraction unit




Check with hydrology





I send the particle analyzer result to Hans & Roohi (Abbas) Malvern

- ① Particle size check Boost - Konst. Heinz
- ② ~~Particle~~ Particle size distribution (pH 1-12)
- ③ Particle size distribution with diff pH
- ④ Hydrology people: → Scattering
- ⑤ ~~Malvern apparatus (pH 1-12)~~
- ⑥ check ~~around~~ in the basement about the apparatus

 to find appropriate range of particles

Monday 4<sup>th</sup> June 2012

~~Designing~~ Designing the experiments for different pH 1-12 using Abbas's set up

We already have pH 11 solution  
 (Hopefully, Abbas's ~~apparatus~~ instrument still works, check with Sanjay)

Making of 0.04 w/w% soln from 0.05 g/ml ash disper from earlier pages

6.4 ml of Krastev's solution & 793.6 ml of DD (pH 3) to make 0.04 w/w% of ash solution (800 ml)

3.2 ml of Krastev's solution (pH 11) & 396.8 ml of DD (pH 11) to make 0.04 w/w% of ash solution (400 ml)

Put 10 bottles to make 40<sup>ml</sup> samples each

In order to make pH 11 solution we need to make ~~solutions~~ soln of sodium phosphate dibasic dihydrate & Citric acid monohydrate

|                                                                              |                                                                                               |
|------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|
| $\text{C}_6\text{H}_8\text{O}_7 \cdot \text{H}_2\text{O}$<br>MW/ 210.14 g/ml | $\downarrow$<br>$\text{HNa}_2\text{O}_4 \text{P} \cdot 2\text{H}_2\text{O}$<br>MW 177.99 g/ml |
|------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|



Tuesday 5th June 2012

Wednesday 6th June 2012

10:00 Writing Refractive index info

11:30 Talked to Soost about the preparation of slides. He pointed out that ~~he is~~ it would be done with Hua set up by Dick & technicians downstairs ~~would do the~~ help to prepare slides

3:30 Preparation of pH samples for further investigation

~~Take~~ 6.4 ml of Krastev's sol<sup>n</sup> → 79.36 of DD

0.64 ml of ~~the~~ → 79.36 of DD  
1 ml of pH ~~(11)~~ → 124 ml of DD (pH 11)

Let us add 124 ml of DD (pH 7) & 1 ml of pH (11) to see what pH we get

Reality: → 0.5 ml of Krastev's sol<sup>n</sup> (pH 11)  
~~52~~ ml of DD water (pH 6-7)

0.04 w/w%. 9.09 at 20°C

R.I.

1.3311, 1.33105, 1.3311

at 24.9°C

Thursday 7<sup>th</sup> June 2012 89 ml x ml

9:30 Preparation of pH sample for further investigation

1 ml of Prof. Kraster's soln & 124 ml of DD water  
= 125 ml 0.04 w/w %

35 ml was thrown away (too much in too ~~little~~ small bottle) so 89 ml of soln left

pH = ~~9.20~~ 9.30

Added 1.2 ml ~~8.0~~ 0.1 M HCl to make pH 2.88

Ask Hans if we can use different pH dispersions for Zeta potential testing.

1.33125, 1.3307, 1.3307 at 22°C

12:00

0.64 ml of Kraster's soln & 79 ml of DD water

pH = 9.48  $\xrightarrow{0.1 \text{ ml } 0.1 \text{ M HCl}}$

4.62 pH

1.3307, 1.3307, 1.3307

at 22.5°C

16:00 79.60 ml of DD & 0.70 ml of Kraster's soln

Added 10 ml of 0.1 M HCl to get 1.95 pH

1.3312, 1.3311, 1.3311

temp 25°C

16:30 To make pH 11

77 ml DD + 1.5 ml 0.1 M NaOH = 78.5 ml  
(pH 5.63) 11.04 pH

78.5 + 0.62 ml Kraster = 79.12

11.0

11.26

pH 11.19

1.3311 1.3311 1.3310

temp 25°C



Friday 8<sup>th</sup> June 2012

10-11 Refractive Indexes of previous samples

11:30 Checked particle size analyzer, still cannot login

Meeting with Hans

Points

Samples are ready

- ① Different pH <sup>not much</sup> R.I. change
- ② Could not open the PSA computer / did not check with technician's
- ③ Checked with a friend there is a potentiometer analyzer ~~and~~ with Ger Koper.
- ④ Conference next week: →

⑤ Density changes: →

Monday 11<sup>th</sup> June 2012

with

AOS<sup>A</sup> Do the same pH testing

3.2 ml of Kraster's soln & 397.8 ml water  
for 0.04 w/w%. but we need

6.4 ml of Kraster's soln & 397.8 ml water  
for 0.08 w/w%. (check pH)

Then ~~100 ml of 0.3 w/w% & 350 ml of~~  
50 ml of 0.3 w/w% & 50 ml DD  
= 100 ml 0.15 w/w% AOS  
100 + 100 ml DD = 200 ml of 0.075 w/w%.

100 ml of 0.3 w/w% AOS & 100 ml water  
= 200 ml of 0.15 w/w% AOS  
200 + 200 ml of DD = 400 ml of 0.075

So

100 ml of 0.3 w/w% AOS & 300 ml of  
DD water = 400 ml of 0.075 w/w% soln



Not very much point in preparing ~~exp~~ solutions today as next three days I will be in conference. Important is to make a plan & check what can you with the things.

12<sup>th</sup> June 2012 Tuesday

1<sup>st</sup> Talk John Villo

M. K. Choudhary Nature 2003  
(EOR)

Static structural disjoining pressure

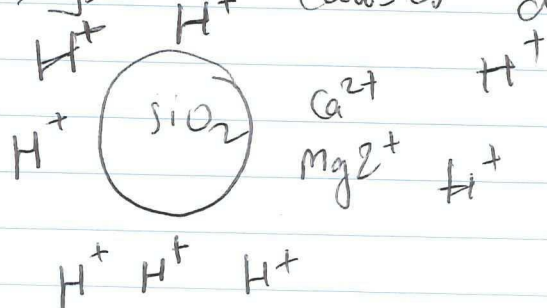
Can you tell something about stability of partic  
~~How is in water stability~~ & oil ~~stability~~ ~~for surface~~  
~~the same particles~~ ? Do you have to ~~change~~  
the properties to maintain the stability?  
nanoparticles in drilling fluids

For silica :- Acidic pH

$Mg^{2+}$  more stabilising than  $Ca^{2+}$

- Ionic strength of water
- Charge density
- Temp. effect

What maintains Inter-colloidal stability in static system  $H^+$  causes disruption in flowing



- Hydrogen ion shield

(Talk to Hans on Thursday about the papers  
on Thursday)

What was the % of silica you used? & Do you see the effect?

@ pH 3 & pH 10

silane: water insoluble  
(functional group)  
formation damage & EOR

Wednesday 13<sup>th</sup> June 2012

9:30 Conference;

11:00 Magnetic particle fluid  
ferromagnetic NPs



Rosenweig equation :- specific loss power

12:10 SiO<sub>2</sub> nanoparticles

- ① sedimentation stability
- ② thermal stress strain & rheology properties
- ③ Interfacial tension & wettability

~~Main~~ Main focus

Stability & Surface tension

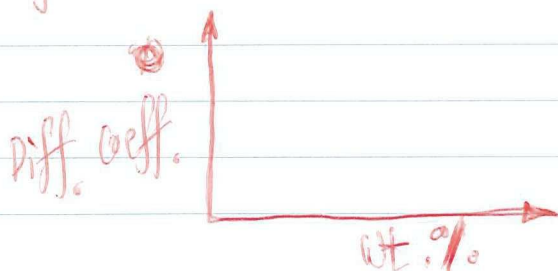
Molecular Dynamics

Combined modeling & experimental studies of  
hydroxylated silica nanoparticles

Habenicht J. of Phy. Chem. B 115, 2011

Is Young-Laplace valid at nanoscale

Charge distribution around the nanoparticles



Mirandola  
J. of chem.  
phy (2012)



(Bit problem with AOS in practical appln)

Contact angle / Interfacial tension

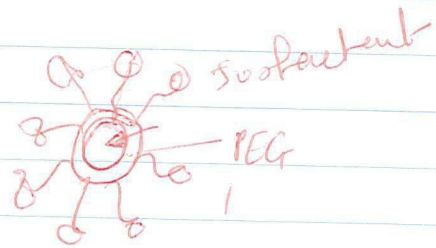
Did you check about the stability of system over time?

Try to find the stability (~~stabilisation~~ Sedimentation equations) for theoretical work.

check the permeability results in our case 4:00

PMA  
PEG  
PEI

Polymers used  
to coat  
nano particles



improved oil recovery Symposium Oklahoma 2010

Hydrodynamic dispersion Coefficient

Dispersion - Advection - Adsorption

Roadmap

- ① Column Expt with simulation
- ② DLS - stability
- ③ QCM - DZ
- ④ AFM - Adsorption

Most people are doing with managing of interface of nanoparticle - Solution.

Mechanical strain  $\rightleftharpoons$  Electric Field

High ionic strength  $\rightarrow$  shrinking of electrostatic layer around particles  $\rightarrow$  shrinking of electrostatic repulsion  $\rightarrow$  agglomeration

Why do this does not appear in low concentration Analysis of nMag



You use buffers for maintaining pH. Don't the particles <sup>surface</sup> would ~~change~~ react. And how do we see the practicality of it?

### Fines Migration

What was the purpose of ~~conducting~~ <sup>using</sup> different salinity in same experiment.

Distilled water is not good for recovery // Slide 9

// Most results in the conference are with brine, Nobody seems to be using distilled water //

Step up the flow rates gradually to avoid fines migration.

Best NP dispersing fluid is brine.

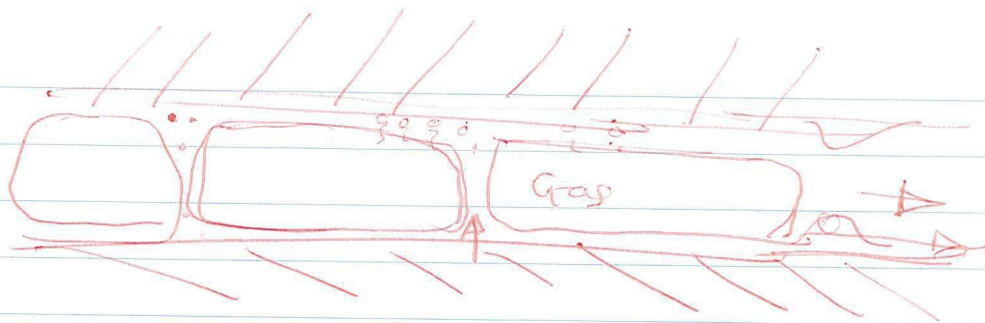
Modeling & Simulation of nanoparticles  
Transport in a two-phase flow in porous media  
A. Salama

- ① Relative permeability
- ② London-Van der Waals
- ③ Electrostatic
- ④ Hydrodynamic forces

Variation of ~~permeability~~ porosity, permeability & relative permeability.

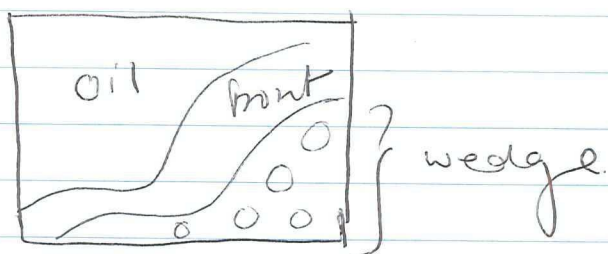
He did not consider: dispersion only diffusion  
wettability considerations are not ~~and~~ somewhat hazy.

Used level-set method  
moving line problem



Thursday 14<sup>th</sup> June 2012

9:30



frac tech NPD solutions

fluid Design & Properties : →

- ① stability of colloids ; surfactant combination
- ② particle surface modification

- Imbibition & core floods

Did you check particles upstream & downstream conditions ? Any quantitative studies ?

10:30

TNO talk : →

sensor vs traces

SRN.Kapoorchan@gmail.com - Shantie

16:00

SYMPA

17:00

Talk about the report : →

zeta potential

Steven Huynh

Took pictures of feras's laser

③ Electrical conductivity Instrument with Karel

④

## meeting with Hans

1. Laser
2. Electrical conductivity
3. Zeta Potential : Steven ~~the~~ Huynink
4. Shell Report
- 5.

Send email to Abbas & Fera2

Jager W.F. UV-vis Spectrometer

Use webcam to  
graph light intensity

intensity change

How to measure

with a ~~laser~~ ~~classer~~ laser pointer : choose

Friday 15th

- ① Karl-Heinz for laser
- ② Contact Jager & Steven
- ③ Buy laser pointer / webcam

F.A.H. Abdullwani

Spectrophotometer

① UV-vis, wavelength, transmission, reflection, UV  
Spectrophotometry 015 27 82626

② 10 am to 6 pm

Monday  
Tuesday

0.320



Monday 18<sup>th</sup> June 2012

9:00 talked to Yolanda about ~~the~~ table

10:30 Preparation of AOS sample / Talked with Arno, ~~Hea~~ Yolanda,

11:30 400 ml of 0.075 w/w% AOS  
pH ~~6.53~~ 6.53

~~12:05~~ 12:05 400 ml of 0.08 w/w% Ash  
pH 9.83

40 ml of each sample.

① 80 ml total 9.36  
② 79 ml total pH  $+ (1 \text{ ml})$  0.1M HCl  $\rightarrow$  80 ml 2.92 pH  
(9.39)

Observation: If you add the ~~part~~ 0.1M HCl in  
a 9 pH solution to make it 3 pH, you  
can literally see particle co-agulating.  
This is because particles are ~~first~~ stabilised  
at pH 11 ~~firsthand~~.

③ 79 ml total pH  $+ 0.2 \text{ ml HCl} \rightarrow$  80 ml  
(9.29) 4.12 pH

④ 79 ml total pH (9.20)  $+ 1 \text{ ml } 0.1 \text{ M NaOH} \rightarrow$  80 ml  
11.05 pH

4:00 Working of ~~photo~~ spectrophotometer

1. Rinse cuvette with Ethanol, dry with air

UVprobe 233  $\rightarrow$  connect  $\rightarrow$  make a baseline  
(baseline press) (without anything  
inside)

Edit → method → wavelength, speed

After doing the baseline

Fill one cuvette with base water & other one with your sample

Try care in putting the sample  
(do not touch the clear part of the cuvette, light will be passing through it).

Print wavelength vs Absorbance  
Select the column

~~8-10~~ 8-10

~~0663~~ 0634419482  
Roman

~~Thurs~~

~~Wedn~~

Tuesday 19<sup>th</sup> June 2012

1000 nm - 200 nm

| 1. Ash samples in Ultrasonic | For 30 min                      |
|------------------------------|---------------------------------|
| Sample pH                    | File_time <del>Time</del>       |
| 1. Ash <del>0.82</del> 2-82  | 120619_104236<br>104909<br>1056 |
| 2. Ash 4.62                  | 1102<br>1106<br>111             |
| 3. Ash 9.09                  | 1117<br>1121<br>1127            |
| 4. Ash 11.19                 | 1134<br>1138<br>1143            |

pH

Time (file name)

5. AOS-Ash 2.92

1253

1258

1302

6. AOS-Ash 4.12

1308

1312

1317

7. AOS-Ash 9.0g

1325

1329

1333

8. AOS-Ash 11.05

1340

1345

1349

Data processing 15:30 - 17:30

Turbidity Formula from Overbeek

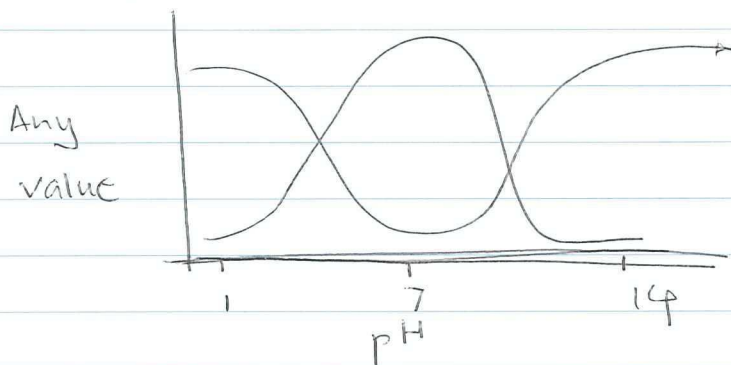
Send mail to Feraz about the setup (key)

Wednesday 20<sup>th</sup> June 2012 Particle size check at chem  
tech

Thursday 21<sup>st</sup> June 2012

9 to 12 Zeta potential measurement

Analysis 13-15:



Could not find keys to the laser 17:30

Could not find Karel 15:30

Talk to Joost & Gert (he has 50 mW laser pen at home)

Writing mail to Karel about keys 15:30



Ethanol has been used in most cases of silica testing.

To calculate rates of sedimentation use

Lesson 14: Particle size determination. Optics in Overbeek part 2 Lyophobic colloids

$$v = \frac{2}{9} a^2 \frac{(\rho_{\text{particle}} - \rho_{\text{liq}}) g'}{\eta}$$

$\rho$ : densities  $\cdot a$  = radius of spherical particle  
 $g' = g$  for regular gravity  
 $= \omega^2 r$  for centrifugation with  
 $\eta$  = viscosity of the liquid

Check with Krishna Kowgi about UV vs spectrophotometer

$$\frac{dI}{dx} = -kI$$

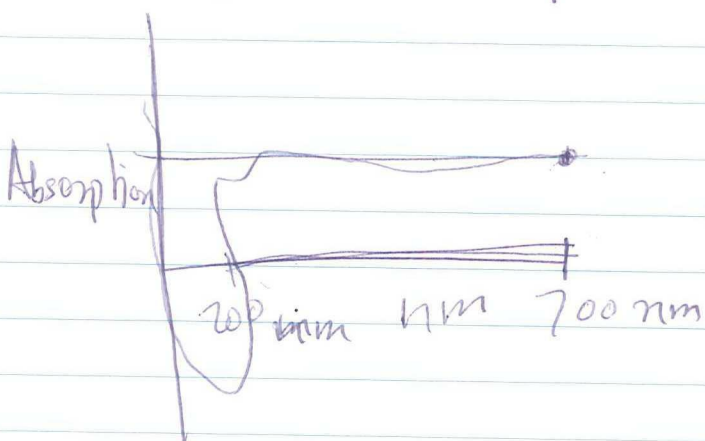
$$\frac{d \ln I}{dx} = -k$$

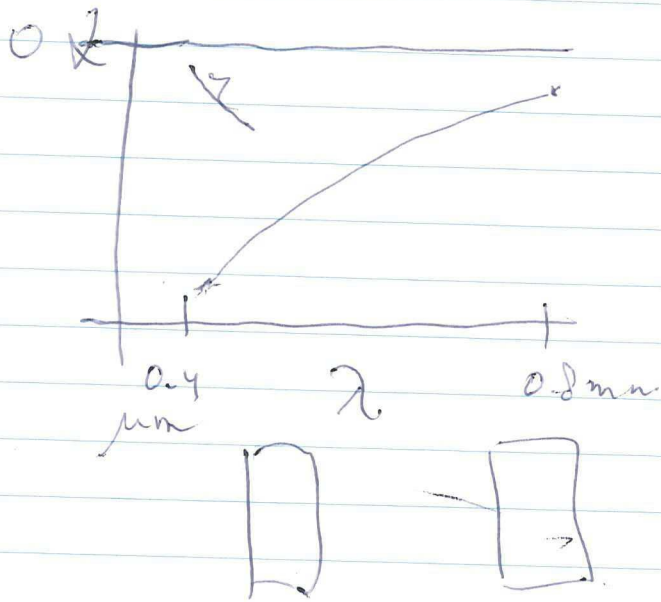
$$\ln \frac{I}{I_0} = -kx$$

transmittance

$\alpha_c c$   $\rightarrow 0.2$   
 $\rightarrow 0.04$   
 $\rightarrow 1 \text{ cm}$

uv 1800 PDF

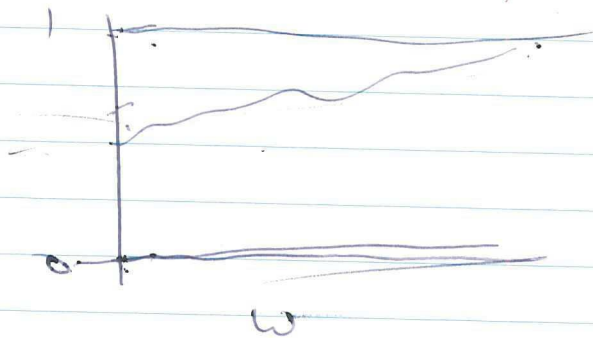




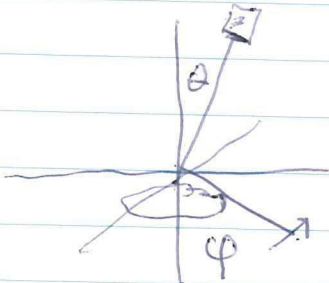
$$\ln \frac{\bar{I}_0}{I_0} = 0$$

$$\alpha \sim \omega^4$$

$$I/I_0$$

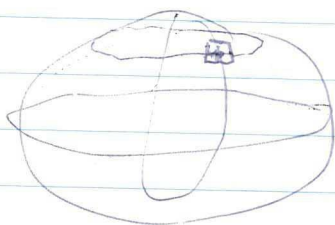


$$\bar{I} = I_0 - \bar{I}_{scat} = I_0 \left( 1 - \frac{\bar{I}_{scat}}{I_0} \right)$$



check  $\frac{I_s}{I_0}$

$$= \frac{2\pi^2 n^2 (1 + \cos^2 \theta) \left( \frac{dn}{dc} \right)^2}{N_{AV} \lambda_{vac}^4} \quad \text{QM}$$



$$r \sin \theta \, d\theta \, d\varphi \, dr$$

$$4\pi r^2$$

$$\ln(1-x)$$

$$\int (1 + \cos^2 \theta) \sin \theta \, d\theta \, d\varphi$$

$$x \sim x$$

$$\frac{n_{mix}^2 - 1}{n_{mix}^2 + 2} = v_1 \frac{n_1^2 - 1}{n_1^2 + 2} + (1 - v_1) \frac{n_2^2 - 1}{n_2^2 + 2}$$

photo multiplier & I go with some samples  
& check ① & ②

~~Was~~ Friday 22<sup>nd</sup> June 2012

(Sample put after 15 minutes of ultrasonic)

With Krishna's ~~set up~~ Kuvett's did some tests after failing with previous cases.

Did full range (190-1100) <sup>43 times</sup> & 10 min gap after each test

Ash - 2.82 pH

13:13

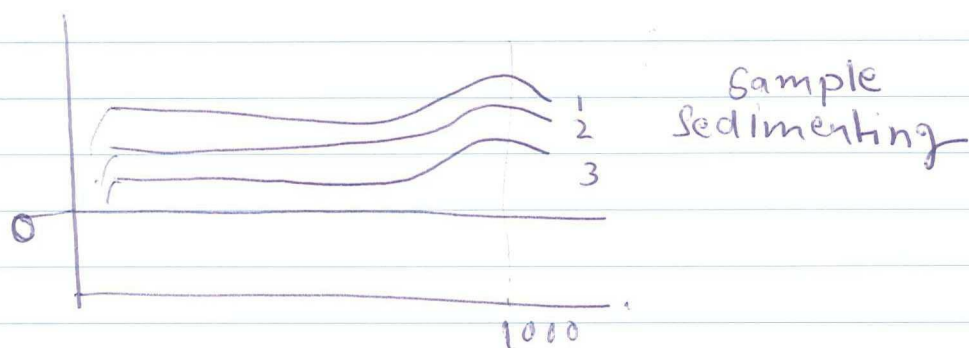
Mix - 2.82 pH

13:42

Ash - 4.62 pH

14:12

Slot is booked for Monday 9-14 hrs.



0 Saturday 23<sup>rd</sup> June 2012  
Preparation of ~~the~~ notes from HELOS



Sund

Monday 25<sup>th</sup> June 2012

Preparation of pH samples: →

Take ~~75 ml~~ 70 samples (4) & ~~ph~~ prepare  
pH 2.82, 4.50, 9.09, & 11.05

pH of double distilled water 5.72

① 76.4 ml of DD water + 1.4 ml 0.1 HCl = 78 ml of  
~~ph~~ 4 2.84 pH

② 76.4 ml of DD + 0.5 ml 0.1 HCl = 77 ml of  
4 ~ 3.93 pH

③ 76.4 ml of DD + 1.5 ml 0.1 NaOH = 78 ml of  
11.26 pH

④ 76.5 ml of DD + 0.2 ml 0.1 NaOH = 77 ml of  
9.75 pH

(Result with pH as reference resulted into negative  
20 minute shaking before ~~each~~ first test spectrum)

| Sample                                                                   | Time Start | Measure | Time duration (sec) |
|--------------------------------------------------------------------------|------------|---------|---------------------|
| Ash - 2.82 pH                                                            | 11:14      | 3       | 1200 -ve sp         |
| Ash - 4.62 pH                                                            | 12:22      | 3       | 1200 -ve sp         |
| Ash - 9.09 pH                                                            | 13:35      | 3       | 1200 -ve sp         |
| *Ash - 9.09 pH                                                           | 14:02      | 3       | 1200 first          |
| (Started using milipore water as <del>reference</del> positive spectrum) |            |         |                     |

\*Ash - 9.09 pH 14:28

|                 |       |   |               |
|-----------------|-------|---|---------------|
| *Ash - 11.05 pH | 15:19 | 3 | 1200 Positive |
| *Ash - 4.62 pH  | 16:07 | 3 | 1200 +ve      |
| *Ash - 2.82 pH  | 16:55 | 3 | 1200 +ve      |

Starting

(Turbidity value should be same for each sample)

Turbidity seems high in 4.62 & 2.82 as % of  
particles is high as compared to 9.09 & 11.01

Tuesday 26<sup>th</sup> June 2012

| Testing        | NOS-Ash mix | samples | (20 minutes (chucking)) |
|----------------|-------------|---------|-------------------------|
|                | start       | measure | duration weighing       |
| Mix - 2.82 pH  | 9:14        | 3       | 1200 sec                |
| mix - 4.12 pH  | 10:02       | 3       | 1200 sec                |
| mix - 9.36 pH  | 10:53       | 3       | 1200 sec                |
| mix - 11.09 pH | 11:39       | 3       | 1200 sec                |

Someone 9.36 pH sample has less particles,  
you also see that there is some agglomeration  
at in the base.

(Just wash the ~~sample~~ <sup>cuvette</sup> bit better)  
next time

cuvette 10 x 10 x 35  
Analysis of the expt 15 - 17:30  
✓ Wednesday 27<sup>th</sup> June 2012

Analysis of the expt 9 to 11

Thursday 28<sup>th</sup> June 2012

9:40 11 Saskia's talk

11:40 12:30 Talk with Hans, Joost, Gans, Karl-Heinz

13

15:00 Searching for cuvette

18:30 ~~Go~~ Supper with Jurjen

Friday 29th June 2012

~~6:30~~

Mails to Jolanda & Ellen 11:30

Robert B.Sc. Thesis 13:00 - 14:00

\* Fractional flow theory / Theoretical studies

Strong Foam vs Weak Foam

(Gravity over side) :  $\rightarrow$

Embedding in a MS Excel spreadsheet &  
using Euler method

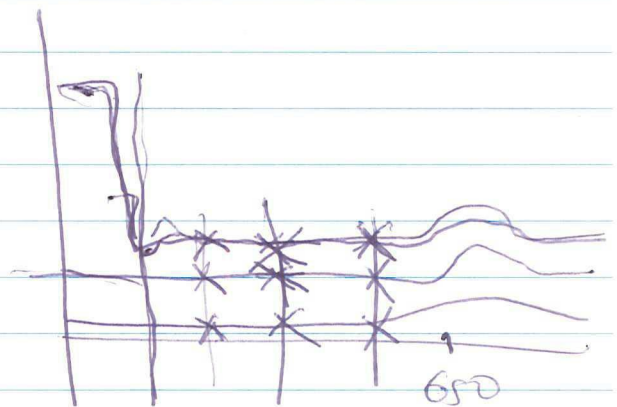
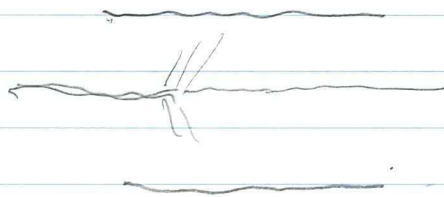
Meeting with Hans 15:00

101 Micro cells with PTFE

10 x 10 mm

101057-Q5 Code

Turbidity equation



$$\ln \frac{I_0}{I} = \alpha n$$

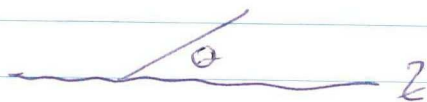
$$\alpha \sim \frac{1}{\lambda^4}$$

wavelength



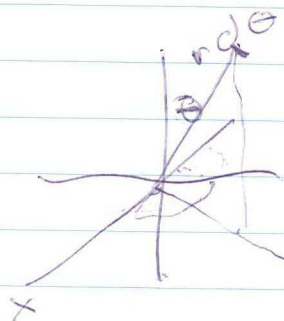
$$I = I_0 \frac{1 + \cos^2 \theta}{2R^2} \left( \frac{2\pi}{\lambda} \right)^4 \left( \frac{n^2 - 1}{n^2 + 2} \right)^2 \left( \frac{d}{2} \right)^2$$

$$I = I_0 \propto \frac{1 + \cos^2 \theta}{R^2}$$



Rayleigh Scattering

[Wikipedia]



$$\int_0^\pi \int_0^\pi R \sin \theta \sin \phi R \cos \theta d\theta d\phi$$

$$\frac{I \propto R^2}{R^2} \int_0^\pi \int_0^\pi \sin \theta \sin \phi \cos \theta (1 + \cos^2 \theta) d\theta d\phi$$

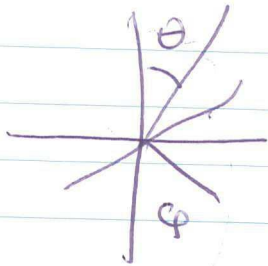
$$2\pi I_0 \propto \int_0^\pi \int_0^\pi \sin \theta \cos \theta (1 + \cos^2 \theta) d\cos \theta$$

$$2\pi I_0 \propto \left. \pi (1 + \cos^2 \theta) \right|_0^\pi$$

$$\left( \frac{1}{2} x^2 + \frac{1}{4} x^4 \right) \Big|_0^\pi \approx \frac{3}{4}$$

$$I = I_0 \frac{3}{4}$$

$$\int_0^{2\pi} \int_0^{\pi/2} I_0 \propto (1 + \cos^2 \theta) \sin \theta d\theta d\phi$$

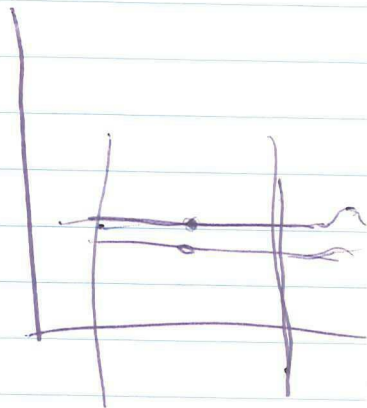


$$\sin \theta \rightarrow \cos \theta.$$

$$= -2\pi \int_{-1}^{+1} I_0 \propto (1 + \cos^2 \theta) d(\cos \theta).$$

$$= 2\pi I_0 \propto \int_{-1}^{+1} (1 + x^2) dx.$$

$$2\pi I_0 \propto \left[ x + \frac{1}{3} x^3 \right]_{-1}^{+1}$$



$$= \left( \left[ 1 + \frac{1}{3} \right] - \left[ -1 - \frac{1}{3} \right] \right) \cdot 2\pi I_0 \propto$$

$$= 2 + \frac{2}{3} = 2\frac{2}{3} = \frac{8}{3}$$

$$\frac{8}{3} \times 2\pi I_0 \propto$$

$$I = \frac{4I_0}{3} \left( \frac{2\pi}{\lambda} \right)^4 \left( \frac{n^2 - 1}{n^2 + 2} \right)^2 \left( \frac{d}{2} \right)^6 \cdot 2\pi$$

$$I = \frac{8\pi}{3} I_0 \left( \frac{2\pi}{\lambda} \right)^4 \left( \frac{n^2 - 1}{n^2 + 2} \right)^2 \left( \frac{d}{2} \right)^6$$

$$\frac{dI}{d\lambda} = \frac{d\pi}{3} \left( \frac{2\pi}{\lambda} \right)^4 \left( \frac{n^2 - 1}{n^2 + 2} \right)^2 \left( \frac{d}{2} \right)^6$$

16 July 2012 Monday  
Back from India

\* laser testing <sup>reacting from emails</sup> @ 7:30 in the morning

\* Hans is on vacation, could not find Guus & Joost.

Talked to Karel about EC

\* must ~~test~~ ~~work~~ work some strategy for next coming months

Thesis: Sanjay 1:30

Analysis of polymer injectivity in Porous Media

\* shear rate :  $\rightarrow$  rpm ?

damaged permeability ? Slide 22

$$\text{Shear rate} = C \times \text{shear rpm}^{\frac{1}{5}}$$

Water Injectivity Prediction: Experiments & Modelling  
decreased  
formation Damage  $\times$  Injectivity

Van der Waals forces  $\times$  Electrostatic Interaction forces  
(Electromagnetic interaction) ~~circle~~ <sup>Gustafin Formula</sup>

what is viscosity model? What is 2.5°C?

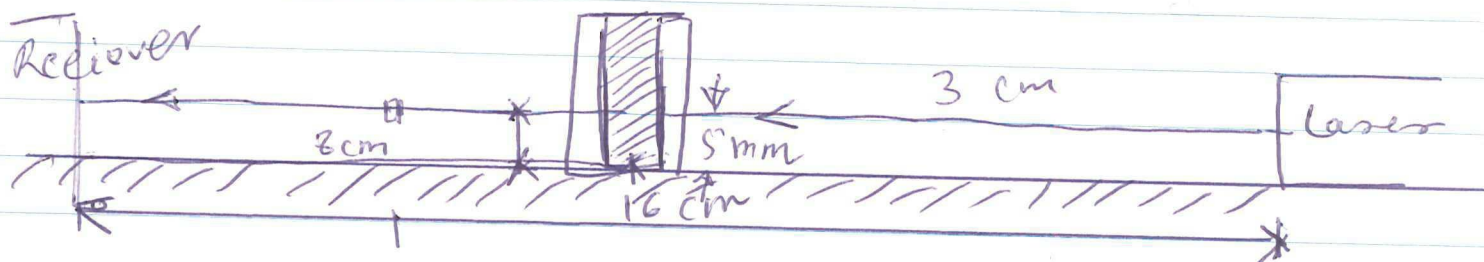
slight 12: Blocking of some pores?

particle concentration before & after the flowing through the core.



17<sup>th</sup> July Tuesday  
wuddinxween

18<sup>th</sup> July Wednesday



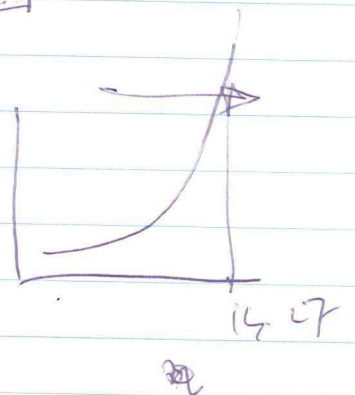
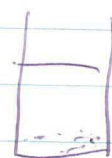
1) ~~Through~~ DP water

2) 11.26 pH 0.04 Ash  
After 10 min

14.27  
7.13  
13.04

11.26 pH 0.04 Ash

13.32 ← 0  
13.67 ← 5  
10  
15



19<sup>th</sup> July 1

- 1) Ultrasonicate
- 2) first reading immediately
- 3) ~~second reading after 20 minutes~~ reading every 5 min
- 4) till 30 minutes

\* Distance betn laser & specimen has to be checked

(Always check where the diffraction point is)

↓ High first & then lower & lower as time proceeds

Ash 0.04 pH 11.19 (fluctuation  $\pm 0.05$ )

min 0 5 10 15 20 25 30

reading 13.55 $\pm$  13.83 $\pm$  14.01 $\pm$  14.20 $\pm$  14.26 14.26  
Stable

Ash 0.04 pH 9.09 C1

min 0 5 10 15 20 25

reading 13.15 $\pm$  13.85 $\pm$  13.95 $\pm 0.05$  14.00 $\pm 0.07$  14.03 $\pm 0.02$  14.20 $\pm 0.05$   
top

Ash 0.04 pH 4.62

min 0 5 10 15 20

reading 10.90 $\pm 0.1$  11.25 $\pm 0.05$  11.55 $\pm 0.02$  11.79 $\pm 0.05$  12.05 $\pm 0.05$

Ash 0.06 pH 2.82

min 0 5 10 15 20

reading 12.05 $\pm 0.05$  12.15 $\pm 0.1$  12.48 $\pm 0.05$  12.58 $\pm 0.04$  12.79 $\pm 0.01$

Aos-Ash pH 2.92

min 0 5 10 15 20

reading 10.15 $\pm 0.03$  10.45 $\pm 0.01$  10.72 $\pm 0.02$  10.80 $\pm 0.01$  10.95 $\pm 0.05$

Aos-Ash pH 6.12

min 0 5 10 15

reading 11.40 $\pm 0.02$  11.75 $\pm 0.1$  11.96 $\pm 0.02$  12.33 $\pm 0.01$

Aos-Ash pH 9.36

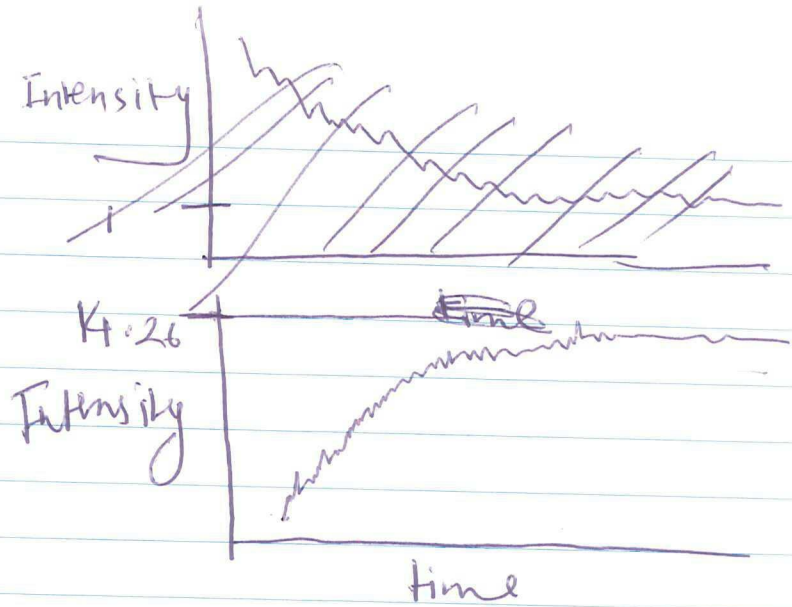
min 0 5 10 15

reading 12.85 $\pm$  12.97 $\pm 0.02$  12.94 $\pm 0.05$  13.00 $\pm 0.1$

Aos-Ash pH 11.09

min 0 5 10 15

reading 11.30 $\pm 0.04$  11.69 11.85 $\pm 0.04$  12.05 $\pm 0.02$



30  
14.26  
stable

|              |              |                  |               |       |       |
|--------------|--------------|------------------|---------------|-------|-------|
| 25           | 30           | <del>35</del> 35 | <del>40</del> | 40    | 105   |
| 12.30 ± 0.02 | 12.44 ± 0.04 | 12.60 ± 0.05     |               | 12.75 | 13.94 |

|              |       |              |    |
|--------------|-------|--------------|----|
| 25           | 30    | 40           | 60 |
| 12.91 ± 0.01 | 12.93 | 13.26 ± 0.02 |    |

|              |              |              |
|--------------|--------------|--------------|
| 25           | 30           | 40           |
| 11.12 ± 0.01 | 11.22 ± 0.02 | 11.28 ± 0.01 |

|              |              |               |              |       |
|--------------|--------------|---------------|--------------|-------|
| 20           | 25           | <del>29</del> | 30           | 40    |
| 12.47 ± 0.02 | 12.78 ± 0.02 |               | 12.80 ± 0.01 | 13.13 |

|              |              |              |              |
|--------------|--------------|--------------|--------------|
| 20           | 25           | 30           | 40           |
| 13.09 ± 0.03 | 13.20 ± 0.05 | 13.35 ± 0.05 | 13.57 ± 0.05 |

|              |              |              |       |
|--------------|--------------|--------------|-------|
| 20           | 25           | 30           | 40    |
| 12.10 ± 0.03 | 12.15 ± 0.04 | 12.10 ± 0.03 | 12.56 |



Friday 20<sup>th</sup> July 2012

\* Writing about the experiment

Monday 23<sup>rd</sup> July 2012

\* Writing about the experiments : the whole day

making a document about the travel in December - January.

Tuesday 24<sup>th</sup> July 2012

writing about the experiment : the whole day

Booked tickets to India : → 15<sup>th</sup> Dec 2012 →

Wednesday 25<sup>th</sup> July 2012

Morning writing email to Hans Joost,

(checking surface tension of few ~~experi~~  
Samples

Thursday 26<sup>th</sup> July 2012

laser & USB ~~Buy~~ Buying

|              |        |                |         |
|--------------|--------|----------------|---------|
| Ash 2.82 pH  | 69.692 | std dev 0.039  | at 29°C |
| Ash 4.62 pH  | 69.444 | std dev. 0.04  | at 29°C |
| Ash 9.09 pH  | 68.985 | std dev. 0.132 | at 30°C |
| Ash 11.05 pH | 68.615 | std dev. 0.174 | at 31°C |

|              |        |                     |         |
|--------------|--------|---------------------|---------|
| Mix 2.92 pH  | 26.242 | std dev. 0.011      | at 30°C |
| Mix 4.12 pH  | 24.630 | std dev. 0.062      | at 30°C |
| Mix 9.36 pH  | 25.849 | std dev 0.010 mN/m  | at 29°C |
| Mix 11.05 pH | 25.838 | std dev. 0.027 mN/m | at 31°C |



1st Aug

Latex takes png & jpg files ~~even~~ and not bmp which is supposed to take for print output

References: the bibliography file has bit of problem

Tried to convert Endnote file to bibtex, it's not working, something is going wrong so that will see ~~that if~~ to find the 105 files in science direct again

Yes finally managed to do it properly 10:37 ~~without~~ ~~quitting~~ ~~without the~~ ~~need to~~ do anything about science direct.

Thursday 2nd Aug

Folder

Project/File

- ① Report on colloidal stability : Latex\_new
- ② Fan flow experiment 2012 : My document
- ③ Zeta potential studies : Latex files
- ④ Shell Report : Latex files : Not properly done yet

Friday

3rd Aug

figured out how it needs to be done with figures mostly ~~write~~ it has to be saved in EPS format

Print Chart  
~~transfer~~ ~~fig~~ from excel <sup>AI</sup> directly copy to Adobe PDF & open into Adobe Illustrator & then save it in EPS format to use it in Latex. Then adjust the size of the figure by scale or width & angle commands



Saturday 4th August 2012

There needs to be no separation in the words in the title of EPS files. Otherwise the figures tend to put themselves at the sides & not in the middle of the page, where it is intended.

~~worked on~~ Sunday 5th August 2012  
worked on LaTeX again

Monday 6th August 2012

Tuesday 7th August 2012

Meeting with Hans 12:30 - 14:30

Paul 15:30 - 16:00

Writing report : completed the graph analysis of the work

Wednesday 8th August 2012

Day mostly spend on correcting things and making plots nicer. Solved the problem with bibliography.

Thursday 9th August 2012

Combined ~~both~~ the work of past six months in a ~~Latex Project~~ called Report on Colloidal stabilizing

Friday 10th August 2012

Putting ~~the~~ figures from earlier report in EPS format. Noticed that the figure name should not have spaces in between them, otherwise it shifts to the side of the page.

4:47 learned how to put table inside LaTeX from excel & save the excel file as CSV, ~~change~~ see that there are no gaps in the comma separated file (CSV), using command `{sideways table}`, need to have user packages such as `{pgfplotstable}` `{rotating}` etc.

4:47 learned to input the file in LaTeX. No need to write `begin` or `end {document}` in those files or calling user packages etc. just needs to save as tex file

Saturday & Sunday also was spent on correcting the LaTeX things.

Monday 13<sup>th</sup> August

Talked Paul & about working two ~~to~~ photo diodes. He is going to ~~make~~ make two of those ~~about~~ to test. Again major <sup>part of the</sup> day was spent on ~~testing the~~ LaTeX things. Further experimentation about it ~~is~~ is due.

Tuesday 14<sup>th</sup> August

Minute correction & rewriting of the things. Real literature reading is due.

Wednesday 15<sup>th</sup> August

Borrowed books from library about journal paper writing & correcting things accordingly.

Thursday 16<sup>th</sup> August

- \* Laser box from Paul
- \* Further corrections ~~from~~ (change from passive to active voice)
- \* Changes in the Introduction / methods



Friday 17<sup>th</sup> August

\* Meeting with Monique Drijer

- Hans is unhappy with the progress of all student
- ~~Info~~ Information about the paper
- Information about ~~the plan~~ next four month plan
- No need for further consultation / or possibly by the end of the year

Ajay / Mohammad

Saturday 18<sup>th</sup> August

- Fixed the bibliography & reference by using `userpackage [comma, authoryear] {natbib}`

& Changing bibliography style {~~Ap~~ alpha} to  
" — {apalike}

Sunday 19<sup>th</sup> August

worked all day long on fixing methods, & results & discussion

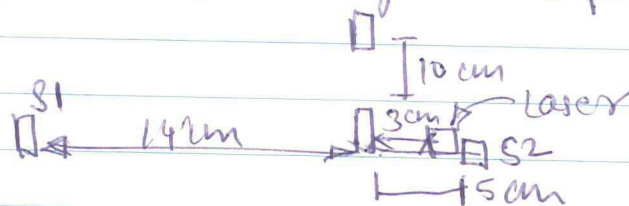
Monday 20<sup>th</sup> August

Simulation of oil down-coming in a single well scenario using FEM →

checked the ~~the~~ bulk fluid results part from the discussion

Tuesday 21<sup>st</sup> August

Starting new experiment ~~for~~ on Laser, may be only four samples // Recording on laptop



intensity in ~~terms of~~ presence of water 10.61



Real mess in measurement, finally decided to get put  
 paper input signal & measure the data  
 without liquid it is 8.20

Ash 2.22 pH laser\_2012\_08\_21\_004  
 Ash 4.62 pH laser\_2012\_08\_21\_005  
 Ash 9.09 pH laser\_2012\_08\_21\_006  
 Ash 11

7  
8  
9  
10  
11

Thursday: Preparation of draft

~~Thurs~~ Friday 2012 - 24<sup>th</sup> August

Alma  
 Defensor

$R^2 = \text{Sum of squares of residuals}$  (RSS)

conductivity decrease, what do you mean?

~~viscosity of oil~~ oil swelling is higher for  
 less viscous oil.

How did you get the permeability?

what is Bond number?  $N_B^{-1} = c \frac{8\sqrt{\gamma/k}}{\Delta p g H}$

water wet core x oil wet core

Master thesis: Water 3 o'clock PHREEQC  
 750 PPM salinity

① low salinity water = how much low  
 Geochemical interaction

pH → electrical conductivity  
 connection between

Did you  
 consider the  
 wall surface

②

In what case ~~oil~~ ions interacting  
 with wall surface  
 (interaction bet<sup>n</sup> ion)

LATEX

~~(error)~~  
: The problem with `\endcsname` is solved by deactivating `\usepackage{ansinew}` {inputenc} while keeping others such as

`\usepackage{[T1]fontenc}`

`\usepackage{modern}`

Monday 10:00 clock

injectivity in Non-Newtonian Two-phase Flows  
Latoij ~~Monday~~

① Fractional Flow Theory

~~Surfactant~~ previously flushed - Assumptions: uniform concentration

Newtonian vs Non-Newtonian  $\checkmark$  shear thinning

Changes in mobility  $\leftrightarrow$  changes in pressure difference  
Cheng 2000: Non-Newtonian Rheology  
Foam collapse

① Effect of velocity on the results

Tuesday ~~28~~ 28<sup>th</sup> August  
look in Google calendar

Wednesday 29<sup>th</sup> August

Analyzing flow results

~~Friday~~

Thursday 30<sup>th</sup> August

\* lesser analysis, went to market to buy stuff,  
meeting with Hans  $\leftrightarrow$



Friday 31<sup>st</sup> August  
Durgesh Kawale presentation

Influence of dynamic surface tension on foams:  
Application in gas well deliquification

dynamic surface tension  $\Delta P = \frac{2\gamma}{R}$

viscosity of foam > viscosity of water

Reading Ger Koper's book again to make a literature report: More effort on surface tension, surfactant studies etc.

(Saturday & Sunday) worked on writing /  
Splitting the data.  
~~Monday~~

Monday 3<sup>rd</sup> September 2012

Test Laser 2012 09 03\_013 Test with water

when ~~the~~ laser is not on and ~~the~~ the box is covered completely with ~~bb~~ black cloth. The reading is 0.52 on both sensors.

Tuesday 4<sup>th</sup> September 2012

Test with references n-octane

laser 2012 09 03\_014

~~The~~ On the side of the  $\perp$  sensor <sup>(2)</sup> we put paper to shield it from the light from paper covered ~~with~~ ~~the~~ ~~laser~~ sensor 1.

~~Talk by B.~~

Correcting some things with Zeta Potential studies 2 0' clock



# Lars Nonhekes ECMOR

## Gas diffusion in porous media

Simon Cox

What do you mean by weaker ~~to~~ <sup>Cor</sup> foam vs

R.v. saying diffusion is necessary for movement of lamellae through porous media

At high pressure diffusion plays little part.

Nephelometer design is complicated to run

The ~~re~~ easiest way is to collect sample and figure out the particle concentration after words by some Nephelometer

~~70ml each~~ The small plastic cups measuring  $\sim 70$  ml each, so it would measure 500 ml of sample in  $\sim 7$  cups. ~~meaning~~

$12 \times 7 = 84$  cups we need  
Exp

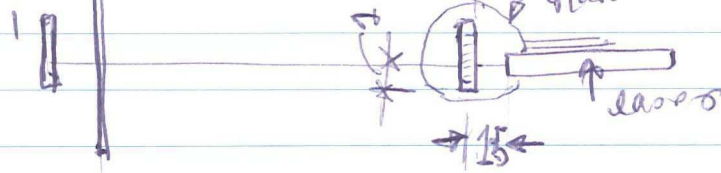
Thursday 6<sup>th</sup> September 2012

As4 2:02pm with sensor 1 & sensor 2  
lurer-2012-09-06-015

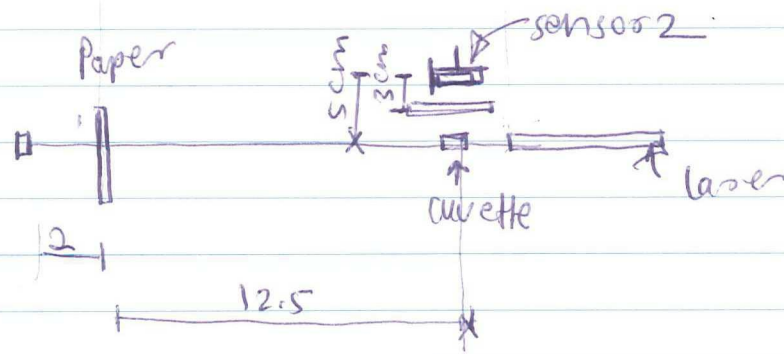
Take the result to Hans & check if it is possible to continue with the set up or ask him more time to check with ~~the~~ ~~thing~~ build up of seal set up.

PD water for reference

lurer-2012-09-06-016



front view



top view

Glass lens 5.5 cm

Calculation

$$\frac{I_0}{I_{0,u}} = \frac{9\pi^2 (n_1^2 - n_0^2)^2}{2 \times 4r^2 (n_1^2 + 2n_0^2)^2} v^2 N_p (1 + \cos^2 \theta)$$

$\uparrow$  633 nm       $\uparrow$  5 cm

$$1 \text{ nm} = 1 \times 10^{-9} \text{ m} = 1 \times 10^{-6} \text{ mm}$$

$$1 \text{ ml} = 1 \text{ cm}^3 =$$

$$3 \text{ ml} = 3 \text{ cm}^3 =$$

$$1 \text{ cm} = 10 \text{ mm}$$

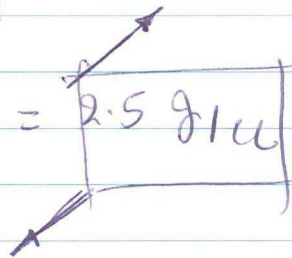
$$1 \text{ cm}^3 = 1000 \text{ mm}^3$$

$$3 \text{ cm}^3 = 3000 \text{ mm}^3$$

$$1 \text{ cc} = 1 \text{ ml}$$

Density of silica = 2.5 g/cc

$$\rho = \frac{m}{V}$$



$$2.5 = \frac{0.12}{V}$$



$$V = \frac{0.12}{2.5} = 0.0488 \text{ cc}$$

$$0.0488 \text{ cc}$$

$$48.8 \text{ mm}^3$$

$$\sqrt{2} N_p = 1.94 \text{ E-}09$$

$$N_p = \frac{1.94 \text{ E-}09}{48.8 \times 48.8}$$

Overbeck 3<sup>rd</sup> Book 14 Chapter

$I_0$  is the intensity gone through the cuvette.

- ① Polarizes ② Check these liquids ③ Fitting arrangement (optical bench & .

$I_0$  is the intensity of the reference as we imagined

Einstein - Cabannes equation

Formula for turbidimeter

$$\frac{4\pi}{3} \frac{\alpha}{m^3} \rho = \frac{n^2 - 1}{n^2 + 2}$$

CGS units

$$\frac{dn^2}{dp}$$

$$\frac{1}{v} \left( \frac{\partial v}{\partial P} \right)_T$$

$$\frac{1}{m^4} \left( \rho \frac{d\varepsilon}{dp} \right) \beta$$

$$\frac{\rho \alpha m^3}{m^4}$$

$$\rho \alpha'' \sim m^{-1}$$

/particle  
volume

$$\frac{9\pi^2 (n_i^2 - n_o^2)^2}{2\lambda^4 r^2 (n_i^2 + 2n_o^2)^2}$$

$$v^2 N_p (1 + \cos^2 \theta)$$

$$\frac{\pi \text{ particles}}{\text{volume}}$$

$$\frac{m^6}{m^3} \frac{m^6}{m^3}$$

$$15.0 \times 10^{-6} \text{ cm}^{-1}$$



3:00 checked the pump & gas cylinder for permeability expt.

Tuesday 11th September 2012

- Got the rails for laser

Wednesday 12th September 2012

Worked in the morning with Flow cell set up: →  
Abdul-Hamid: The influence of the presence of oil in the produced geothermal water on injectivity

DeiA Zandsteen formatie 495 mD 50 meter

sample is same as ours 2-27D

Gezeefd tot 300 um deeltjes

Explain the <sup>flow</sup> process in our case like terms of relative permeability.

$1.8 \times 10^{-3} \text{ m/s}$

Skim oil test

duplo: → Dutch word?

Fonten-analyse { Monte-Carlo methods }  
on the error analysis

Pressure | Flow-Pressure  
|  
Flow

Thursday 13<sup>th</sup> September 2012

Got lenses, polariser, rail etc from Tom & looking for a place 2:00 pm  
working on FF setup try to work on sandpack and then shift to Bentheimer

Checking new system with sandpack  
~~on~~ { Tuesday morning be here in the lab }

Temp 16°C,  $P_{in}$  0.48  $P_{out}$  0.47  $P_{dT1}$  1.3  
 $P_{dT2}$  -3.3 mbar at 100 ml/h DD

Boiled water for tomorrow, ~~to~~ checked the system running, everything is all right.

Meeting with Hans

$$v_{min} = 0.12 \frac{\mu m}{s} / (v/cm) \sim \frac{\epsilon \zeta}{\eta}$$

Size of the particle does not play a role

$$v = \int_{\zeta}^{\phi=0} \frac{\epsilon \epsilon_0 E}{\eta} d\phi = - \frac{\epsilon \epsilon_0}{\eta} \zeta E$$

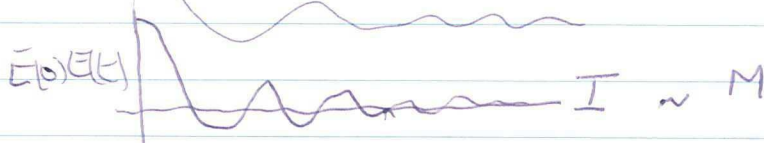
This is how they calculate  $\zeta$  potential.

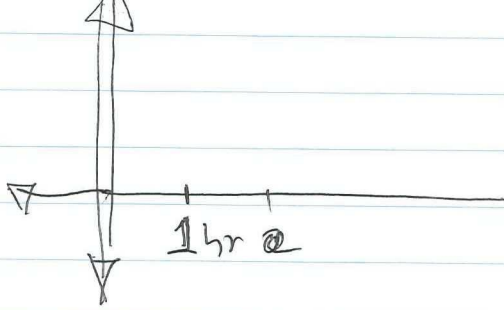
Electrophoretic mobility

Single particle  $\rightarrow$  Doppler effect  $\rightarrow$  ~~Electro~~  
millions of particles  $\rightarrow$  ? Doppler effect

(Heterodyne)

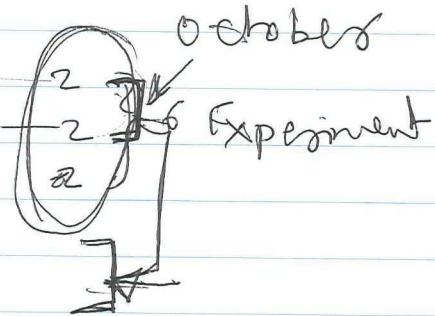
Manual of Malvern { Try to see where laser light is hitting the photodetector }



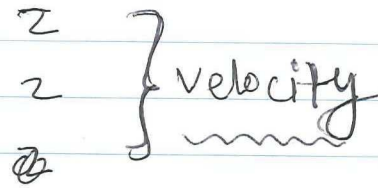


AOS with particle  
AOS without particle  
AOS with particle

Velocity



AOS with



Powerpoint presentation about Zeta potential

Friday 14th Sept

The effect of miscibility conditions on Gas Oil Gravity Drainage,  
an experiment study in a simulated fractured medium  
Kris Hopstaken

what in opinion determines miscibility?

H miscibility

Brinkman model → console

Navier-Stokes flow what is effective? //

10:00 — 12:00 worked on absorbance

1:00 — 1:30 looked for 0.1M HCl for pH change but  
could not find. So need to send mail to ~~Ellen~~ Jolanda



$$10 \text{ ml/hr} = \frac{10}{6} = \frac{1 \text{ cc}}{6 \text{ min}} = 0.16 \frac{\text{cc}}{\text{min}}$$

Preparation of pH samples for zeta potential & other studies: Design

|     |   |      |      |     |     |      |       |    |
|-----|---|------|------|-----|-----|------|-------|----|
| Ash | 1 | 2.82 | 4.62 | 6.0 | 7.5 | 9.09 | 11.19 | 13 |
| mix | 1 | 2.92 | 4.12 | 6.0 | 7.5 | 9.36 | 11.05 | 13 |
|     |   | 1.5  | 1.5  | 1.5 | 1.5 | 1.5  | 1.5   |    |

Tuesday 18th Sept 2012

13:00 Permeability expt conducting  $\rightarrow$  Water 459.9m pH 6.5 added 24ml of 0.1M HCl to make 3.1 pH

CO<sub>2</sub> blown for 5 minutes Back pressure applied 1 bar

Started pumping water at 50 ml/hr

Opened PdT1 (-V) line to get rid of bubbles

Closed the ~~back~~ line (CO<sub>2</sub> should dissolve in the incoming water)

Start measuring at 14:30 pm — stopped at 15:00

Restarted at 15:15 upon PDT reaching 0

Back pressure was difficult to maintain

15:45 Finally managed to get pressure wanted 1.04 ~~to~~ measuring from now onwards.

| Flow rate     | ΔPdT1 | ΔPdT2 | P1   | P2   | Time             |
|---------------|-------|-------|------|------|------------------|
| 50            | 14.0  | 13.6  | 1.01 | 1.01 | 15:50            |
| <del>50</del> |       |       |      |      | <del>16:05</del> |
| 100           | 24.0  | 23.3  | 0.91 | 0.88 | 16:05            |
| 150           | 33.3  | 32.8  | 0.82 | 0.76 | 16:20            |
| 200           | 42.3  | 42.2  | 0.77 | 0.62 | 16:50            |
| 250           |       |       |      |      | 17:20            |
|               |       |       |      |      | 17:50            |

stopping flow rate, gas pressure etc.

Name of the test Test 2012-09-18-062

laser experiment set up full day

Thursday 20th Sept

laser experiment setup full day

Hans meeting

- Polariser from Elke - Polariser
- Need bigger box to - (show picture to Hans) put in everything
- Talk about focal length problem
- ~~About the light which is~~ to put the shadows across other light emitter
- Talk about toluene work
- Joost has to go away early.

toluene has larger scattering than retraction

$$C_{av} = \int_0^{\infty} C_R U(2 - U_R t) f(R) dR$$

Particle concentration of particles with radius R

Initial intensity value

Remember to collect the solution in big jar to collect for measurement of particle concentration just like earlier but in greater quantity.

Avogadro's number =  $6.0 \times 10^{23}$

$m^6$

14.10 Overbeek

$$N_w \left[ \frac{\#}{\text{mol}} \right] \left[ \text{m}^6 \right] \left( \frac{dn}{dg} \right)^2 \frac{dg}{dc} \text{ g kg}^{-1} \text{ M}^2$$

$$\sim \text{M}^2$$

Units

$$\frac{dn}{dc} = \text{M} \quad \text{mass concentration}$$

$$c = \text{g} / \text{M}$$

Sedimentation  
vs  
Electric kinetic

$$\left( \frac{dn}{dg} \right)^2 \text{ g M}^2$$

$$\left( \frac{\text{kg}}{\text{m}^3} \right)^2 \left[ \frac{\text{kg}}{\text{m}^3} \right] \left( \frac{\text{mol}}{\text{kg}} \right)^2$$

$$\frac{\text{mol}}{\text{m}^3} \quad \frac{\text{kg}}{\text{mol}} \quad \text{kg}$$

$$\frac{\#}{\text{mol}} \left[ \text{m}^6 \right] \left( \frac{\text{mol}}{\text{m}^3} \right)^2$$

Comparison with expt. data from 2 apparatuses



DD water boiled for foam experiment

9:15 calculation of Aes soln

Adding 100 ml of 0.3 w/w% Aes & 700 ml of DD water to get 0.0375 w/w% system

checking the gas valve, ~~gas~~ Gas valve OK

calculation for flow velocities

~~gas~~ Gas Designed velocity  $3.75 \times 10^{-5}$  ✓

$3.75 \times 10^{-5}$  x area of the core = flow rate

$$3.75 \times 10^{-5} \times 0.001256 = 4.71 \times 10^{-8} \frac{\text{m}^3}{\text{s}}$$

$$= 4.71 \times 10^{-8} \times 1 \times 10^{+6} \times \frac{60}{\cancel{3600}}$$

$$= \frac{4.71 \times 10^{-2}}{3600} = 0.130833 \times 10^{-4}$$

$$= 4.71 \times 10^{-2} \times 860$$

$$= \frac{170 \text{ ml/hr}}{1.413}$$

$$= \boxed{2.826 \text{ ml/min}} \sim 3$$

Liquid Designed velocity  $1.875 \times 10^{-5} \text{ m/s}$  ✓

$1.875 \times 10^{-5}$  x area of the core = flow rate

$$1.875 \times 10^{-5} \times 0.001256 = 2.355 \times 10^{-8} \frac{\text{m}^3}{\text{s}}$$

$$= 2.355 \times 10^{-8} \times 10^{+6} \times 3600$$

$$= \boxed{84.78 \text{ ml/hr}}$$

Total flow rate  $3.75 \times 10^{-5} + 1.875 \times 10^{-5} = 5.625 \times 10^{-5} \text{ m}^3/\text{s}$   
 $= 5.625 \times 10^{-5} \times 3600 \times 24 = 4.86 \text{ ml/day}$  is OK

foam quality



~~3.75~~

3.75

$$\frac{3.75}{5.625} =$$

$$\frac{3.6}{2.4} = \frac{3}{2} = 1.5 \quad \frac{2}{3} = \underline{\underline{0.66}}$$

$$5 \cdot \frac{3}{5} =$$

Gas flow rate changed to 2.828 ml/min  
 Water flow " " " 85 ml/hr

~~Before~~

It is planned that ~~but that~~ First 100 ml water would be pumped at 84 ml/hr before the introduction of the gas

The DD water which is inside the pump is taken out at the start with "solvent change" and opening at the injection point X  
 or

just continue with usual rate when 30 ml is in output beaker, ~~not~~ separate the output beaker to new output beaker (or put the output water in DD output water) ✓ ~~(copy) (worked)~~

Preparation of sample

100 ml ~~to~~ 0.3 w/w% AOS + 703 ml DD water = 803 ml

Take 10 ml out  $\therefore$  793 ml of 0.0375 w/w% sample of pH 6.5 0.1M HCl (6 ml) 3.12

Put the backpressure to 3 bar.

Start measuring the data without flow rate for couple of minutes

~~Test 2012-09-21-002~~

Test 2012-09-21-002 perm

After 30 ml change the beaker ~~to~~ <sup>of inlet</sup> for Foam one  
 First 100 ml let it run before ~~gas~~ pushing the gas  
~~so total 130 ml before pushing the gas~~

100 + 500 + 0.50 + 150

~~Pre~~ Saturate Foam Post flush Input beaker

There is a leakage in the middle of the core ~~at~~ <sup>at</sup> 15:15 (place where earlier it use to be the hole for pressure manometer) mostly gas is leaking from

3263, 3292, 3345, 3351, 3460, 3504, 3478, 3450, 3435,  
3318, 3232, 3164, 3128, 3079, 3041, 3098, 3283  
3260, 3318, 3353, 3352, 3332, 3298, 3273, 3232  
mention in the writing that we used Pin-Point diff.  
3320, 3307, 3265, 3249, 3239, 3472,  
3610, 3654, 3657, 3600, 3425, 3355,  
3302, 3327, 3349, 3337  
3314, 3274, 3270, 3265, 3264, 3260, 3257  
3300, 3647,

(Take as a difference betn Pin-Point or

Experiment stopped due to unsurity of the data of  
results, Monday again pushing the expt with lower  
flow rates

~~Mon.~~

Monday 24<sup>th</sup> sept

Flowing 50 ml Ethanol at 50 ml/hr 11:00

Flowing 200 ml of DD water at 50 ml/hr ~~for~~ with  
1 ~~bar~~ bar BP. 12:30



Tuesday 28<sup>th</sup> sept

checked with Toluene but it is <sup>not</sup> scattering light.  
Also changing the positions of lenses / Diode  
cell ~~changed~~. did not work.

① Bill Talk : 5 models

- ① local equilibrium
- ② fraction flow modeling
- ③ gravity override (Stone 1982)
- ④ SAG
- material balance

② Michiel :  $\rightarrow$  wetting,  
capillary number  
of wetting

George Hirasaki : fundamentals

③ Singoo :  $\rightarrow$  (miscible)

④ Adrianov :  $\rightarrow$   $\text{CO}_2$  is ~~good~~ available in US but  
not here in Europe or Asia : so that  $\text{CO}_2$  is  
good for  ~~$\text{NO}_2$~~   $\text{N}_2$  (immiscible)

Turta & singhal SPE 48895, SPE 152113

$\downarrow$   
MRF (67-107)

Check fractured reservoirs  
Break

⑤ Henri Burton : foams in porous media

- Generation
- viscosity
- stability
  - Outside & Inside
- trapping
- scaling

Hirasaki-Lawson model

$$h_f = h_g + \frac{\alpha n_f}{v^{1/3}}$$

Transport equation } Balance for  
Capillary pressure relationship } generation of  
Coalescence of bubbles

Rechecking PV

STARS Foam model

$$\mu_{app}^f = \frac{1}{\frac{k_{rw}}{\mu_w} + \frac{k_{rg}^f}{\mu_g}}$$

SPE 24179

Find epdny function research ~~of~~

It is OK to use Simgoo's viscosity. <sup>Also dependence on (core)</sup>  
Apparent viscosity  $\times$  Effective viscosity  
In the literature give info about various  
viscosities

we need to do experiment  
foam stability against oil.

~~We need~~ what is drainage & Imbibition

Drainage: non-wetting phase displaces wetting  
phase (gas)

Imbibition: wetting phase displaces non-wetting  
phase (water)



2<sup>nd</sup> September 2012

9:30-12:00 Mohammad Simjoo's Defense

1:00 Foam experiment with lower flow rate  
(half of previous expt ( $6E-05$  m/s) that is  
around  $3E-05$  m/s)

Back pressure 3 bar,

Same steps:

Liquid  $42.4$  ml/hr

$9.38 \times 10^{-6}$  m/s

Gas  $1.413$  ml/min

$1.875 \times 10^{-6}$  m/s

mass balance =  $385$  ml

13:30 waiting for PDT to be steady state

13:45 Started pumping. We are going to do same like  
previous experiment. Keep  $30$  ml in the same beaker &  
then change the beaker. When  $100$  ml is over  
Push the gas at  $1.413$  ml/min (in around 3 hours)

On the pressure cylinder: each black strike is  $2$  bar, so  
 $3$  bar is between ~~2~~ 1 & 2 strike after  $0$  bar  
sign.

The idea is now

$75 + 250 + 75 = 400$  ml for each expt.  
Preflush In the foam in the beaker

Single phase flow at  $42$  ml/hr is  $10$  mbar

~~25~~

Fluctuation occurring But it is OK flow with some ~~res~~  
pattern & observation: when the foam is <sup>at</sup> outlet, there is  
high AP at the ~~match~~ sensor?

(CV writing at 4-5)

When high AP is seen, no flow of foam or liquid,  
so foam gets blocked by something & that is  
why we see the high AP.

In the night we prepared another ~~set~~  $400$  ml of solution to



Mapping graphs for looking on new experiments

- ① Permeability result Test 2012-09-18-062
- ② Slow flow rate result Test 2012-09-23-04

Permeability is calculated to be ~~0.96 Darcy~~ <sup>1 Darcy</sup>  
1 Darcy  $\pm 0.007$   
 $\sim 1.04 \text{ Darcy } \pm 0.00761$

40000 - 42000 mbar 1m

Places where  $\Delta P$  exceeds limit use P1-P2

At times ~~pore volume~~

Points which ~~are~~ do not have Gas flowing are removed.

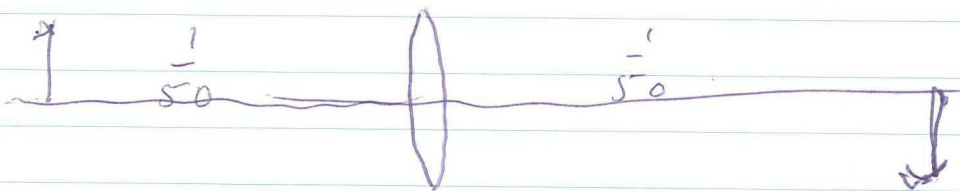
In this case,  $\Delta P$  without core is considered 150 mbar  
 $\Delta P$  is not allowed to go beyond 7 bar. Everytime  $\Delta P$  goes beyond 7 bar, the gas flow shuts down, resulting in no gas in the system thereby not affecting foam

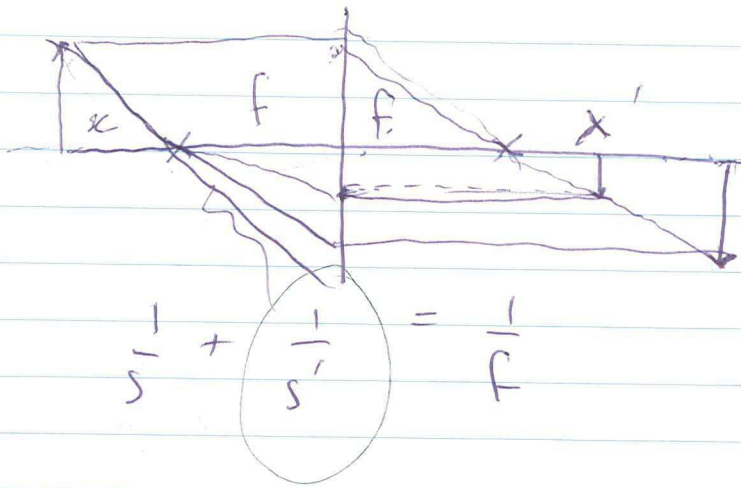
~~8.00~~

Hans meeting

$$\frac{1}{50} + \frac{1}{50} = \frac{1}{25}$$

$\uparrow$  focal length of the lens





Try by lenses : →

$$\frac{\phi \times \text{length } A}{A \times \text{time} \times v_{\text{tot}}} = \text{pore vol}$$

$$\frac{\text{time} \times v_{\text{tot}}}{\text{new } v_{\text{tot}}}$$

$$PV = \frac{\text{time} \times v_{\text{tot}}}{\phi \times \text{length}}$$

Steady state

Friday 28<sup>th</sup> September 2012

- ① Did corrections in PV of Bentheimer experiment
- ② Plotted graph of AOS - AOS repeat, AOS-shell - AOS-shell repeat & shell particles (5 curves) cleaned
- ③ AOS lot of PV to ~~saturate~~ steady state
- ④ AOS-shell not much PV to steady state ~~not cleaned~~
- ⑤ AOS lot of PV to steady state ~~not cleaned~~
- ⑥ AOS-shell Core was thoroughly cleaned ~~cleaned~~
- ⑦ AOS-shell C takes lot of PV to ~~stabilize~~ saturate foam

~~study~~ meeting with simjoo. The fig that Hans mentioned is for long core (~~diameter~~ <sup>length</sup>) i.e. that is why ~~we get~~ he gets small PV to generate foam.



finally yesterday it was decided to use designed gas velocity instead of actually measured reason for that is it is fluctuating a lot & we can't remove the wide points. Currently we have started to delete the points which are not near designed values. and further ~~use~~ use designed values for the calculation in place of measured values.

Corrected the Test 2012-09-26-004

checking earlier Bentheimer experiments & putting the changes in LaTeX.

Putting changes in all foam experiment results

Did <sup>some</sup> changes in the Table of all foam expt. The strategy is to give gas velocity, water velocity, <sup>total velocity</sup> foam quality, ~~dates~~  $\Delta P$  for single phase total velocity. & in a separate chart.

Table of expt would give liquid cone, particle cone,  $\Delta P_w$ ,  $\Delta P_f$ , ~~viscosity~~  $M_f$ , MRF

Sunday 30 September 2012

Corrections ~~to~~ in the sandpack experiments calculation for

single phase  $\Delta P$  for  $2.81E-05$  &  $2.03E-05$

$$\frac{2.81E-05 - 2.03E-05}{3.49E-05 - 2.33E-05} = \frac{x - 24}{33.3 - 24}$$

Test 2012-09-18-002

$$\frac{0.48}{1.16} = \frac{x - 24}{09.3}$$

Test 2012-09-2-01

$$0.48(9.3) / 1.16 + 24 = x$$



we did not do any permeability test between  $5.68E-05$  &  $2.81E-05$  total velocities. The case was run with ~~perm~~ Ethanol (50 ml) & water (200 ml). So we have to take ~~same~~  $B$

$\Delta p / u_{w \text{ tot}}$  for both experiment from same perm experiment.

~~found~~ Found MRF for latest experiment with flow rate

(corrected some old experiments (Sept 2011)) need to find ~~the~~ the original files from which we can plot  $\Delta P$  vs PV diagram & compare all of them in a single way.

Monday 1st October 2012

checked lots of variation with laser set up. ~~some~~ varied the ~~the~~ length between lens & ~~the~~ photo detector lots of time to get some signal on scattering but it is not working to give any signal. Sensor 2 continued to show 6.01 in dark.

~~state~~ The only way scattering <sup>measures</sup> ~~works~~ is by keeping photo detector 2 close to cuvette.

Calculation of total reduced intensity  $R_t$  (Rayleigh ratio) is  $\frac{\text{Scattered Distance betw light detector \& cuvette}}{I_0 \leftarrow \text{incident}}$

$$R_t = \frac{I_s r^2}{I_0}$$

$$= \frac{6.5 \times (1.5)^2}{10.61} \quad I_0 = 10.61$$

$$R_t = \frac{1.5 \times 10^{-4} \times 0.61 \times 10^{-4} \text{ m}^{-1}}{10.61} = R(90) = \text{Rayleigh ratio}$$

$$= \frac{I_0}{10.61} (1)^2 = \boxed{0.65}$$

Rayleigh ratio (IUPAC Compendium of Chemical Technology 2nd Edition (1997))

$$R(\theta) = \frac{I(\theta) r^2}{(I \cdot f \cdot v)}$$

$$f = \frac{1 + \cos^2 \theta}{2}$$

for unpolarised light

$$= \frac{1 + \cos^2(90)}{2}$$

$$r = 1 \text{ cm}$$

$$= 10 \text{ mm}$$

$$= 1 \times 10^{-2} \text{ m}$$

$$f = \frac{1}{2}$$

$V =$  scattering volume

$$= 10 \times 10 \times 30 \text{ mm}^3$$

$$= 3000 \text{ mm}^3$$

$$1 \text{ mm} = 1 \times 10^{-3} \text{ m}$$

$$1 \text{ mm}^3 = 1 \times 10^{-9} \text{ m}^3$$

$$\frac{1 \text{ mm}}{1 \text{ mm}} = 1$$

$$R(\theta) = \frac{6.9}{10.61} \left\{ \frac{(10)^2}{\frac{1}{2} \times 3000} \right\}$$

$$= \frac{65.03}{30} \left\{ \frac{100 \times 2}{3000} \right\}$$

$$= \frac{2 \times 65.03}{30} = 4.335 \text{ mm}^{-1}$$

$$1 \text{ mm} = 0.1 \text{ cm}$$

$$R(\theta) = \frac{4.335}{1 \text{ mm}} = \frac{4.335}{0.1 \text{ cm}} = \frac{43.35}{1} \text{ cm}^{-1}$$

Ans

$$= \frac{6.9}{10.61} \left\{ \frac{(10)^2}{\frac{1}{2} \times 3000} \right\} \left\{ \frac{(1)^2}{\frac{1}{2} \times 3} \right\}$$

from Lou & Maron (1954)

$$= \frac{6.9}{10.61} \times \frac{21}{3} = \frac{6.9}{15} = 0.46 \text{ (mT)}$$

$$\tau = \frac{16 \pi}{3} \frac{I_{90} r^2}{I_0} = \frac{16 \pi}{3} R_{90}$$

Rayleigh ratios for Toluene from above paper  
 at 25°C  
 4358 Å 5461 Å  
 60.3 20.5 Lou & Maron (1954)  
 32.2 11.8 Stamm & Button (1953)

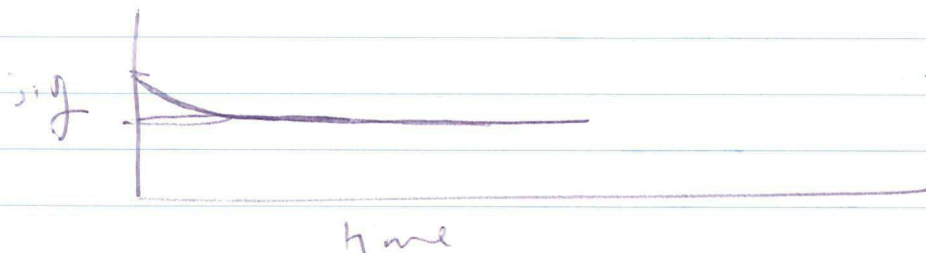
$$R_{90} = 2\pi^2$$

$S_u$  = depolarization ratio  
 for Maron f L

Tuesday 2nd October 2012

Correction in the tests 84, 86 & 87, ~~new~~ files processing with (PV) in case of 71 & 72, putting these data in summary of all experiments. Focusing on expts around July August 2011. 12:00

Fortunately most technicians are fat. It meant that I could chess them down whenever I wanted to.



With Hans in laboratory

water 7.11  
 toluene 6.70  
 without anything 5.99  
 with empty cuvette 6.6



really difficult from the excel sheets. No idea  
what what flow rate (ml/min or ml/h) was  
used & can we use  $(P_1 - P_2)$  instead of PDT  
reading.

I thought skip perm test thing & tell  
that we passed some 600ml of liquid to  
clean the sand pack.

Checking foam expts from Feb 2011 - June 2011  
The ~~start~~ <sup>Coarse</sup> has to be explained ~~in~~ <sup>fine</sup> in context of  
expts  
our present expt with Bentheimers. (pv of Gas & liq)

Combining expt @ 1<sup>st</sup> March ~~2011~~ 2011 20, 22

Expt 23 is done by changing total vel. which change pv  
& so not included in the expt 20-22 ensemble.

3<sup>rd</sup> October 2012

toluene 6.00 with given combination of  
things.

But when there is no laser it is still 6.00, so  
toluene simply do not give anything.

Chloroform 6.02 } But to no avail  
Iodobenzene 6.02 }

Tomorrow trying with higher sensitivity &  
possibly with milk.

Trying to connect the sandpack expt 7:00 pm

On most ~~good~~ days I feel like a slave. On special  
days like these, I feel like a slave from  
third world country. 7.02 pm

making some more progress with foam - coarse sand pack experiments. Correcting tests around Feb 2011. Main problem is that all recording has been done in the midway (somewhere after pushing the gas) even the csv files are done like that.

Try to make some sense in terms of pore volume.

4<sup>th</sup> October Thursday 2012

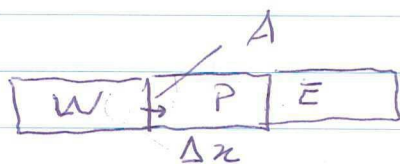
checking milk, but it is absorbing ~~everything~~ every photon of laser, nothing is passing through.

Only when you take out lens & polariser out of photo detector's way, I can somehow get signal from the scatter.

Trying with 2.82 Ash sample, same problem of not enough signal strength.

made a plot of 2.82 Ash from ~~end of~~ ~~sept~~ ~~sept~~ 25<sup>th</sup> Sept: →

4<sup>th</sup> October meeting



$$m = A \Delta x \phi S \rho_w$$

$$\frac{dm}{dt} = \left[ u_w A \rho_w \right]_x - \left[ u_w A \rho_w \right]_{x+\Delta x}$$

$$A \Delta x \phi \rho_w \frac{dS}{dt} = (u_w|_x - u_w|_{x+\Delta x}) A \rho_w$$

$$\phi \frac{dS}{dt} = - \frac{(u_w)_{x+\Delta x} - (u_w)_x}{\Delta x}$$

$$\phi \partial_t S = - \partial_x u_w \Rightarrow \phi \partial_t S + u \partial_x S = 0$$

$$+ \varepsilon \partial_x (\varepsilon \partial_x S)$$



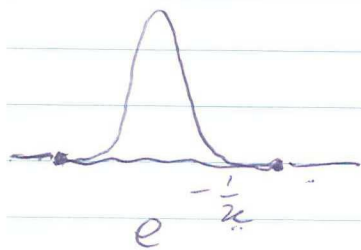
multiply by test function  $\psi$  and integrate  
it necessary by parts

$$\int \partial_t S \psi + \int \partial_x F \psi - \int \epsilon \partial_x (\epsilon \partial_x S) \psi$$

$$\left[ \int \partial_t S \psi = \int F \partial_x \psi + \int \epsilon \partial_x S \partial_x \psi dx \right]$$

$$+ \int \frac{1}{\epsilon} \psi = \int (\epsilon \partial_x S) \psi$$

$$= K \psi$$



~~delete~~

$\frac{ax}{\epsilon}$

start BL from Excel  
starting saturation 0.4

Trying to find effect of back pressure from Amin

Install 4.3 and run Hans's program & Mohammed's program. Try to make focus model.

5<sup>th</sup> October 2012 Friday

9:30 checking again with laser  
10:00 Hans came together we found that milk  
indeed scatters an image and it is around  
50 cm from the object with lens (25 cm f)  
at 25 cm. However the image is projected on  
the detector, ~~the~~ detector fails to show any  
increase in the reading. It shows 6.026-  
6.013 but in the dark you have the same reading  
without the laser.



Things to do

- mail Paul about detector sensitivity & check if we can find more sensitive detector
  - ~~do~~ Try to use web cam but see first how people managed to do it Ask PhD student from Applied Physics.
  - Need to find a fixture for cuvette, because even if it is difficult to place it <sup>at</sup> right place.
- ~~do~~ Excel sheet expt. work →  
~~do~~ ~~found~~ connecting the ~~expt~~ excel files again.

These tests are in one file 15, 18, 20, 22, 23, 26, 30  
Did some corrections in the expt data from June 2011.

{ Must look into folders Data-till Sept 11 & results processed in 11 & 12 } to fix things such as velocities, ~~BP~~ BP etc.

7<sup>th</sup> October 2012

Sunday: 13:00 - 15:00 Did ~~ex~~ Fill the data from ~~for~~ June - July 2011. Important to know the problems.

8<sup>th</sup> October 2012 Monday

Skipped COMSOL introduction course. Instead worked on various files from sandpack expts. prepared folders such as fine sandpack & coarse sandpack.

worked with Paul on laser equipment to figure out that with changing distance detector can give good results. Next step is to ~~fix~~ get cuvette fixture because that is very critical in these cases. Once we have this fixture, we can really make some solns going.

Flowing 50 ml ethanol at 50 ml/hr rate BP 3 bar  
(10:00) plastic 10.5 bar  
cleaned items put tags on the beaker, heated water  
for permeability test  
Did some email sending 11:00 - 12:30  
13:00

Sample preparation for permeability test 13:20

473.00 ml ~~for~~ DD water Boiled pH 6.20 at 25°C  
final 477.07 ml of DD water with pH 3.07

② Flowing  $\text{CO}_2$  gas afterwards for 5 minutes  
Temp. 16.5°C

③ Pushing 100 ml of DD water to replace ethanol  
at 50 ml/hr (After 30 ml <sup>at outlet</sup> the beaker will be  
changed assuming all ethanol is extracted)  
480 gm at the inlet

~~After~~ at 438 mers Balancel & Bwe  
started to ~~start~~ the expt because this might be  
one of those <sup>record</sup> ~~gas~~ ~~no~~ one phase replacing  
expt (BL) or may be not. But we can do  
something if we have data recorded.

Test2012-10-09\_061 (1) started measuring  
at 15:10

Meanwhile ~~in~~ from Simjoo's thesis, comparison  
to be made between  $\Delta P$  from various concn. & AOS.  
We consider  $\Delta P$  vs  $P_v$  as a basic graph to  
compare in all ~~cases~~ cases as it is the basic  
property. MRF has been calculated by different ways.

Expt stopped and in the meanwhile the  
water from the beaker thrown away. 15:55

④ new expt started Test2012-10-09\_062  
with zero PdT line  $P_1 = 3.50$   $P_2 = 3.80$



| Flow rate<br>ml/h | Pd1,<br>mbar | Pd12<br>mbar | P1<br>bar | P2<br>bar | Time  | Mass balance<br>Temp |
|-------------------|--------------|--------------|-----------|-----------|-------|----------------------|
| 0                 | -0.4         | -6.4         | 3.43      | 3.43      | 16:00 | 395                  |
| 50                | 9.5          | 9.0          | 3.61      | 3.57      | 16:35 | 371.7                |
| 100               | 18.7         | 18.0         | 3.61      | 3.57      | 17:03 | 326.1                |
| 150               | 27.3         | 28.0         | 3.65      | 3.56      | 17:35 | 245 17.1             |
| 200               | 36.9         | 36.7         | 3.73      | 3.54      | 18:06 | 145                  |
| 250               | 46.0         | 46.0         | 3.72      | 3.52      | 18:28 | 54 17.4              |

stopping the expt & stopping to record the data

10th October Wednesday 2012

Foam Flow test

Preparing soln for foam flow : 9:15

Recipe from 3 26th April / 4th April, Calculations

|                        |               |              |              |
|------------------------|---------------|--------------|--------------|
| Double distilled water | 686.5         | 786.5        | 786.5        |
| 0.1M HCl               | 7.0           | 7.7          | 10.7         |
| Kracker's soln (5%)    | 6.5           | 7.1          | 7.1          |
| Aos soln (3%)          | 100.0         | 109.0        | 113.0        |
|                        | <u>800 ml</u> | <u>914.3</u> | <u>917.3</u> |

pH 2.90

Everything is arranged. Bit of glitch in preparing soln but finally worked out. magnetic stirrer has been used continuously. The weighing machine is put at the outlet to measure outlet water. (After 80 ml we will remove it to DD water Perm outlet)

Pd1 shows -26 mbar but ~~do shows~~ anyway we go forward. BP is 3 bar. water flow 42 ml/hr

Test 2012-10-10-663 (1)

Pd1 8.6 Temp 14.5°C P1 3.65 P2 3.63 20.13 gms

we ~~took out~~ first 50 ml to perm beaker. Now waiting till further 50 ml is deposited in outlet beaker before pushing the gas.

13:10 Gas flow started 1.426 ml/min

Termin



Exp CAOS + Ash) went perfect. no need to manipulate anything. However no Stabilisation. Now compare with another case Ash only and then

Just noticed that Time we take for recent (2012) expts should be 10, 20, 30 sec <sup>For (Pr)</sup> because we measure it that way

Trying to calculate permeability ~~4.0E-05 m~~ but the ratio does not make sense.

12<sup>th</sup> October 2012 Friday  
Worked on the experiments of sandpack pressurized.

13<sup>th</sup> October 2012 Saturday  
- fight with fellow colleague. Decision to move downstairs to avoid conflicts.

Worked again on sandpack expts, changes in the structure of shell report.

Trying to work on BL theory for foam flow but going to library to read it due to people talking around.

14<sup>th</sup> October 2012

~~Prob~~ Reading probability theory: first steps / First  
 Chapter ~~A1~~ ~~A2~~ ~~A3~~ ~~A4~~  
 HH, HT, TT, TH

~~HT~~

Urn model

$$P(A) = \frac{3}{7}$$

A

3 white balls & 4 black balls

$$P(B) = \frac{4}{7}$$

B

for drawing two balls

$$n = C(7, 2) = \frac{7 \times (7-1)}{1 \times 2} = \frac{7 \times 6}{2} = 21$$

$$= \frac{C(n-1, 1)}{n!}$$

$$\frac{1 \times 2 \times 3}{7} = \frac{6}{7}$$

Probability of 4 numbers right

$$P(A) = \frac{C(6, 4) \cdot C(43, 2)}{C(49, 6)}$$

$$= \frac{6 \cdot 5 \cdot 4 \cdot 3 \cdot 43 \cdot 42}{49 \cdot 48 \cdot 47 \cdot 46 \cdot 45 \cdot 44}$$

Reading BL theory: →

Concentrate more on ~~B~~ displacement than on  
~~the~~ steady state flow. :-

Gas-oil displacement

Can we do ~~it~~ according to water displacement  
 at least 2012 expts? Our results shows  
 basically that

$\Delta P$  vs  $PV$

A

Gas-oil ratio

(Foam-water in our case)

We see the effect of low pressure (low velocity?)  
 and high pressure (high velocity?) in our case. ~~and~~  
 This is also case where we see how they  
 affect with pressure and without pressure.

checking data once again from lab comp

~~Read~~

15 oct 2012

lane experiment check up, working on Sandpack experiments,

16 Oct 2012

Working whole day on sandpack experiment data collection. In the evening worked on ~~data collect~~ literature collection ~~of~~ for sandpack

17<sup>th</sup> Oct

working whole day on sandpack data correction.

18<sup>th</sup> oct Thursday

comsol working whole day to ~~sh~~ understand some results from Hans. ~~we~~ need to make ~~&~~ check up on foam models used by people to do some initial results working.

Reading from Bill & Hans joint report/work

- ① Capillary pressures calculations
- ②

checking again Comsol model,

\* 16:21 Fixing left BC

Problem: Our case shows prescribed value of  $u$  instead showing prescribed values of  $s$ . as in Hans ~~problem~~ presentation sheet.



meeting with Hans evening

$$\varphi \partial_t \rho_g S_g - \partial_x \left( \rho_g \frac{k_g}{\mu_g} \partial_x P \right) = 0$$

$$\varphi \partial_t S_w \neq \partial_x \left( \rho_w \frac{k_w}{\mu_w} \partial_x P \right) = 0$$

$$\frac{1}{\rho_g} S_g \varphi \partial_t \rho_g + \varphi \rho_g \partial_t S_g - \partial_x \left( \frac{k_g}{\mu_g} \partial_x P \right) = 0$$

$$\varphi \partial_t S_g + \varphi S_g \varphi c_g \frac{\partial P}{\partial t} - \partial_x \left( \frac{k_g}{\mu_g} \partial_x P \right) = 0$$

$$\left( \frac{1}{\rho_g} \frac{d\rho_g}{dP} \right) = c_g$$

$$\varphi \partial_t S_w - \partial_x \frac{k_w}{\mu_w} \partial_x P$$

compressibility

$$\textcircled{1} \quad S_g \varphi c_g \frac{\partial P}{\partial t} - \partial_x \left( \frac{k_g}{\mu_g} + \frac{k_w}{\mu_w} \right) \partial_x P = 0$$

$$\textcircled{2} \quad \varphi \partial_t S_w \neq \partial_x \frac{k_w}{\mu_w} \partial_x P = 0$$

eqn check from Hans theory

$$\begin{cases} P(x=0) = P_{inj} \\ P(x=L) = P_{prod} \end{cases}$$

$$S_w(x=0) = 0.5$$

$$\partial_x S_w(x=L) = 0$$

$$S_w = 1$$

functions

$k_{rw}, k_{rg} \rightarrow$  Piecewise (Global definitions)

compressibility  $1/p \rightarrow$   
initial values for  $P_{inj}$

Try to define function by  $s(t)$  or something

We can ~~rearrange~~ solve this eqn

$$\frac{10^{-12}}{10^{-3}} \times \frac{5 \times 10^5}{0.1}$$

$$\approx 10^{-3} \text{ m/s}$$

Comsol gives error with sign

Friday 19 Oct 2012 Friday

- \* worked on PV calculation of Sandpack expt.
- \* Need to make table of various parameters.

Core  
~~Sand~~ coarse, fine, Bentheimer  
~~Water~~ Brine, DD pH 6.5

Composition 0.5, 0.075, 0.0375, 0.15

Gas velocity  $1.2\text{E-}05$ ,  $6.00\text{E-}06$ ,  $8\text{E-}06$ ,  $3.6\text{E-}05$ ,  $9.1\text{E-}05$

Water velocity  $2.4\text{E-}05$ ,  $4.8\text{E-}05$ ,  $7.2\text{E-}05$ ,  $6\text{E-}05$ ,  
BP  $8\text{E-}05$

water velocity:  $\rightarrow 8\text{E-}06$ ,  $6\text{E-}06$ ,  $1.6\text{E-}05$ ,  $1.9\text{E-}05$ ,  $1.2\text{E-}05$ ,  $2.4\text{E-}05$ ,  
 $3.6\text{E-}05$ ,  $3.2\text{E-}05$ ,  $4\text{E-}05$ ,  ~~$1\text{E-}05$~~ ,  $2.12\text{E-}05$ ,  $4\text{E-}05$ ,

Monday 22 Oct 2012

Try to make a table like table 8 pp. 138 from  
"Yes, NO or May be"

~~a b c d~~

~~a~~  $a_1$   $a_2$   $a_3$   $a_4$   $a_5$   $a_6$   $b_1$   $b_2$   $b_3$   $b_4$   $b_5$   $b_6$

Test  
Test 2  
Test 3

~~factors~~

need to calculate equation of regression or  
coefficients of the factors:

Factors with relatively small coefficients can be discarded as insignificant, without  
recalculating the coefficients.



13:00 Based on 9<sup>th</sup> Oct Tuesday, doing the perm test  
(mass balance is at exhaust)  
Flowing around 50 ml Ethanol at 50 ml/hr BP 3 bar  
Test 2012\_10\_22\_064

just realized that we don't have to change Bentheimer core because we didn't ~~do~~ <sup>change</sup> it in spring experiments, so ~~telling~~ ~~no~~ telling Beard about it.

foam is pushing outside ~~with etha~~ at @ 13:40

14:00 making sample for perm test

475 gm and 6.15 pH ~~3.8~~<sup>3.03</sup> 3.03 pH 478.7

①

14:12 pushing 50 ml Ethanol is complete, pushing CO<sub>2</sub> for 5 minutes

(Note: You see ethanol + <sup>N<sub>2</sub></sup> gas from previous expt coming out this is two phase flow and the conditions measured (P<sub>1</sub>, P<sub>2</sub>, PdT) are characteristics of it.

14:19 Had to open the line to connect to CO<sub>2</sub>. You see the fluctuation due to CO<sub>2</sub> push. We are CO<sub>2</sub> for 5 minutes (30 gpm in the beaker this time)

② should be mixture of Ethanol + AOS + Ash + water etc.)

After 5 minutes shifting water (pH 3) (you see the pressure drop immediately)

③ Pushing water pH 3 at 50 ml/hr (Pump has ethanol but hopefully it will be displaced in the later case) we just remove ~~all~~ produced water 30 gm or so.

④ waiting ~~for~~ 1 hr to collect 50<sup>60</sup> ml of displaced ethanol removing from exhaust beaker. at 14:50

So the sequence can be summarized as

1. Ethanol 50 ml/hr 35 ml (from beaker) 3 bar
2. CO<sub>2</sub> 5 min no pressure
3. Ethanol 50 ml/hr 20 ml (from pump) ~~3.03~~ 3 bar
4. Solvent change to water (pH 3) 100 ml 3 bar



at 50 ml/hr outlet  
 \*waiting till the beaker to total 60 ml (Ethanol)  
 which will be thrown out.

No of calculations possible in our cases : DOE Excel sh  
 $n_a \times n_b \times n_c \times n_d \times n_e \times n_f \times n_g \times n_h \times n_i =$   
 $3 \times 3 \times$

16:13 The beaker 66 ml of Ethanol + AOS + water  
 we assume that ~~everything~~ ethanol has been pushed  
 out completely. and ~~now~~ ~~starting~~ sample is collected  
 in small plastic cup. Now we should wait for  
 30 minutes to push another 50-70 ml of  
 DD water pH(3). Then stop the pump, wait to  
 stabilise and again start the experiment.

pdt 10 mbar

(plan to do experiment from 6:00 to 8:00 pm)

Stopping the experiment at 5, returning to  
 start perm experiment

Back at 18:00, PDT shows negative pressure drop -15, -12  
 But we need to go on with schedule.  
 It seems flushing some ethanol & 500ml DD (pH 3)  
 is not enough to get rid of air or foam  
 AOS.

| Flow rate | Pdt1 | Pdt2 | P1   | P2   | mass   | Time  | Temp |
|-----------|------|------|------|------|--------|-------|------|
| ml/h      | mbar | mbar | bar  | bar  | gm     | mm:ss |      |
| 0         | -16  | -18  | 0.44 | 0.50 | 0      | 18:00 | 14.4 |
| 50        | 9.4  | 9.5  | 3.99 | 3.97 | 18.2   | 18:30 | 14.9 |
| 100       | 19.5 | 19.5 | 3.99 | 3.95 | 65.18  | 19:00 | 14.8 |
| 150       | 29.6 | 28.9 | 4.06 | 4.00 | 135.37 | 19:30 | 14.7 |
| 200       | 39.5 | 39.2 | 4.07 | 4.00 | 226    | 20:00 | 14.6 |
| 250       | 50.1 | 49.6 | 4.11 | 3.99 | 307.0  | 20:20 | 14.6 |

Tuesday 23 October 2012

Note from Montgomery;

Multiple linear regression model

Dependent Variable or response  $y$  may be related to  $K$  independent or regression variable in a way that

$$y = B_0 + B_1 x_1 + B_2 x_2 + B_3 x_3 + \dots + B_K x_K + \epsilon$$

and interaction term is calculated by

$$y = B_0 + B_1 x_1 + B_2 x_2 + \boxed{B_{12} x_1 x_2} + \epsilon$$

we can try by making a matrix

$$\begin{bmatrix} P_1 \\ P_2 \\ P_3 \\ P_4 \\ P_5 \\ P_6 \end{bmatrix}$$

=

$$\begin{bmatrix} B \\ B \end{bmatrix}$$

Reference

Applied statistics & probability for

Engineers

$$Y = XB + \epsilon$$

(matrix approach to multiple linear regression)

check what Hans did for us in the data analysis for permeability test.

Note that there are two different things like finding relationship b/w input & output and ~~regression analysis~~ design of experiments. I am confused here little bit.

R

\* check "origin" again and see how can we use statistical analysis part with our case.

$$y = \begin{bmatrix} y_1 \\ \vdots \\ y_n \end{bmatrix} \quad x = \begin{bmatrix} 1 & x_{11} & x_{12} & x_{1K} \\ \vdots & x_{21} & x_{22} & x_{2K} \\ \vdots & \vdots & \vdots & \vdots \\ 1 & x_{n1} & x_{n2} & x_{nK} \end{bmatrix}$$

we need to make this matrix with our



looking more into DOE thing and continuing with  
analysis of things.

~~should~~ I think we should work more on analysis  
than design of experiments because we already  
done the experiments without design

Use PDFG95 to combine files from DOE

ARCHOS 90 ereader gr Euros

Wednesday 24 Oct 2012

EC, ST, pH testing of various samples 10:30

Outlet from perm 9th Oct 3.60 pH, 41.681(1.018) 19.5°C

Outlet from perm 18th Sept 6.09 pH, 53.48(0.353) 20°C

Outlet from AOS 26th Sept 4.58 pH, 28.736(0.058) 21°C

Outlet from AOS 21st Sept 6.25 pH, 32.727(0.1) 21°C

12:30 ~~sent~~ Bought Bebook e-reader

Sending mail to Jolanda

waiting that Mark finishes his work around  
tensiometer

16:00-18:00 S.T. of above samples.

Thursday 25 Oct 2012

~~PH~~ ~~SET~~ working on Bebook reader thing 10-12  
S.T. of samples 12:30-14:30

Perm & Inlet AOS ~~are~~ were ultrasonicated for  
5 minutes while Ach-AOS mix were ultrasonicated  
for 15 minutes

Inlet perm-180912 69.554(0.062) 21°C, 3.03 pH

Inlet perm-091012 66.07(0.086) 19.8°C, 3.90 pH

Inlet AOS-260912 28.686(0.254) 20.5°C, 3.03 pH

Input mix-101012 25.238(0.062) 20°C, 3.39 pH

Working on changing the format of PDF file to  
EPUB by using calibre.



## Problem with Bebook reader

PDF is difficult to read, cannot zoom in

I tried to convert PDF to epub by using Calibre, really making modification with the original font, not very useful. ~~Tried to solve the problem~~

\* Inflow option gives same problem as converted PDF to epub  
\* Found a epub scientific book but useless ~~as~~ for equations.

\* PDF books are ~~not~~ possible to read but the margin is too much, so it could be possible to edit PDF file by using PDF editor & then check how it looks on Bebook.

- \* ① epub files only text to read (like novel etc.)
- ② no equations (or eq<sup>n</sup> as pictures)
- ② PDF (corrected one)

Or try to find processing of PDF to epub with Calibre such that equations, paragraphs don't get screwed.

## Friday 26<sup>th</sup> October

10:30 working on sandpack paper

12:45 lunch at Aula with Jurjen

1:45 working on paper

16:00 Koffie with Jurjen

16:30 Analysing the data

17:00 At home

19:30 Hockey

21:30 Shower

23:00 Salsa at Delfstede

00:30 Back at home

1:00 reading and sleep

## Saturday 27<sup>th</sup> October

11:00 At library working on analysis

working on literature study

1. make Effective viscosity vs permeability plot in Thesis (for coarse, fine & Bentheimer core sandpack)

writing ~~to~~ description of the table in notepad & save as text file in documents.

Reading about Statistics

- ① Descriptive statistics
- ② Inferential statistics

ANOVA, ~~line~~ Regression analysis (Origin?)

Try to study origin for 1. Regression analysis  
2. Multivariate system

monday 29th oct 2012

working on ~~sa~~ sandpack experimentation

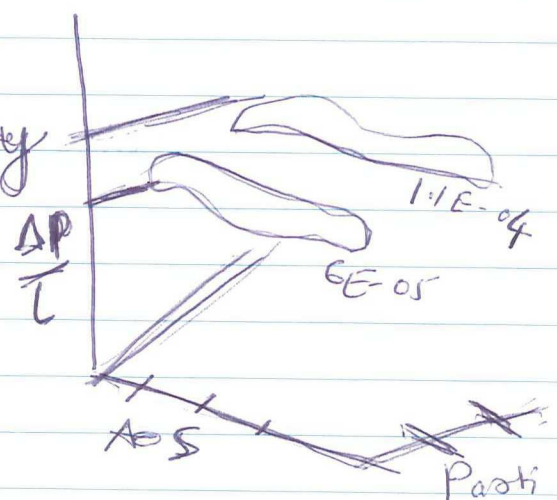
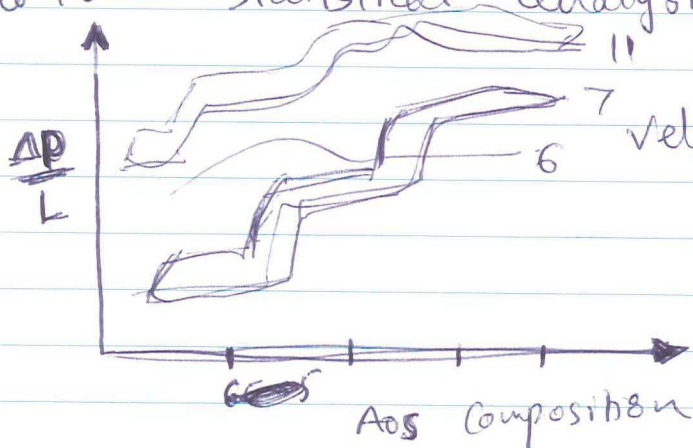
Did import technical diagram & setup ~~photo~~ images in LaTeX.

Restructuring results & Discussion issues.

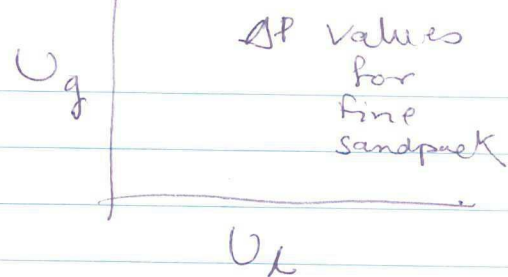
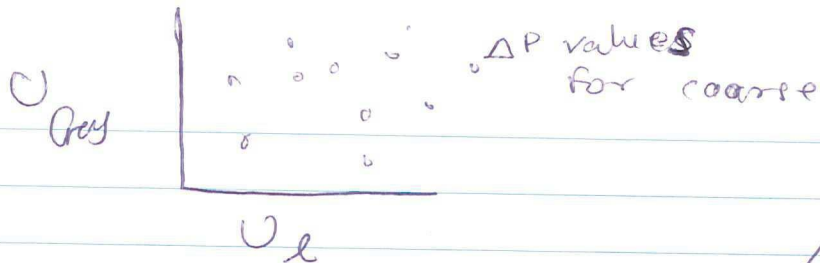
Tuesday 30th Oct 2012

Checking ~~sa~~ sandpack paper again.

Need to rephrase whole paper in appearance of new plots. The idea is to ~~to~~ first introduce summary of the result, then compare the results (which are comparable) and in discussion do the statistical analysis.







no not possible.

Wednesday 31<sup>st</sup> Oct 2012

Preparation of 0.1 M/L HCl sol<sup>n</sup>

~~93 ml~~ 1/10 part should be 1 ml/L

10 ml of 1 ml/L & 90 ml dd water

5 ml of 1 ml/L & 45 ml DD water ✓

Sample 0.04 w/w% Ash preparation from 30<sup>th</sup> March

789.6 ml DD

① step

2012  
788.9 + 2.6 + 7.4

+ 4. ml 0.1 HCl ③ step

+ 6.4 ml Krastev's sol<sup>n</sup> ② step

800 ml of ~~0.04~~ 0.04 w/w% Ash sample

791.5

+ 8.0

799.5

799.5 803.3

- 799.5

3.09 pH

03.8 ml + 2.6 ml = 6.4 ml 0.1 M HCl

Our sol<sup>n</sup> contains

121  
788.9 DD

6.4 ml 0.1 M HCl

8.0 ml Krastev's sol<sup>n</sup>

803.3

Time 14:12

for 1 hr

Starting experiment. First pushing at 42 ml/hr to make get ~~the~~ DD water out then wait again one hour before pushing the gas

Step 1. Start measuring Test 2012-10-31-066

PdTi, PdT2 = 32 mbar P1 0.04 P2 0.03

Mass balance is not working, but going forward anyway. By considering ml sol<sup>n</sup> in beaker

Step 2. Pushing the sol<sup>n</sup> Time 14:30



Pat1 9.3 Pat2 9.4 Pin 4.36 Pout 4.85 T = 15.4°C

15:30 ~~did~~: replaced beaker

~~beaker~~

Pushing gas at 14:30 but noticed that Gasflow meter is broken, so pushing the gas by guessing, probably higher than designed that is ~~2.426~~ <sup>2.126</sup> ml/min, but still OK as it does not really build to be ~~any~~ <sup>any</sup> foam.

B.T.W. seeing particles settle down despite stirring so trying to manually shake the input bottle to stir the particles.

17:00 100ml in beaker outlet

700ml in beaker inlet

So it would still take 14 or 15 hours to push the ~~part~~ solution.

{ need to repair mass flow controller }

18:00 around 80 mbar.  $\Delta P_r = \sim 65 \text{ mbar} \pm 10 \text{ mbar}$

measuring

1st Nov 2012 Thursday

8:00 shut off the ~~the~~ Ash experiment at 20°C

|                         | measuring pH       |      | mN/m (Std dev) | $\mu\text{S/cm}$ |
|-------------------------|--------------------|------|----------------|------------------|
| $\sim 18^\circ\text{C}$ | Outlet of Ash expt | 3.81 | 47.389 (0.184) | 141.3            |
| $\sim 18^\circ\text{C}$ | Inlet of " "       | 3.23 | 69.024 (0.031) | 230              |

EC measurement ref 20°C 11:30

|        |          |         |                        |
|--------|----------|---------|------------------------|
| Output | 26/09/12 | AOS     | 219 $\mu\text{S/cm}$   |
| Output | 21/09/12 | AOS     | 167.3 $\mu\text{S/cm}$ |
| Output | 09/10/12 | Perm    | 142.9 $\mu\text{S/cm}$ |
| Output | 18/09/12 | Perm    | 186.5 $\mu\text{S/cm}$ |
| Output | 22/10/12 | Perm    | 227.5 $\mu\text{S/cm}$ |
| Output | 10/10/12 | AOS-Ash | 373 $\mu\text{S/cm}$   |
| inlet  | 10/10/12 | AOS-Ash | 393 $\mu\text{S/cm}$   |
| Input  | 18/09/12 | Perm    | 317 $\mu\text{S/cm}$   |
| Input  | 09/10/12 | Perm    | 275 $\mu\text{S/cm}$   |
| Input  | 26/09/12 | AOS     | 366 $\mu\text{S/cm}$   |

cleaned <sup>Gas</sup> mass flow controller. 12:45

Flowing some  $N_2$  gas to clean it up.

(At Civil library 13:30)

Can we do 2 or 3 factorial experimental analysis using ~~experi~~ coarse sandpack expts. Can we manage about ~~the~~ liquid velocity, gas velocity & particle concentration.

3 factors

$3^2 = 9$  exp

weekends before presentation

Schedule couple of ~~days~~ to apply  $2^2$  or  $3^2$  design of expts to ~~our~~ our expts.

DOE analysis is the only way to study effect of interaction of various parameters

we need to find cases when we kept ~~other things~~ one variable constant while other varied and vice versa. Third & fourth case would be when both ~~cases are used~~ variables are changed

| $U_1$ | $U_g$ | P | Expt   |
|-------|-------|---|--------|
| 0     | 0     | 0 | ① Expt |
| 1     | 0     | 0 | ② Expt |
| 0     | 1     | 0 | ③ Expt |
| 1     | 1     | 0 | ④ Expt |
| 0     | 0     | 1 | ⑤ "    |
| 1     | 0     | 1 | ⑥ "    |
| 0     | 1     | 1 | ⑦ "    |
| 1     | 1     | 1 | ⑧ "    |
| 0     | 0     | 0 | ⑨ "    |

Check Han's table for calculation of  $SS_{AB}$

need to choose random effects model

need to find replicated experiments

Draw a graph with inlet pH, ~~EC~~ EC & S.T. as x axis (ordinate) & outlet pH, EC & S.T. as y axis (ordinate) And if you can relate them as pp. 116-117 from



direction & percentage of influence of that parameters. However we cannot neglect the terms if the variables are interrelated (like velocity & particle distribution)

(BP, Velocities, sandpack)  
literature survey effect of change of foam quality on  $\Delta P$  or app. viscosity.

"values of factors to be varied in the theory of experiments are called 'levels'".

check multiple experiment to see the variation within the experiments ~~for~~ with same parameters.

Thesis proposition "★

"The success of statistical analysis is determined by the rigour of the formulation of the problem"

(write down in the LaTeX)

②

we can use ANOVA to measure variance of each parameter separately. However when there is a interaction effect

Friday 2 Nov 2012

Response surface methodology is better than  $2^k$  factorial design

The problem with DOE is that I have already conducted experiments.

we can use  $2^k$  design to experiments course sand pack experiments from 14/02/11 to 23/02/11 where only  $U_g$  &  $U_L$  is changing.

Factors 2  $U_g$  &  $U_L$

level for  $U_g$ : e8, e13, e4, e9, e6 = 5 levels

level for  $U_L$ : f5, f6, f4, f2, f9 = 5 levels

$$2^5 = 2 \times 2 \times 2 \times 2 \times 2 = 32 \text{ expts}$$

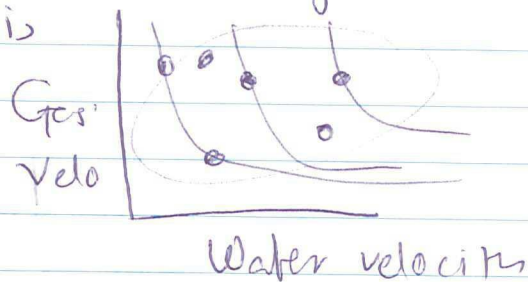
so we did 1/5th expt

6 expts + 2 repeat



Using DOE Statistical analysis to calculate  
relation b/w  $U_g$  &  $U_L$  on Pressure difference.  
--ce.

learning how to convert ~~xyz~~ plot matrix  
in contour line plots in Origin. In excel it  
gives surface graph which is difficult to  
interpret. It is not working with ~~origin~~ origin  
either. All I need is



finally managed contour plot with excel but result  
is ~~bit~~ unsatisfactory. ~~cannot~~ data is less or the  
excel is not good enough plot with such limited  
data. However it is different from our main  
goal of (DOE). But would be useful to produce  
such contour line data.

Monday 5th Nov 2012

working on paper correction. ~~end~~

Tuesday 6th Nov 2012

Send mail to AliEhsan about experimental plans.

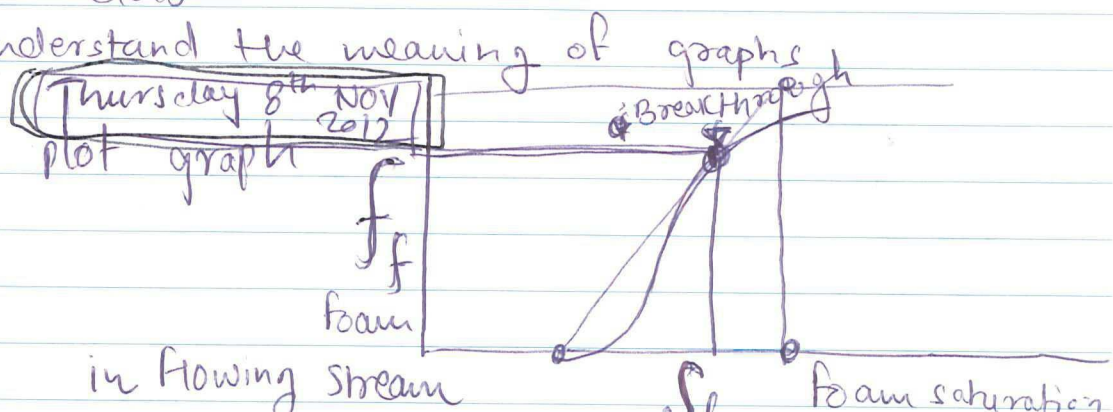
Wednesday 7th Nov 2012

Working on COMSOL

~~com~~ ~~an~~ Foamone : working, checking what sort  
of things it does

need to understand the meaning of graphs

need to plot graph



Now know what is weak form: you multiply a test function (say "test") to your equation & integrate the equation over the domain you are interested.

checking various functions  $K_{rw}$ ,  $K_{rg}$ ,  $s_e$ ,

$$\frac{-\text{perm} (K_{rw}(s) \cdot K_{rg}(s))}{\mu_{nw} + \text{foam}} * P_x (m_{sup}) z < 150 p > * s / kg$$

$$x - P_x$$

what we can do is to try with various permeabilities and use Pressure ~~readings~~ readings to ~~calculate~~ see the graph.

{ semi empirical approach to ~~design~~ simulate two foam flow process }

16:38 checked video of commutant PDEs: method of characteristics, its more like converting PDE in ODE with defining ~~initial~~ boundary conditions

17:00 Running foamone with  $P_{in}$  6E+5 after breakthrough  
from review book

fill breakthrough

$$f_w(s_w) = \left( 1 + \frac{K_{rw} \mu_{wo}}{K_{rw} \mu_{nw}} \right)^{-1} \text{ if } s_w \geq s_b$$

$$f_w(s_w) = f(s_b) \left( \frac{s_w - s_i}{s_b - s_i} \right) \text{ if } s_i \leq s_w \leq s_b$$

$\uparrow$                        $\uparrow$   
 saturation corresponding to the point the tangent line is drawn      initial saturation

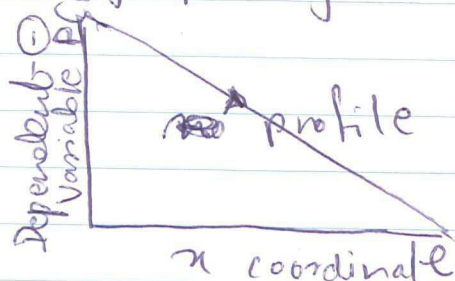
Saturation corresponding to the point the tangent line is drawn



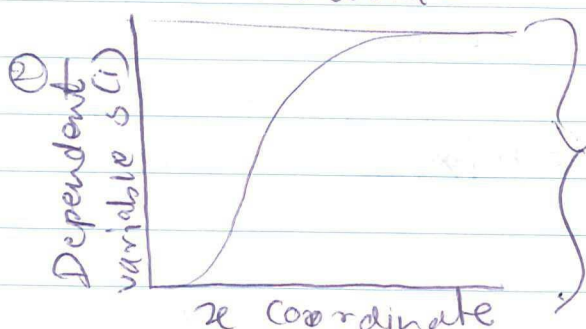
Friday 9<sup>th</sup> Nov 2012  
 worked in the morning on the sandpack expt paper

13:00 - Comsol understanding the program.

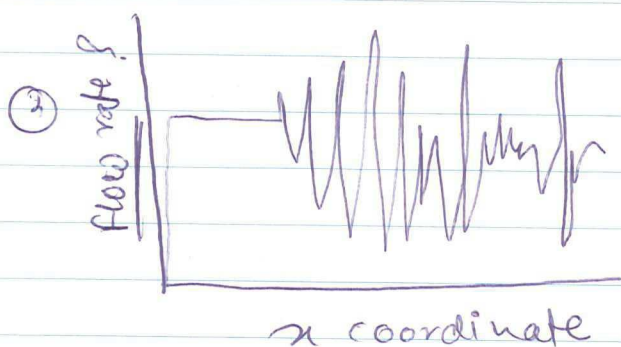
Four graphs generated



we need to see where this profile comes from ~  
 Decrease in pressure across the core



saturation profile



Compressibility eq<sup>n</sup>  
 or  
 fractional flow eq<sup>n</sup>  

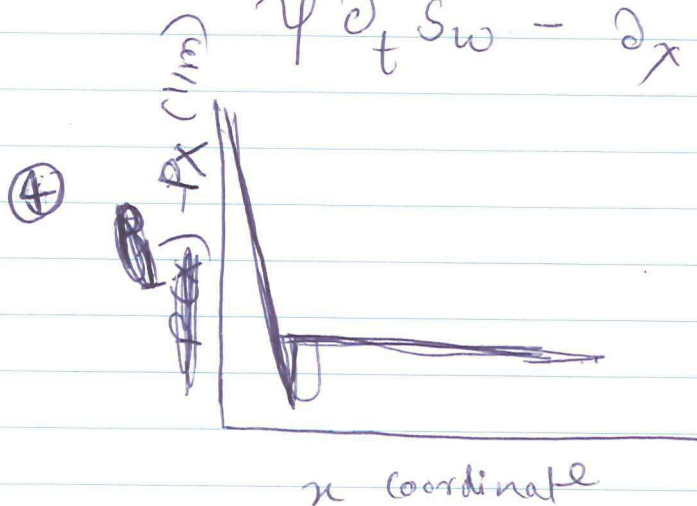
$$- \text{perm} * (K_{ro}(s) / \mu u + K_{rg}(s) / \mu u_{\text{foam}}) * P_x$$
 (m<sup>2</sup> \* s / kg)  
 unit

$$\frac{Q}{A} = \frac{k}{\mu} \frac{\Delta P}{L}$$

compressibility eq<sup>n</sup>

$$s_g \phi c_g \frac{\partial P}{\partial t} - \partial_x \left( \frac{K_g}{\mu_g} + \frac{K_w}{\mu_w} \right) \partial_x P = 0$$

$$\phi \partial_t s_w - \partial_x \left( \frac{K_{fw}}{\mu_w} \right) \partial_x P = 0$$





missing

21<sup>st</sup> Sept 12<sup>th</sup> Inlet : pH, EC & S.T.  
10<sup>th</sup> Oct mix Outlet : pH, S.T. ✓  
22<sup>nd</sup> Oct perm Inlet : pH, EC & S.T.  
22<sup>nd</sup> Oct perm Outlet : pH & S.T. ✓

Monday 12/11/2012

- ① control ~~working on various cases~~
- ② completing reading of theory from review

Tuesday 13/11/2012

working on ~~control~~ laser one again, checking the turbidity of ~~202 202 mixer~~ or toluene or other liquid and try to see if we can some reading worthwhile for the calculation

§ Succeeded in attaching phone to Eduram?

\* 11:54 Problem in measuring : MP3 program does not show sensors values.

\* 13:00 Called Paul but cannot really manage to make contact. Sent mail & waiting to see the mail.

15:00

PhD course

- \* Foam flow experiment
- \* explaining the important results
- \* theoretical explanation
- \*
- \*

Literature review

- \* Results shown earlier
- \* Results showing similar experiments
- \* Different parts

Academic contribution

- \* New development in foam flow experiment
- \* ~~Contribution~~
- \*

## activities I like

- ① ~~being~~ being with friends, eating drinking ②
- ② Hockey ③
- ③ Violin ⑥
- ④ salsa ⑦
- ⑤ Reading E-reader (books) ⑨
- ⑥ watching Tv ⑤
- ⑦ Being with family ①
- ⑧ learning Dutch ⑧
- ⑨ cleaning (sorting things) ④
- ⑩ ~~music~~ shopping ⑩

## work I like

- ① Doing expts
- ② Analysing results
- ③ Making presentation
- ④ Discussing result with colleagues
- ⑤ Discussing results with professor
- ⑥ Writing results & discussion
- ⑦ looking results
- ⑧ reading literature
- ⑨ developing model
- ⑩ Comparing modeling result with expts results

## To do list

- ① Working on console
- ② working on writing papers
- ③ working on laser equipment
- ④ ~~later~~ reading foamHow review
- ⑤ Making chapters for a thesis

first steps & accumulating



① shifted to downstairs 9:30

② waiting for Paul 10:30, called him but no response yet

③ Reading "Earth Science module" from COMSOL which contains foam flow examples through porous media

④ waited like two hours for Paul to come but did not work out (13:00)


working on paper, especially filling Bentheimer experiments till 15:00

15:00 ~~was~~ working on COMSOL

① Taking print of graphs & conditions for Bentheimer core conditions

② 15:15 Running coarse sandpack conditions with 1700 Darcy  $\phi = 0.38$   $\Delta P = 4$  bar length = 15 cm

$$\frac{\Delta P}{L} = \frac{4}{0.15} = \frac{400}{15} = 26.7 \frac{\text{bar}}{\text{m}}$$



So it is OK to have 4 bar or 2 bar

③ fine sand pack for expt test @ 0.0375 AOS  
6 m/s  $\sim 1500$  mbar/m so  $1500 \times 0.15$   
 $= 225.0$  mbar  
 $= 0.225$  bar across

so Atmospheric Press 1 bar  $P_{out}$   
then Inlet pressure  $1 + 0.225 = 1.225$   $P_{in}$

$\phi = 0.3$  Darcy  $\sim 137$  D length 15 cm

This is taking long time wrt. first core of Bentheimer stone.

16:28 it is still taking time, so we will make it run for the night.



read Mechanistic model approach: Bubble population Balance model. 16:30

17:30 Calling off the day: Comsol model till 31% running & we will come in the morning & check.

Thursday 15 Nov 2012

Chris's lecture Ma 2012 Rice University

~~Plotting~~ saving plots in comsol file for fine sandpack.

11:15 making excel sheet of attendees for PE meeting

Lecture from Core van <sup>Cruysdijk</sup> ~~de~~ on EOR 12:30 - 2:10

① van lingen 1998  $\leftarrow$  WAG process in 2008

② Bart suijkerbuijk

③ Direct hydrodynamic interaction

## Digital Rock workflow

15:00 Printed graphs; coarse sand pack expts ~~are bit~~  $S$  vs  $x$  is erratic, not sure what is happening there.

\* The problem of this model is that it ~~doesn't~~ ~~build~~ considers foam with certain viscosity at the beginning. However in reality foam build up after some time a steady state process where you say that it is a fluid with constant ~~de~~ viscosity.

// Assumptions //

\* we assume foam viscosity is constant

\* 
$$- \text{Perm} \times \left( \frac{K_{rw}(s)}{\mu_{uw}} + \frac{K_{rg}(s)}{\mu_{\text{foam}}} \right) \times p_{xx}$$
 function is

$$\text{Perm} \left( \frac{k_{rw}}{\mu_{uw}} + \frac{k_{rg}}{\mu_{ufoam}} \right) \Delta P x$$

$$\frac{1}{m^2} \left( \frac{m^2}{\frac{Ns}{m^2}} + \frac{m^2}{\frac{Ns}{m^2}} \right) m^2 \cdot m$$

$$N = \frac{kg \cdot m}{s^2} \quad \frac{m^2}{Ns} \cdot m$$

$$\frac{m^2}{\frac{kg \cdot m}{s^2} \cdot s} \times m$$



$$\frac{m^2 \cdot s}{kg} \quad \text{so it is right what Hans did}$$

But what kind of ~~set~~ function is this?

Hans has applied Brooks-Corey relations ~~at saturation~~

$$\begin{aligned} \text{Real perm to water } k_{rw} &= k'_{rw} S_{we}^{\frac{2+3\lambda}{\lambda}} \\ \text{Real perm to gas(foam)} k_{rg} &= k'_{rg} (1 - S_{we})^2 (1 - S_{we}^{\frac{2+3\lambda}{\lambda}}) \end{aligned}$$

$$\text{Water saturation at given time } t \quad S_{we} = \frac{S_w - S_{wc}}{1 - S_{wc} - S_{gr}} \quad k'_{rw} = \frac{1}{2} \quad k'_{rg} = 1$$

When  $k'_{rw}$  perm of water at irreducible saturation of gas

$k'_{rg}$  perm to gas at irreducible saturation of water (at  $S_{wc}$ ?)

(wettability &  $P_c$  in porous media PDF from Older Hans / Books)

**Friday 16 Nov 2012**

making a document of understanding so far in LaTeX



# PE meeting schedule

January 17,  
June 13

February 14,

March 14,  
Fatemi

Christian  
April 11, May 16,

Mohammad C, Megar, Roozbeh, Anna,

Saturday 17<sup>th</sup> Nov 2012

Arrangement of Pr data 11:00 - 14:00

Sunday 18<sup>th</sup> Nov 2012

Arrangement of files / document 11:00 - 12:30

Monday 19<sup>th</sup> Nov 2012

Laser work in the morning 9:30 - 12:30

13:30 working on writing of Hans model & understanding of foam flow theory.

$$\phi \cdot \frac{\partial S_w}{\partial t} = \frac{\partial}{\partial x} \left( D \frac{\partial S_w}{\partial x} \right) - q_t \left( \frac{df_w}{dS_w} \right) \left( \frac{\partial S_w}{\partial x} \right)$$

$$\phi \frac{\partial S_w}{\partial t} = -q_t \frac{df_w}{dS_w} \cdot \frac{\partial S_w}{\partial x} \frac{dx}{dt}$$

$$\phi \frac{\partial S_w}{\partial t} \cdot \frac{dx}{dt} = -q_t \frac{df_w}{dS_w} \cdot \frac{\partial S_w}{\partial x} \frac{dx}{dt}$$

$$\phi \frac{dx}{dt} = -q_t \frac{df_w}{dS_w}$$

$$\phi dS_w \cdot dx \cdot dt = -q_t \cdot dt \cdot df_w$$

$$\phi S_w$$



wednesday 21st Nov 2012

|                                |                            |      |
|--------------------------------|----------------------------|------|
| Outlet perm 22/10/12           | S.T.                       | pH   |
| <del>Outlet mix 10/10/12</del> | 35.496 std dev. 0.382(15°) | 3.42 |
| Outlet mix 10/10/12            | 28.460 std dev. 0.075(15°) | 3.47 |

Repeat of monday 22nd oct 2012 perm procedure

13:00 Flowing around 50 ml Ethanol at 50 ml/hr BP 3 bar  
Test 2012-10-21-067

13:40 Preparation of pH

495 6.15 pH 4.7 ml 0.1M HCl  $\Rightarrow$  499.7 ml of  
2.96 pH

14:13 Pin 5.24 Pout 5.20 PdTI 17.3 PdT2 17.1

14:17 30 ml in Exhaust waiting to get stability  
Stopped recording

14:28 Co<sub>2</sub> push for 5 minutes // Not recorded

14:33 stopped Co<sub>2</sub> & Flushing DD water at 50 ml/hr  
waiting to get 20 ml in beaker & then remove  
the ~~stop~~ beaker as Ethanol. // Not recorded

15:20 changed solvent after 50 ml Ethanol  
running it for ~~one hour~~.

starting the water test ~~15:00~~ 16:00

~~PdTI PdT2~~

| flowrate             | PdTI | PdT2 | Pin | Pout | mass | Temp | Time |
|----------------------|------|------|-----|------|------|------|------|
| <del>4.90</del> 4.89 |      |      |     |      |      |      |      |

|   |     |     |      |      |   |      |       |
|---|-----|-----|------|------|---|------|-------|
| 0 | 0.5 | 0.2 | 4.90 | 4.90 | 0 | 14.2 | 16:00 |
|---|-----|-----|------|------|---|------|-------|

50

changed BP to 2.5 bar / waiting to get stability

| Flow rate | Pd T1 | Pd T2 | P1   | P2   | Temp | Time  | m |
|-----------|-------|-------|------|------|------|-------|---|
| 0         | 1     | 2     | 3.27 | 3.27 | 14.4 | 16:12 | 0 |
| 50        |       |       |      |      |      |       |   |
| 100       |       |       |      |      |      |       |   |

We need to flow around 50 ml water before doing the expt. So it is decided to continue till 17:00 hrs at a rate of 50 ml & then stop the expt. & Tomorrow morning do the test permeability.

Donderdag 22<sup>nd</sup> Nov 2012

| Flow rate | Pd T1               | Pd T2 | P1   | P2   | Temp | m      | Time  |
|-----------|---------------------|-------|------|------|------|--------|-------|
| 0         | <del>17.8</del> 7.8 | 7.0   | 1.7  | 1.7  | 13.4 | 1.57   | 9:15  |
| 50        | 15.2                | 14.5  | 4.51 | 4.48 | 13.5 | 18.59  | 9:45  |
| 100       | 26.0                | 25.4  | 4.52 | 4.48 | 13.9 | 63.95  | 10:15 |
| 150       | 35.1                | 33.5  | 4.56 | 4.45 | 13.9 | 204.35 | 11:15 |
| 200       | 44.1                | 43.8  | 4.50 | 4.44 | 14.4 | 304.14 | 11:45 |

Test 2012-11-670

Talked with Hans 10:45-11:15, More focus on laser setup  
& on comsol

meeting with Hans  
comsol model fabrication  
gas constant 8.34 J/mol K

$$\int \partial_x \left\{ \left( \frac{k_g}{\mu_g} + \frac{k_w}{\mu_w} \right) P \partial_x P \right\} x dx \quad \left. \vphantom{\int} \right\} \text{Int. by parts}$$

$$\int (u'v)' = \int u'v + \int uv'$$

$$uv = \int u'v + \int uv' \Rightarrow \int u'v = uv - \int uv'$$

21:40 Adding diffusion term (smaller  $\rightarrow$  longer time)

21:45 running 10 sec

IF reciprocal of step size goes up then it will take long time to converge

Time dependent solver

changing  $K_{rw}$  ~~properties~~ boundary

conditions

[22:26]

$$u_w = - \frac{k_w}{\mu_w} \frac{\partial p}{\partial x}$$

$$u_g = - \frac{k_g}{\mu_g} \frac{\partial p}{\partial x}$$

$$\frac{\partial p}{\partial x} u_w + u_g = - \left( \frac{k_g}{\mu_g} + \frac{k_w}{\mu_w} \right) \frac{\partial p}{\partial x}$$

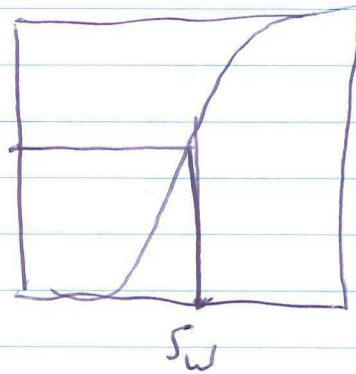
$$\frac{- \textcircled{\bar{u}}}{\frac{k_g}{\mu_g} + \frac{k_w}{\mu_w}} = \left[ \frac{\partial p}{\partial x} \right] \textcircled{\phantom{0}}$$

$$\frac{\partial}{\partial t} ( ) + \frac{\partial}{\partial x} \left\{ \right\} = 0$$

$$u_w = u$$

Figure

$$\textcircled{0.5} \rightarrow \underline{0.9}$$



① why  $S$  is  $\neq 1$  at the end of the process

② flow rate

③ Breakthrough



23 Nov 2012 Friday

10-11:00 Correction in LaTeX-modelling program

11:00-12:00 Filling the gap S.T.p; Ec. & pH

Unknown — 4.45 pH

Input 22 Nov 12 Perm — 2.096 pH

Output 22 Nov 12 perm — 3.89 pH,  $40.639$  ( $0.604$ ) ( $18.5^\circ\text{C}$ )

24<sup>th</sup> Nov 2012 Saturday

10:30-14:00 worked on abstract, selected colloidal stability as a topic, next weekend complete the abstract and send it to people.

26<sup>th</sup> Nov 2012 Monday

9:30 laser work: try to see if we get some signal from AOS-Ash mix to make it work.

with laser on through cuvette,

10:46

S1 10.612 S2 6.013

with AOS-Ash mix 2.92 S2 6.024

Very feeble laser light is shown upon the sensor & it turns out to be 6.024-6.029 fluctuation. 11:00

Try to change the position of ~~the~~ cuvette but it is still not giving higher signal than 6.024.

no. given are 6.024, 6.029, 6.031, 6.034, 6.021  
trying to get the signal with milk again

more or less stabilisation 6.034-6.044

Stopping the work 12:00

without laser it gives the same signal of 6.034

sol<sup>n</sup> { ~~the~~ fix the position of fixtures with milk & then replace it with AOS-Ash sol<sup>n</sup> }

Tomorrow

Agenda  $\leftrightarrow$  SASDeHtc@gmail.com

Preparation of ~~Aos~~ Samples for bulk fluid tests

|             |       |       |
|-------------|-------|-------|
|             | 80 ml | 80 ml |
| Ash         | 6     | 7.5   |
| Aos-Ash mix | 6     | 7.5   |
|             | 80 ml | 80 ml |

Preparation of the sample // Tuesday morning

|       |        |               |
|-------|--------|---------------|
| Total | 160 ml | - Aos-Ash mix |
| Aos   | 80 ml  | - 0.075 w/w % |
| Ash   | 80 ml  | - 0.08 w/w %  |

To prepare Aos 160 ml 0.075 w/w %.

80 ml 0.3 w/w %  
+ 80 ml dd water  $\Rightarrow$  80 ml 0.15 w/w %  
+ 40 ml dd water  
80 ml 0.075 w/w %

so 20 ml 0.3 w/w % of 80 ml dd water

Reference from 7<sup>th</sup> June

①

To prepare Ash sol<sup>n</sup> for Aos-Ash mix

~~0.64~~ 0.64 ml of Krastev's sol<sup>n</sup> & 39.78 dd water  
0.08 w/w %.

② Same procedure as above

To prepare ash only sol<sup>n</sup>s

② ~~0.64~~ 0.32 ml of Krastev's sol<sup>n</sup> & 79.4 dd water  
& ~~0.64~~ 0.32 ml of Krastev's sol<sup>n</sup> & 79.4 dd water

③

To prepare ~~Aos only~~



Note take care about pH, we might need to shake them after preparation

$$\begin{array}{rcl} \textcircled{1} & & \\ 39.5 & 0.075 \text{ w/w} & \\ 0.7 & \text{praster's sol'n} & \\ \hline 41.2 & \text{DI water} & \\ \hline 41.4 & 9.85 \text{ pH} & \\ + 0.2 \text{ ml } 0.1 \text{ M HCl} & & \\ \hline & 5.5 \text{ pH} & \end{array}$$

$$\begin{array}{rcl} \textcircled{2} & & \\ 39.6 & & \\ 0.7 & & \\ \hline 39.2 & & \\ \hline 39.5 & & \\ + 0.1 \text{ M HCl} & & \\ \hline & 7.2 \text{ pH} & \end{array}$$

$$\begin{array}{rcl} \textcircled{3} & & \\ 0.4 & \text{praster's sol'n} & \\ 82.8 & \text{DI water} & \\ \hline 83.2 & & \\ + 0.2 \text{ M HCl} & & \\ \hline & 6.0 \text{ pH} & \end{array}$$

$$\begin{array}{rcl} 0.4 & \text{praster's sol'n} & \\ 79.2 & \text{DI water} & \\ \hline 79.6 & & \\ + 0.1 \text{ M HCl} + 0.1 \text{ M NaOH} & & \\ \hline & 6.9 & \end{array}$$

11:20 Samples were ~~shaked~~ shaken for 15 min

13:20 testing of samples for EC, fST

13:25 Ash only 6.8 pH degasing (5 min)

Testing stopped because of propane leakage in the lab.

Tomorrow the work at ChemTech would be done.

~~Wednesday~~ Wednesday 28 Nov 2012

work at ChemTech

Zeta potential & Size measurement on the same sample

Open Malvern Zeta potential software

Open file measurement data .DTS file



Ash - 6 pH 2

Ash - 6 pH 3

1013

970

### ZP measurement

Ash - 6 pH 1 -18.5

Ash - 6 pH 2 -18.1

Ash - 6 pH 3 -18.7

### Size number mean dia

Ash - 7 pH 1

851

Ash - 7 pH 2

1791

Ash - 7 pH 3

883

} Did not  
ultrasonicate

### ZP measurement

Ash - 7 pH 1

-16.7

Ash - 7 pH 2

-16.5

Ash - 7 pH 3

-17.9

### Size number mean dia

~~Ash~~ mix - 5.2 pH 1

378

mix - 5.2 pH 2

153.6

mix - 5.2 pH 3

120

### ZP measurement

mix - 5.2 pH 1

-38.4

mix - 5.2 pH 2

-37.8

mix - 5.2 pH 3

-35.3

### size number mean dia

mix - 7.2 pH 1

216.2

mix - 7.2 pH 2

316.7

mix - 7.2 pH 3

176.7

### ZP potential

mix - 7.2 pH 1

-35.5

mix - 7.2 pH 2

-34.9

mix - 7.2 pH 3

-36.5

②

Saved data in D:\rahul: 281112

~~Size~~ → Size : → Volume

ZP : → ZP distribution, Intensity

Other modules (for size): number distri. mean  
~~are not~~ shows <sup>(VB)</sup> error upon clicking. ~~Talked~~  
Need to talk to Roman

16:30 - 18:00 made ~~cor~~ addition in EC, ZP, PZ graphs.

~~10:30~~

Thursday ~~28~~ 29 Nov 2011

10:30 working on scheduling

13:30 - 14:30 work on laser

① laser on sensor does not give sufficient signal  
② Toluene sample does not show ~~laser~~ visible laser ~~ref~~ scattering.  
Vandana

meeting with Hans 28:00

As does not change zeta potential

Landolt bornstein

Beilstein ↔ Handbook of organic chemistry.  
Libgen.info

Laser scattering by Tarasov

(Remove the foam part zeta potential studies paper)

\* More work on the understanding

\* lecture shifted to 17 Jan

COMSOL

: changing pressure but not the pressure difference



Results into full saturation each (i)

22:37, geometry change, mesh change,

22:45 Adaptive mesh refinement

Try to understand  $U_g / U_w$

①  $-k r_w (s) * P_x / \mu u_w$

Data set

Solution 2

②  $-k r_g (s) * P_x / \mu u_{foam} U_g$

Selection

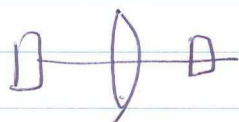
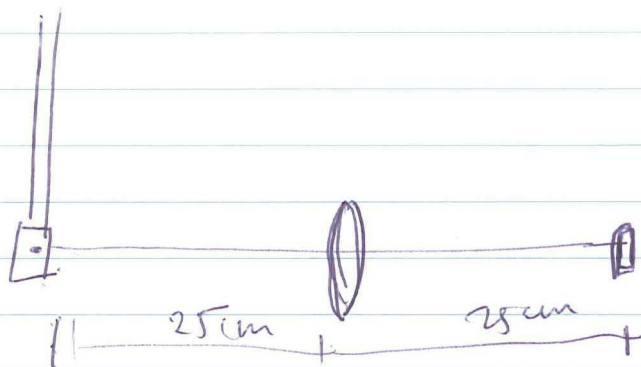
last

f  $\frac{②}{①}$  Graph  $\frac{U_g}{U_w}$

check how it graphs

12:30 Putting things very close, then we get some signal for pH 4.12 pos-ABH mix & it is sure that it decreases with respect to time

laser\_2012-11-30\_025



11:01 measuring

laser\_2012-11-30\_026

Mix 2.92

we do get good signals with this arrangement  
(lens & detector close to cuvette)



Monday 3<sup>rd</sup> Dec 2012

10:00-14:00 ~~Replaci~~ Shifting ~~laser~~ laser setup from Joost's lab to 1<sup>st</sup> Floor.


13:00-17:00 Writing the result

Tuesday 4<sup>th</sup> Dec 2012

10:00-12:30 Working on safety report

13:30- Setting laser equipment

Recording bar click 6.093

at  when full managed Sensor 2  
laser-2012-12-04-027 10.60g  
High sensitivity

When <sup>laser</sup> not put on  low sensitivity 6.095  
6.095

Found some result different than upper or lower cases @ 6.5 - 6.7 around 700 sec after starting experiment. Use the same result to ~~calculate other results~~ configuration

Wednesday 5<sup>th</sup> December 2012

Sintklaas Day

Working with UV-vis at ChemTech  
Using procedure from 18<sup>th</sup> June

- ① Rinse cuvettes
- ② Edit method → wave length, speed
- ③ UV2-33 → ~~so~~ connect → make baseline (without anything inside)
- ④ Reference sample milipore water

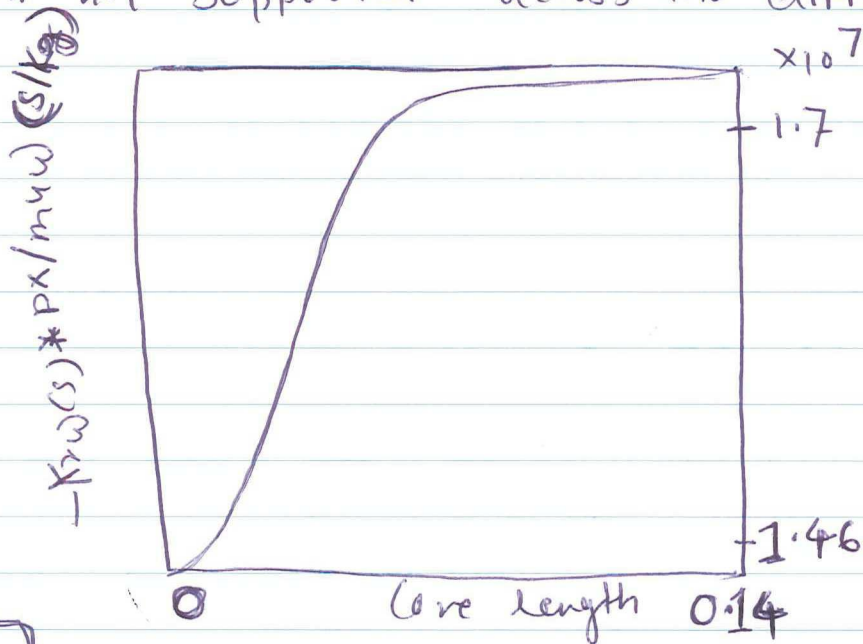
| Sample                | Time start | measure | Duration Time (sec) | Spectrum |
|-----------------------|------------|---------|---------------------|----------|
| Ash-6pH               | 11:54      | 3       | 1200                | +ve      |
| Ash- <del>6</del> 8pH | 12:55      | 3       | 1200                | +ve      |

reading from stability of aqueous silica  
nanoparticle dispersions 10:30

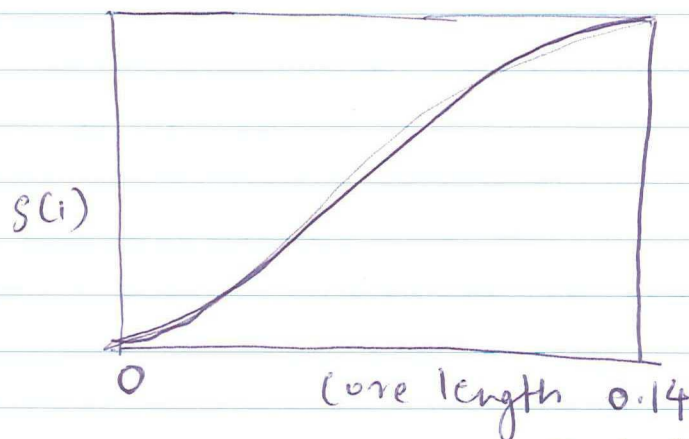
making corrections in the excel of yesterday's  
experiment 13:30

① working on COMSOL ~~with~~ / running the last  
program by Hans. finesandpackg 15:40

\*Evaluation not supported across the different  
meshes



What are  
solution 1  
& solution 2  
in this case



② Trying to get the results from <sup>Data set</sup> solution 1 15:54

In the model builder, there are ~~\*~~ in the  
~~the same way~~ graphs,  
∴ we get some results when data set is  
changed to ~~per~~ solution 1 or solution 2

called at home 16:30

trying to understand some results like solution 1, solution 2 etc.

structure of ~~an~~ a model

① Assumptions

② Approximations

Friday 7 Dec 2012

10:00 - working on paper

~~set~~

18:00 Printed paper for correction

Saturday 8th Dec 2012

10:30 - 13:30 - library working on correction of paper

Sunday 9th Dec 2012

13:30 - 15:30 Corrected the paper,



10:00 Working on CS<sub>2</sub> with laser

11:01 Could not get any signal with ~~any other~~ changes

Afternoon was spend on getting programs fixed on laptop

Tuesday 11<sup>th</sup> Dec 2012

10:00 - 12:00 Corrections in the paper

12:30 - 15:30 making VPN connection / COMSOL 4.3a work.

Wednesday 12<sup>th</sup> Dec 2012

10:00 - 12:00 Correction in the paper

13:30 - Working on laser issue looking into theoretical thing.

| We use 632 nm laser from Finnigan |                |               |                            | Depolarisation ratio |
|-----------------------------------|----------------|---------------|----------------------------|----------------------|
|                                   | $\lambda$ (nm) | $T(^{\circ})$ | $R(g^{\circ}) \times 10^6$ | Leite (1965 PRL)     |
| Toluene                           | 632.8          |               | 8.77 $\checkmark$          | 0.359 $\pm$ 0.017    |
| CCl <sub>4</sub>                  | 632.8          |               | 3.1 $\checkmark$           |                      |
| CS <sub>2</sub>                   | 633.7          | 22            | 32.9 $\checkmark$          |                      |

3:36 Toluene laser 2012\_12\_12\_028

Constant signal of 6.029 - 6.034

Same problem after taking off laser, signal

$\otimes$  still shows 6.021 - 6.034

you get the ~~relect~~ signal only when lens & collector is very close.

15:55 Found some signal at placing lens close & collector at 25 cm. But not sure if it is due to scattering or light due to ~~to~~ somewhere else (refracted or so)

laser\_2012\_12\_12\_029

round 7.5 signal seems to stabilise

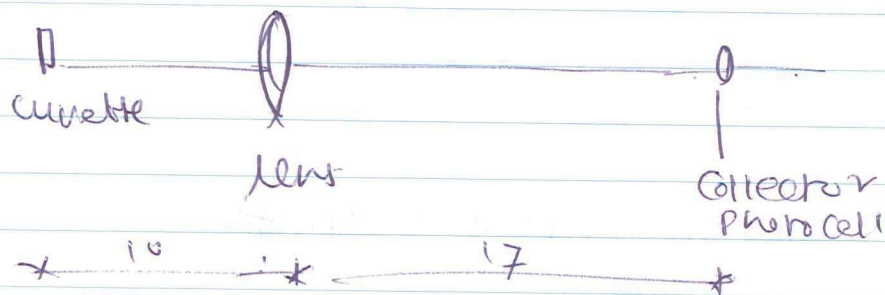
16:49 Sensor shows increase in signal (no idea what is happening)

Test-2012-12-12-030 we get the signal at distance of 25 cm (same as before)  
7.000

17:42 Stabilising @ around 6.643

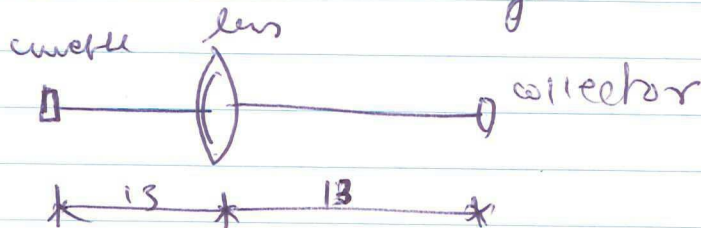
17:38 Another expt ~~7:38~~ later-2012-12-12-031

Showing similar 7.5  shape



Tomorrow check with 25 cm focal length lens because the one we use now is cheap & does not have  $f_c$  known (possibly 10 cm)

~~18:08~~ 18:08 Another reading 7.5



Also check for our sample, the result

- ① 25 cm length lens
- ② Our sample to compare
- ③  $\text{CHCl}_3$ , or  $\text{CCl}_4$

} Thursday

The trouble was with lens.

~~Eclp~~ ① Eclipse

② MORES

Miscible gas gives more EOR than immiscible

Pentheimer core perm 1.34

~~Try to~~ ask Bill about ~~Record~~ & voice recorder

We do not inject air because combustion could be the problem.

~~Residual~~ oil saturation - Bill

GOGD - Gas oil gravity drainage

Contact angle : how to manage tolerance in measurement

Surface free analysis  $\longleftrightarrow$  wettability

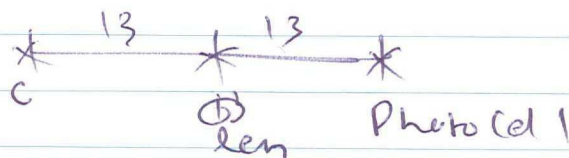
Talk with Hans : concentrate on

① Toluene,  $\text{CHCl}_3$ ,  $\text{CCl}_4$

② Our sample (1)

~~Test 0~~ Test\_2012-12-13-035(1) Toluene

12:00



13:35

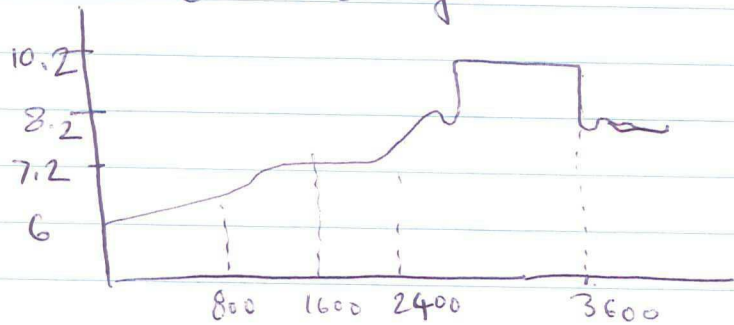
Stabilised around 7.031 for given lengths

Stopping the experiment



CS<sub>2</sub> 13:30

increasing from ~~6.1 to 8.2~~ 6 to 8.4  
in the meanwhile we get

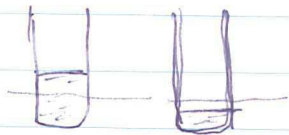


Consider till 1800 only, as CS<sub>2</sub> is getting  
evaporated so around 7.2, ~~we can consider~~

Sample 10<sup>th</sup> oct 2012 AOS-Ash mix 12\_13\_037 8.038  
full signal at 25 cm length.

~~Test~~

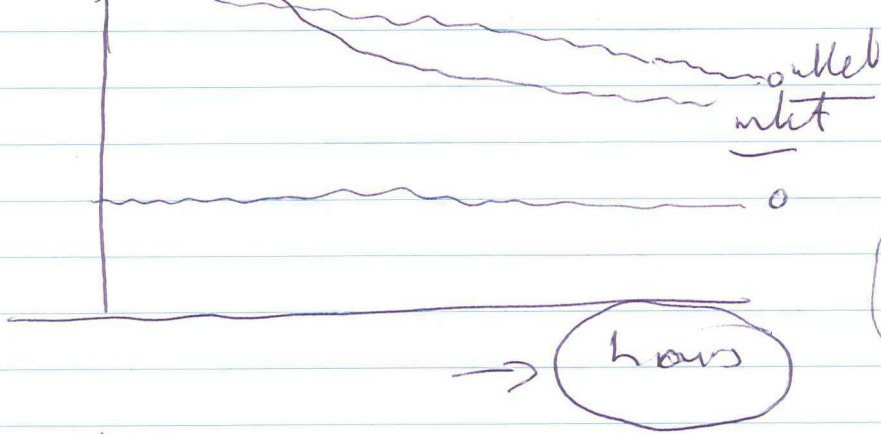
|            |                   |              |       |
|------------|-------------------|--------------|-------|
| 35         | Toluene           | 7.2 - 7.5    | 13 cm |
| test 36    | CS <sub>2</sub>   | 8.4 - 8.5    | 13 cm |
| test 37-38 | AOS-Ash mix-Inlet | 10.6 Highest | 13 cm |
| test 39    | outlet            |              | 13 cm |



Add the ~~the~~ polarizer

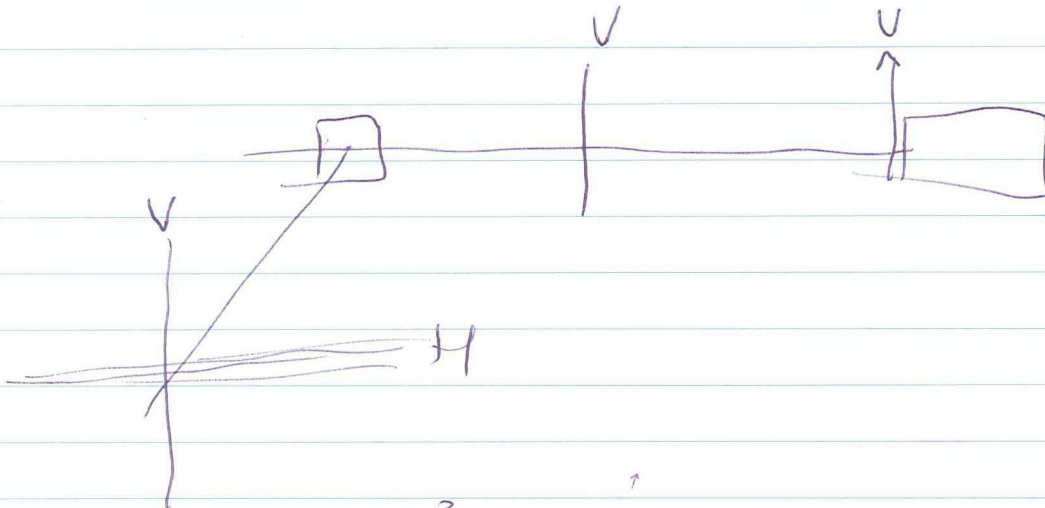
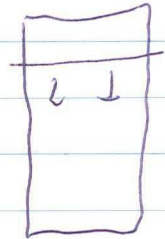
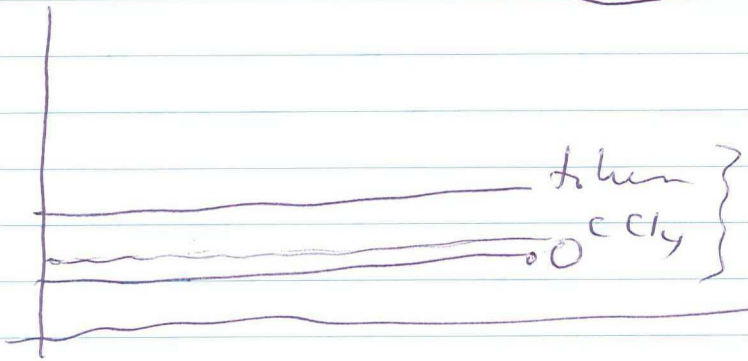
measure zero line, measure cell, once again

CCl<sub>4</sub> 6.08  
Toluene 7.0



$$v = \frac{\frac{4}{3} \pi r^3 \rho g}{\eta}$$

1  $\mu$

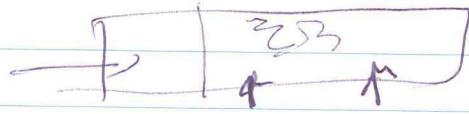


$$\frac{4\pi}{3} \rho R^3 g$$

$$6 \pi \eta r$$

$$k = C Z = \frac{1}{150} \frac{\varphi^3}{(1-\varphi)^2} \frac{d_p^2}{\eta} \approx \frac{\varphi v^2}{\rho}$$

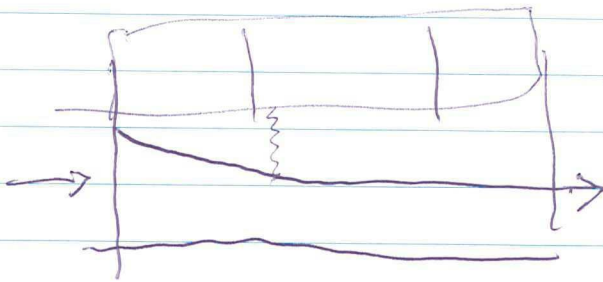
1) There is a filter cake



Pavel

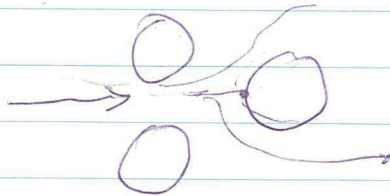
??

where are particles settling?  $\Leftarrow$



particles in the pump  
evidence)

( $\Leftarrow$  no circumstantial



a) Pressure decline with added particles  
is somewhat larger than without

b) Particles are settling.  $\Leftarrow$

c) Trap  $\rightarrow$   $\S$   $\rightarrow$   $\S$

d) COMSOL  $\rightarrow$

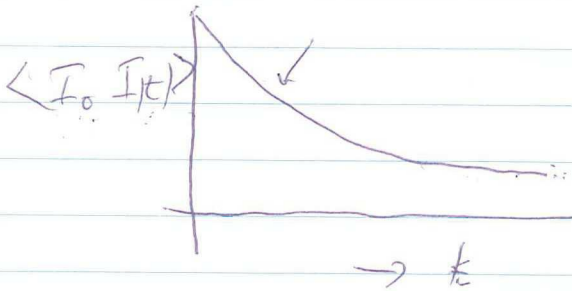
$\Leftarrow$  equilibrium time is due to compressibility.



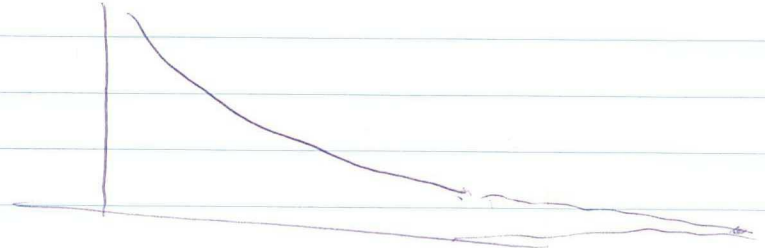
$$\frac{dI}{dx} = -kI$$

$$\ln I_0/I = -kx$$

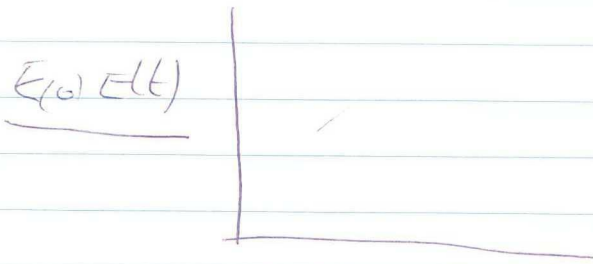
$$= -kcn$$



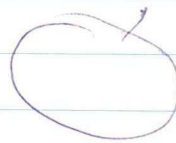
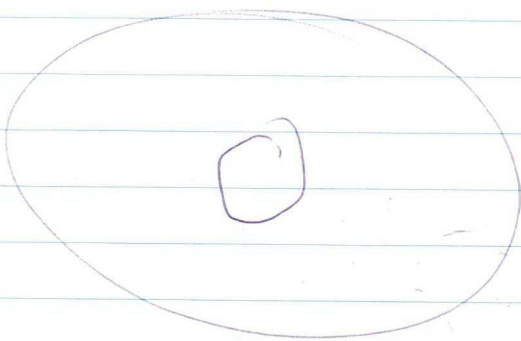
$$P(x) = \exp(-x) + \exp(-2x)$$



$$\textcircled{D} = \frac{kT}{6\pi\eta r}$$



heterodyne  
homodyne



Refraction from conglusions

\* Barbara ~~Fass~~ Thuss

\* steric repulsion - Israelichvili

\* Avoid adaptive mesh refined

\* ~~Can~~ Avoid ~~s=0 or s=1~~  $1-s=0$  22:45

21st Dec 2012 Friday India

~~4pm~~ 3:30 working on the presentation of 17th Jan

~~the~~ Bond between

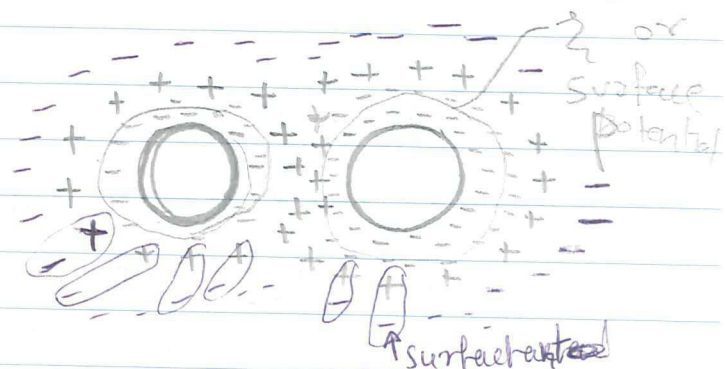
- ① ~~Need to explain mechanism~~ Colloidal stability in bulk to foam flow ~~the~~ effect of particles
- ② ~~what kind~~ parameters affecting the stability of ~~the~~ colloidal particles in bulk fluid  
pH, electrolyte, surfactant
- ③ Which are the "Symptoms" Characteristics & how can we measure them ~~again~~ use Krastev's photos
- ④ Zeta potential, electrical conductivity, response to light, response to laser, surface tension, particle size
- ⑤ zeta potential: Definition, applicability, results, interpretation; <sup>sort of</sup> conclusion
- ⑥ electrical conductivity is  $\frac{1}{\kappa} \quad \frac{1}{\kappa} \quad \frac{1}{\kappa}$

⑦ Particle size

⑧ Surface-tension

⑨ particle size (result)  
slide in Discussion  
Stability at 3 pH

22nd Dec 2012 Saturday

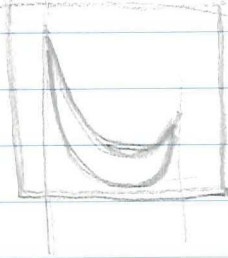


(result)

slide in discussion / Particle size measurement

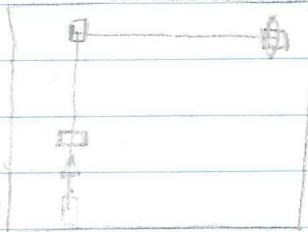
varying pH does not affect aggregation in case

higher



slide about AOS surfact & charge

slide about laser set up & description



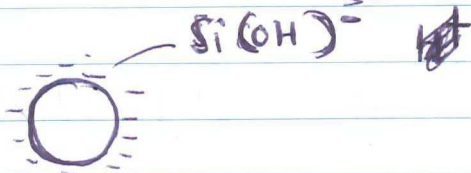
Total 4 hrs spent

← 23<sup>rd</sup> Dec 2012 → Sunday.

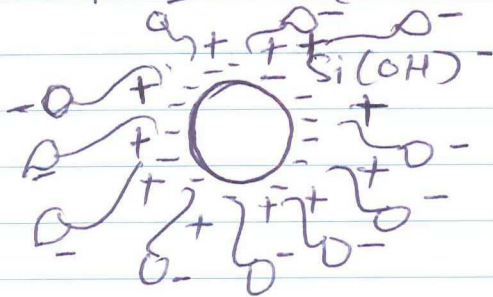
We are already in micelle formation case.

Reading Ger Koper's book

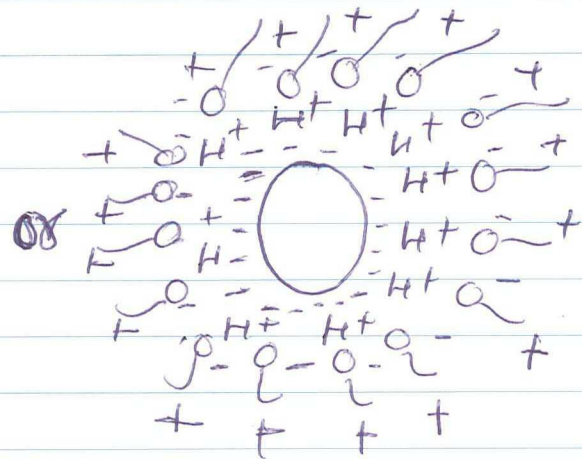
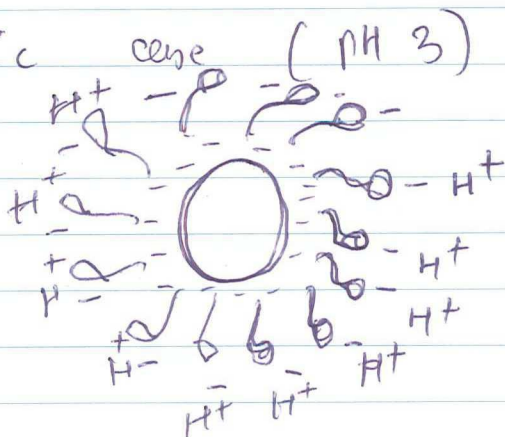
Interaction between surfactant & particles.



In Neutral case (no  $\text{H}^+$  or  $\text{OH}^-$  ions)



In acidic case (pH 3)





side Tyndall effect & light scattering  
to explain laser scattering // hidden slides

|                 |                      |                                 |
|-----------------|----------------------|---------------------------------|
| Bulk<br>Studies | Flotation<br>Studies | Foam Flow<br>in porous<br>media |
|-----------------|----------------------|---------------------------------|

use of surface tension for flotation studies & then to understand foam flow with particles in ~~porous~~ porous media.

$$\gamma_{SV} - \gamma_{SL} - \gamma_{LV} < 0 \quad \gamma_{SV} < \gamma_{SL} + \gamma_{LV}$$

for flotation to occur the surface tension of S-V interface is to be smaller than the sum of S.T. of S-L & L-V interfaces

Total 2hrs study

Zisman's expt work Contact angle ~~decreases~~ with decreasing liquid vapour surface tension.

11:15 Possibly a slightly better knowledge of mechanical engineering is required for making public opinion, but the process is the same.

Both can be stamped out in the quantity required, and delivered anywhere to order.

{The behavior of crowds 27/193}

Hence the crowd is a device by which the individuals "right" may be baptized "righteousness" in general, and this personality by putting on ~~per~~ impersonality may rise again to new levels of self-appreciation. He "belongs to something", something "glorious" & deathless. He himself may be but a miserable clod, but the glory of his crowd reflects upon him.

{26/193}

24<sup>th</sup> Dec 2012 Monday

10-12 worked on various google calendar issue

14:30-17:00 worked on inserting various slides.

13:00 - 14:30 inserting some more slides & organizing.

~~Some more~~ Effect of addition of <sup>Aos &</sup> particles in comsol files (or two phase mass flow equations)

Note that we have micron sized particles.  
Input: surface tension, viscosity, Pressure (slight increase)

~~Slide 6~~ → slide for comsol

Attributes of successful model

- ① Reduced gas mobility in the presence of foam
- ② Non-newtonian foam flow behavior
- ③ Foam property variability with surfactant conc.
- ④ an accurate representation of surfactant transport partitioning & adsorption.

total hrs  $2\frac{1}{2}$

26<sup>th</sup> Dec 2012

9:30 - 12:00 Put some more slides & pictures in the presentation

27<sup>th</sup> Dec 2012

9:30 - 12:00 working on presentation

14:00 - 16:00 send presentation

17:00 - 18:30 Violin

28 & 29 ~~was~~ traveling

~~Wedge tangent construction~~

1<sup>st</sup> Jan. 2013 Tuesday

Reading Theoretical part

General eqn of water  
high injection rate → negligible capillary forces  
P.D.E by method of characteristics  
wedge tangent construction



Unlike water-oil phase, the foam phase ~~the~~ pushes water out in this case.

MR F ~~are~~ to represent foam mechanisms

←: Hans model :→

mass balance eqn for water & gas  
testing ~~several~~ program from Hans, & test 41  
question to Hans: what is Prob Plot 1

3<sup>rd</sup> January 2013

KK travels

Rahulin India

02024367997

009960273524

KKtravels@KKtravels.com

Kohrud depo, chandi chowk, shivpadm society  
8888440002

14765 Mumbai-Frankfurt 1:40

7-01-2013 Monday

TG043

Darcy's law: 9:30

comsol: →

Darcy velocity = volumetric flux  
 $= \frac{Q}{A}$

$$1 \text{ cp} = 10^{-3} [\text{Pas}] \frac{\text{Ns}}{\text{m}^2}$$

$$0.987 \times 10^{-12} \text{ m}^2 = 1 \text{ Darcy}$$

working on comsol 4.3a (i) putting in parameters in comsol

(2) Analytic function putting

function name u

connecting Darcy's law to Navier Stokes

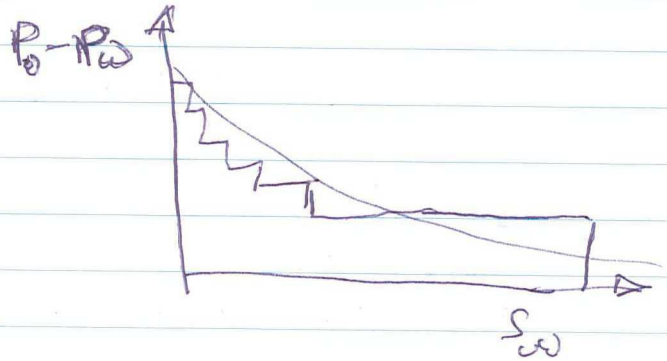
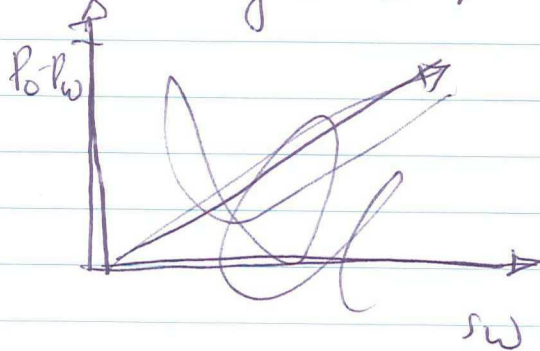


9-01-2013 Wednesday

Contact angle

$$pH = -\log [H^+] > 2.3$$

for silica



Blumen

Brooks corey relation & sorting factor

initial water saturation = connate water saturation

Buckley leverett theory 11:20

$$u = - \left( \frac{K_{rw}}{\mu_w} + \frac{K_{ro}}{\mu_o} \right) \nabla p$$

$$u \equiv \nabla p$$

$$f_w = \frac{1}{\frac{K_{rw}}{\mu_w} + \frac{K_{ro}}{\mu_o}}$$

$$\lambda = 0.5$$

$$S_{wc} = 0.15$$

$$S_{or} = 0.25$$

Global definitions

① Parameters ~~of~~ piecewise functions ( $K_{rw}$  &  $k_{ro}$ )

$$= \underline{a + bx}$$

$$K_{rw} = \frac{(1-S_{or})^{2+3\lambda}}{S_{wc}^2 \lambda}$$

~~$K_{ro}$~~

$$S_{wc} \rightarrow 1 - S_{or}$$

$K_r$

$$K_{rw} =$$

$$1 - S_{or} \text{ to } 1 \quad K_{rw} =$$

Inducing capillary pressure  $\rightarrow$  2 pm equation

18:30 ~~the~~ mass balance ~~outside discontinuities~~

$\partial_x u = 0$   $u$  independent of space & dependent on  $t$  only.

mass balance eqns for water & oil.

to transform from partial to O.D.E.  $\rightarrow \eta = \frac{x}{t}$

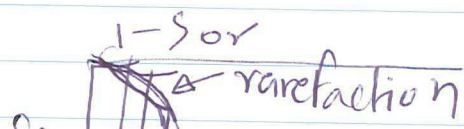
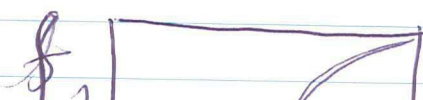
$$-\phi \eta \frac{dS_w}{d\eta} + \frac{u \cdot df_w}{d\eta} = 0 \quad S_w(\eta=0) = 1 - S_{or}$$

$$S_w(\eta \rightarrow \infty) = S_{wc}$$

$$\left( \frac{u \cdot df_w}{dS_w} - \phi \eta \right) \left( \frac{df_w}{d\eta} \right) = 0$$

$$\frac{u \cdot df_w}{dS_w} = \phi \eta$$

$$\frac{u}{\phi} \frac{df_w}{dS_w} = \eta = \frac{x}{t}$$



$$u = u_w + u_0 = - \left( \lambda_w \frac{\partial u_w}{\partial x} + \lambda_0 \frac{\partial u_0}{\partial x} \right)$$

$$\lambda = \frac{k}{u}$$



$$u = u_w \left( 1 + \frac{\lambda_0}{\lambda_w} \right) - \lambda_0 \frac{\partial p_c}{\partial x}$$

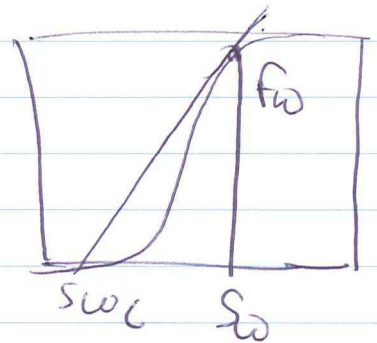
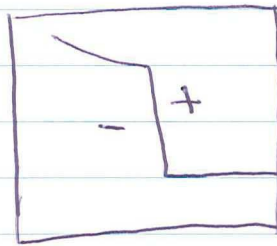
(Telling the joke & laughing on it yourself)  
(laughing on your <sup>own</sup> jokes)

$$v \frac{\partial s_w}{\partial t} + \frac{\partial u_w}{\partial x} = 0$$

$$v \frac{\partial s_w}{\partial t} + u \cdot \frac{\partial f_w}{\partial s_w} \frac{\partial s_w}{\partial x} = 0$$

$$\frac{\partial}{\partial x} \left( \frac{-\lambda_0 \lambda_w}{\lambda_0 + \lambda_w} \frac{\partial p_c}{\partial s_w} \right) \frac{\partial s_w}{\partial x}$$

sol<sup>n</sup> to this eq<sup>n</sup>





10-01-2013

10:00 FF curve derivation  
EOR - Larry Lake

Hugoniot conditions

derivation by Lax :

Leibnitz rule

$$\frac{\partial}{\partial \lambda} \int_{u(\lambda)}^{v(\lambda)} b(x, \lambda) dx$$

=

Wedge construction

V1 Arnold O. differential equations

Dimensionless numbering using peckan numbering

$$\frac{\partial S_w}{\partial t} + \frac{\partial f_w}{\partial x_D} = \frac{1}{Pe} \frac{\partial^2 S_w}{\partial x_D^2}$$

12:01 Adding model using mathematics

~~win~~ in console is saturation  
value including

2:00 To improve the results tolerance change, mesh,  
solver change etc.

Adaptive mesh refinement : Geometry 1

time dependent  
solver  $\rightarrow$  time stepping  $\rightarrow$

changing peckan number

higher order elements 15:45

$$\frac{\mu_w}{\mu_o} \Delta P_w$$

canceling  
relative velocities

$$q_L = \frac{k}{\mu_L} \frac{\Delta P_w}{L_L}$$

$$\Delta P = \Delta P_w + \Delta P_o$$

$$Q = Q_w + Q_L$$

$$Q = \left( \frac{k k_{ro} \Delta P_w}{\mu_w L_w} + \frac{k k_{ro} \Delta P_L}{\mu_L L_L} \right)$$

=

viscosity of

viscosity of displacing fluid must be higher than displaced fluid to make

Capillary number  $N_{pc} = \frac{\mu L}{\mu_o}$

$$\text{movable oil} = 1 - S_{wc} - S_{or}$$

macroscopic sweep

horizontal - cusping

vertical - coning

Gas + surfactant  
water + polymer

critical wavelength calculation

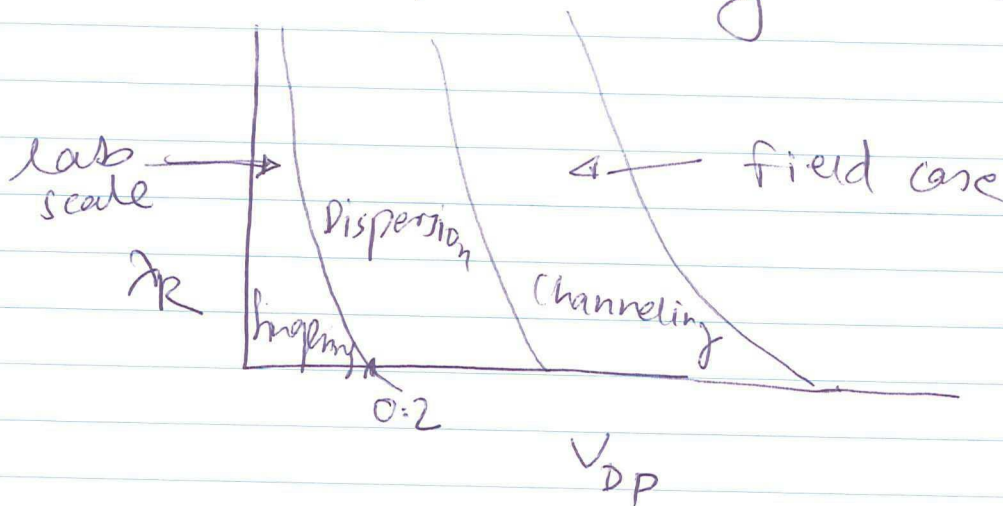
~~to do~~ Considering miscible conditions

for w. need to figure out which condition to be used.

This is for homogeneous permeability

vertical sweep efficiency

$$\frac{k}{\phi \Delta s}$$



1 - watercut = oil

Dykstra-Parsons Approach

Explaining the exercise at 11:41

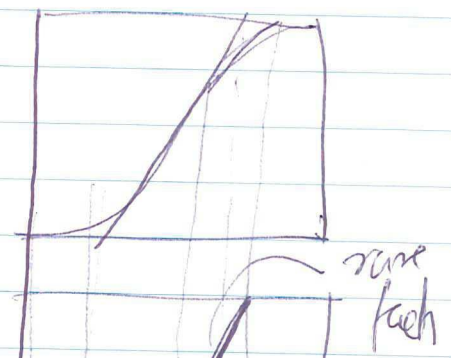
Fractional flow curve 12:30

Koval theory

13:38

distance → Profile  
time → history

$$\frac{df}{dV} = \frac{\Delta F}{\Delta s}$$





otherwise

$$\frac{f_g - 0}{s_g - s_{oc}}$$

function Vlookup  
lookup

$$N_p = (s_g - s_{gc}) + \frac{(1 - f_g)}{df/ds}$$

15:30

Recovery in practice is more than theory: Koval theory gives info about it.

Todd & Longstaff 1972

Applying Koval method

15:45

16:00

Gravity Fingering  
(non physical parameter)

meeting with Hans & Rouhi & Ali 5 PM  
Enschede

~~Urban~~ Krastev's particle pH=5

Ultrasonication setup

Light scattering setup

0.0375  $\leftrightarrow$  0.05

3 bar BP

80 % foam quality

Tuesday ~~15~~ 15-01-2013

meeting with Hans 13:30

Hans vacation 18-01-13 to 25-01-13 India  
03-03-13 to 03-04-13 Brazil

logarithmic scale + Put insert



Wednesday 16-01-2013

PP. 87 Her Koper book:

low surfactant ~~concentr~~ %: both particle & ~~surfactant~~ bubble surface are sparsely loaded with surfactant & the surfactant facilitates floatability.

thinning of liquid film

Particles ~~with~~ which have enough kinetic energy to overcome the energy barrier can attach to the bubble  $\rightarrow$  in the primary energy minimum. Fine particles may not have enough kinetic energy & can then be stabilized at the bubble in the secondary energy minimum.



what is molar concentration? Search in .

Putting graph of references material laser scattering  $\rightarrow$

surface tension  $\times$  dynamic surface tension

1 to 20 mm

400 Cross section

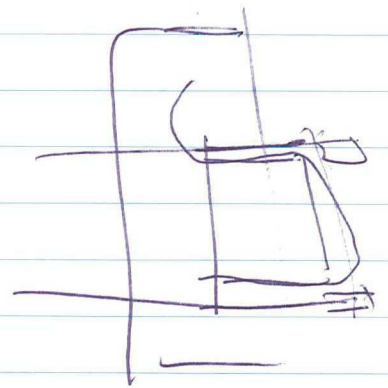
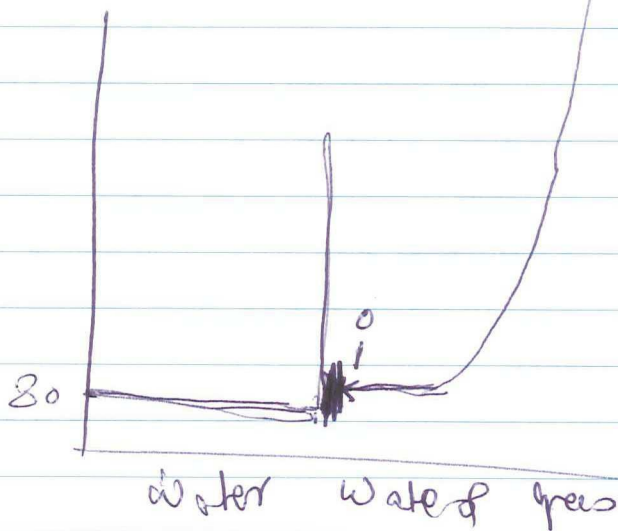
$1.04 \times 10^{-5}$

Foam development  $\times$  Formation damage

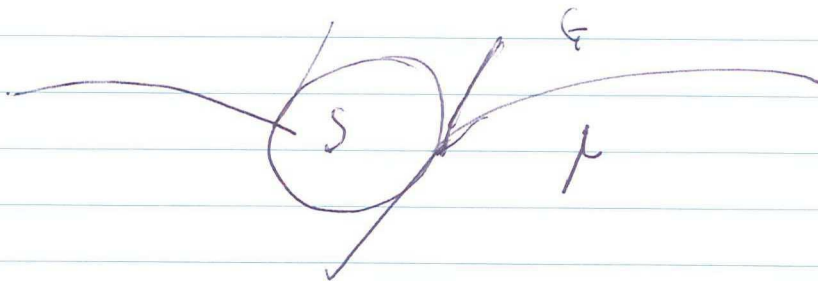
↓  
Permeability  
remains  
same

Permeability changes  
(deteriorates)

$6.5 \frac{\text{bar}}{\text{m}}$      $0.1 \frac{\text{bar}}{\text{m}}$



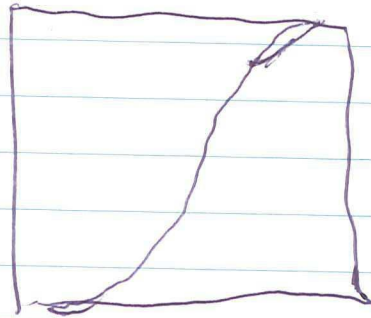
Newer  $\delta \rightarrow$  Changing viscosity     $0.0015$   
Newer  $\eta \rightarrow$      $2 \times 10^{-5} \text{ Pa.s/m}^2$   
Using gas seek     $0.934 S_{\text{bound}}$





Meeting with Hans ~~13:30~~

13:30



change the particle size slide  
remove contact angle side

9.36 pH Aor-Ash

~~at~~ lambda = 12 [1]

at 15:34

again good stick

$sw = 0.805$

ing sat excel sheet  
saved as eqs10

~~Do you to Kern~~

~~people~~ Pressure in COMSOL ~~at least~~ is ~~less~~ <sup>(1 bar / m)</sup> High  
than what we see in ~~in~~ real expt.

changing ~~the~~ relative permeabilities <sup>(0.1 bar / m)</sup> to get

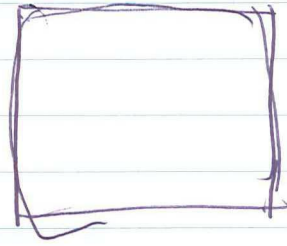
~~per~~ 0.1 bar / m

changing range 2 - 180

15:49 Changing lambda to 12 & changing  
function ~~lambda~~ (1.0) / m

tolerance 5.

~~write~~ a get a report from report section



Thursday 17-01-2013

Under 2013 01-17-039 & 040

(maximum signal)

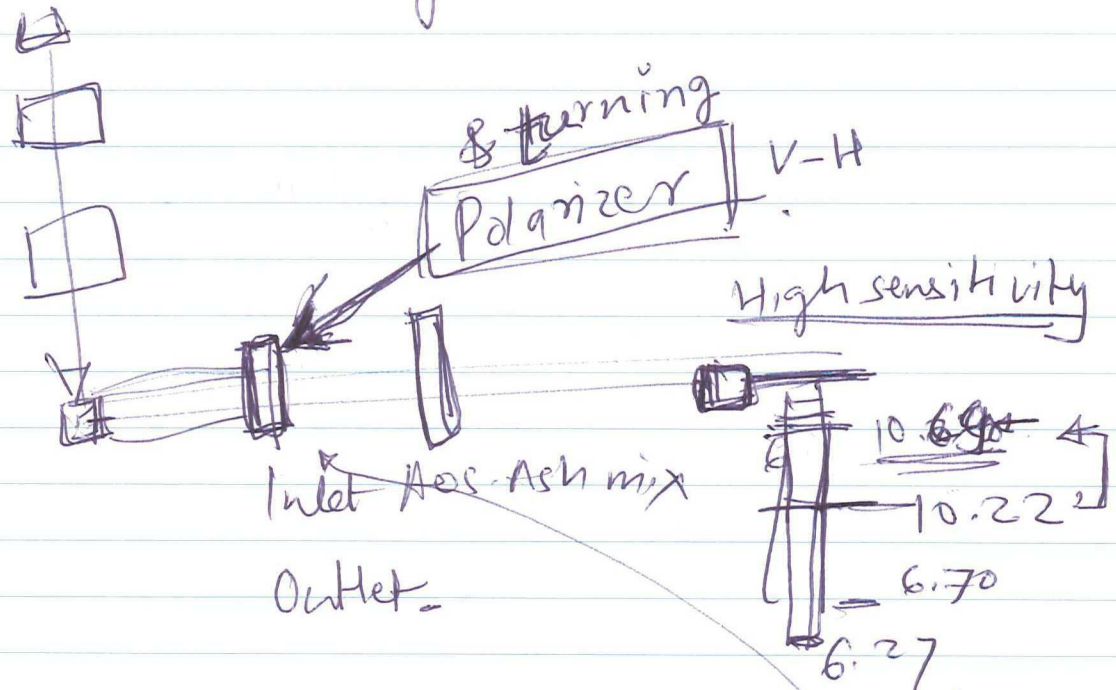
10 Oct inlet

AOS-Ash

16:30 Time

Full blast of laser scatter on photo cell  
No sign of change of signal

meeting with Hans 21:00



① The problem with oversaturation of signal detector

Suggestion by Hans

② ① Check polarizer (put it here)

②

$$\frac{\rho_w \rho_w g x}{\rho_w}$$

mass balance  
with gravity 21:10

$$\frac{\partial_t \rho_g}{\rho_g} = \partial_t \ln \rho_g$$

$$\frac{1}{P} \left( \frac{dP}{dP} \right) = c = - \left( \frac{\partial v}{\partial P} \right)_T$$

$$P = \frac{m}{v} \Leftrightarrow v = \frac{RT}{P}$$

$$-\frac{1}{v} \left( \frac{\partial v}{\partial P} \right)_T = - \frac{RT}{P^2} \frac{P}{RT} = - \frac{1}{P}$$

adding  $\rho_g$  function : Analytic 21:30

$$6 \text{ cm} \quad \rho \times g \times h$$

$$1000 \times \frac{1000}{10} \times 0.06 = 600 \frac{\text{N}}{\text{m}^2}$$

Calculation of Darcy from 4<sup>th</sup> Oct 2012

2.98 Darcy



$$u_g = - \lambda_g (p^x - p_g g)$$

~~$$\frac{u_w}{\lambda_g}$$~~

$$\frac{u_w}{\lambda_w} = - p^x + \rho_w g$$

$$\frac{u_g}{\lambda_g} = - p^x + \rho_g g$$

$$\frac{\frac{u_w}{\lambda_w} - \rho_w g}{\frac{u_g}{\lambda_g} - \rho_g g} = 1$$

what if  
analysis

between  $\rho_w$  &  $\rho_g$  further is 0.82  
in +ve to -ve.

Hirasaki & Lawson eqn of effective viscosity

$$\mu_f = \mu_g + \alpha \frac{\mu_l}{f} \rightarrow 0 \text{ then enormous viscosity of foam}$$

if foam =  $\mu_g$  at the start

changes in  $\lambda$  (higher values) & see how it develops (12)

Model by Mohammad Sinyou  
(third eqn of population balance model)

Advice by Bill but  
maple file from Hans about HPL equation

Friday 18 Jan 2013

~~March 18~~ Username & password for safety report sys

17:46 Comsol file changing <sup>65</sup>"lambda" to 12  
(Sorting factor)  
neweqsrhog1.mph

& see how it looks & very high  $\Delta P$  14:00

~~So~~ So open inisat2 excel, went to VBA  
(by changing options "Developer")

In VBA changed the  $\lambda$  value to 12 & saved

coming back to excel repeated what if  $\rightarrow$   
Goal seek  $\rightarrow$  ~~see~~ value 1 of  $\frac{u_w - p_{w2}}{\frac{u_g - p_{g2}}{\lambda g}}$  - by

changing  $S_w$

Thus obtained  $S_w = 0.78$

14:55 Using this value in Comsol  
neweqsrhog1-with-sortingfac-12.mph





