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CL310: SFO LAB
Experiment 07
Rotary Drum
Vacuum Filter.

ROTARY DRUM VACUUM FILTER

Objective: To study the performance of a Rotary Drum filter operating under vacuum.

Aim: To determine the specific cake resistance for a given slurry of $CaCO_3$.

Introduction: A most common type of continuous vacuum filter, is a rotary drum filter, which consists of a horizontal drum, with a slotted face, turns at a speed of 1.5 to 2 rev/min, in an agitated slurry, through a filter medium, such as canvas convers the face of the drum, which is partly submerged in the liquid. Under cylindrical face of the main drum is a second smaller drum with a solid surface. Bentween two drums are radial partitions, deviding the annular space into separate compartments. Due to vacuum applied inside the drum, the filterate is drawn in through the filter medium and the cake is deposited on the outer surface of the drum.

Theory: In a continuous rotary drum filter, the feed the filterate and cake move at a steady constant rate. For any perticular element of the filter surface, however conditions are not steady but transient. The process of filtration consists of cake formation, washing drying, and discharging. The cake thickness is not allowed to increase to large values and therefore the filtration process can be conducted at a constant rate using a constant pressure difference.

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A rotary drum vacuum filter consists of a cylindrical drum partly submerged in the feed slurry. At any instant, a segment of the dram is in position and thus in contact with the slurry. Due to vacuum applied inside the slurry/Drum, the filtrate is drawn in through the filter medium, and cake is deposited on the outer surface of the drum. As the drum rotates, this segment moves up where it is subjected to dewatering, to washing and finally the caked is removed by the scrapper/doctor knife. The cake can be loosened by application of slight positive air pressure. A full rotation of drum is equivalent to a complete batch cycle.

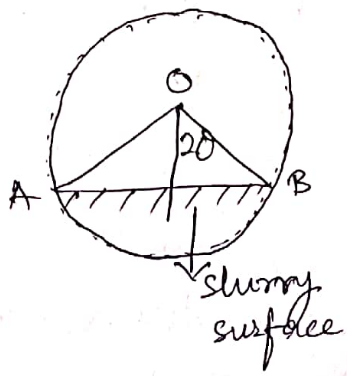
For one full rotation of the drum:

$$\frac{dt}{dV} = \frac{\mu_f}{A(-\Delta P)}\left[\frac{\alpha v}{A} V + R_m\right] \quad (1)$$

Integrating

$$t = \frac{\mu_f}{A(-\Delta P)}\left[\frac{\alpha v}{A} \times \frac{V^2}{2} + R_m V\right] \quad (2)$$

then $t = f t_c \Rightarrow f = \frac{2\theta}{360}$ (3)



Rate of filtration $= \frac{v}{t_c}$

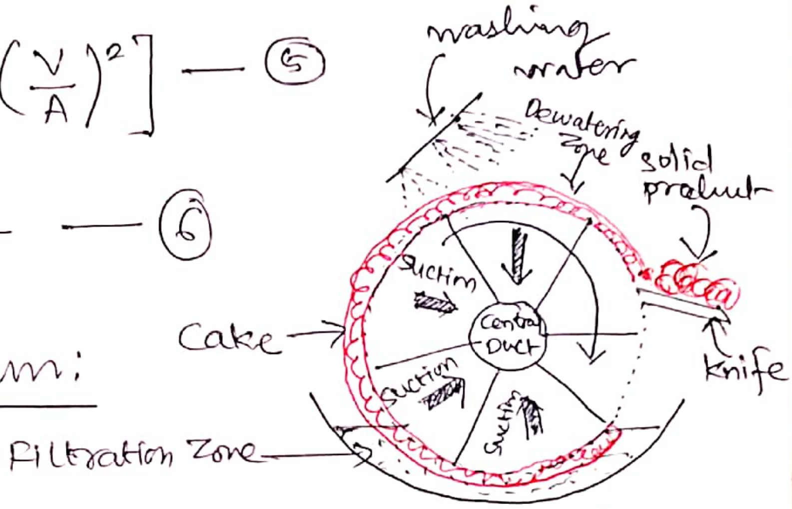
Neglecting the filter medium Resistance R_m, compared to the specific cake resistance α, eq(2) can be rewritten as:

$$t = \frac{\mu_f}{A(-\Delta P)}\left[\frac{\alpha v V^2}{2A}\right] \quad \text{—— (4)}$$

$$\frac{-\Delta P}{1} = \left[\frac{\mu_f \alpha v}{2t} \times \left(\frac{V}{A}\right)^2\right] \quad \text{—— (5)}$$

$$v = \frac{x}{1-x} \times \frac{\rho_f}{\rho_s} \quad \text{—— (6)}$$

Schematic Diagram:



Observation:

$D = 0.3\,m$ $\quad D_F = 0.25\,m$ $\quad \rho_F = 1000\,kg/m^3$

$L = 0.45\,m$ $\quad A_F = 0.35343\,m^2$ $\quad \rho_s = 2710\,kg/m^3$

$A = 0.424116\,m^2$ $\quad \theta = 68.284$ $\quad \mu_F = 8.9\times10^{-4}\,Pa.s$

$t_c = 65\,sec$

Serial NO	ΔP (mm Hg)	ΔH (cm)	T (sec)	V	weight of the cake
01	300	4.7	84.9	1.11	3.9
02	350	4	74.9	1.26	3.9

Sample Calculation:

$\Delta P = 300\,mm$ of $Hg = 39.984\,KN/m^2$

$$x = \frac{\text{kg of solid}}{\text{kg of solid + kg of water}} = \frac{0.05}{0.065} = 0.769$$

$v = \frac{x}{1-x}\,\frac{\rho_f}{\rho_s} = 1.23$, $V_{fh} = 0.0166\,m^3 = A_f h$, $V' = \frac{V_F}{T} = 2.461\times10^{-5}\,m^3/sec$

volume of filtrate in one rotation $= V = \frac{V'}{RPS} = 1.599\times10^{-3}\,m^3$

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$$f = \frac{20}{360} = 0.379$$

$$t_c = \frac{f}{RPS} = 24.658 \text{ sec}$$

$$L_c = \frac{V v}{A} = 0.004639 \text{ m}$$

$$\left(\frac{V}{A}\right)^2 = 1.4225 \times 10^{-5} \text{ m}^2/\text{s}^2$$

Calculation Table:

Ser. No	ΔP ($\frac{KN}{m^2}$)	X	v	V_f (m^2)	V' (m^2/s)	V (m^3)	f	t (sec)	L_c (m)	$\left(\frac{V}{A}\right)^2$ (m^2/s^2)
01	39.984	0.769	1.23	0.0166	2.461×10^{-5}	1.599×10^{-3}	0.379	24.66	0.004639	1.4225×10^{-5}
02	46.648 ~~350~~	0.8333	1.845	0.01414	2.325×10^{-5}	1.641×10^{-3}	0.379	24.66	0.007138	1.4969×10^{-5}

We now plot ΔP vs $\left(\frac{V}{A}\right)^2$ on the next page

From the plot we see that the slope $= 8.95 \times 10^6$

Hence we now can calculate α, using the following formula:

$$\alpha = \frac{2t \times \text{slope}}{v' \times S_F \times \mu_F} \quad (\text{m/kg})$$

$\therefore$ For set 1: $\alpha = 4.03 \times 10^8$ m/kg

And For set 2: $\alpha = 2.688 \times 10^8$ m/kg.

Results & Discussion:

1) Result is tabulated as followed:

serial No	ΔP (mmHg)	$\left(\frac{V}{A}\right)^2$ (m^2/s^2)	α (m/kg)
01	39.984	1.4225×10^{-5}	4.03×10^8
02	46.648	1.4969×10^{-5}	2.688×10^8

2) With increase in slope of ΔP vs $\left(\frac{V}{A}\right)^2$ curve, α (cake resistance) decreases.

Precautions:

1) Proper cleaning of Drum & its Cloths
2) Filter slurry before feeding it to the tank
3) Low flowrate is best for operating
4) Vacuum pump connection must be tight

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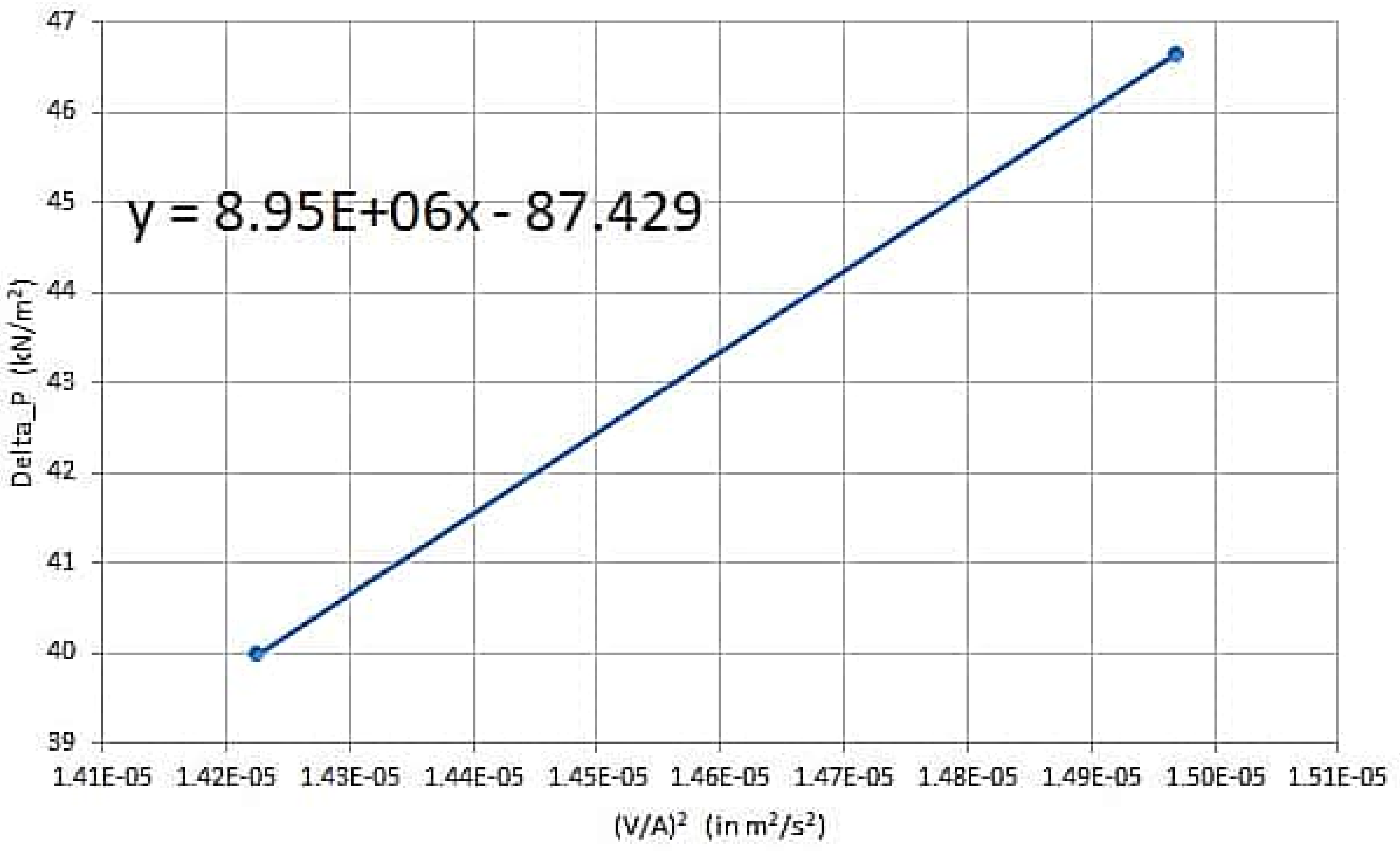

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