LECTURE 10/31/2017

SLIDE 9

mean velocity in the pipe at 8

$$\Delta P_{K_{1\to 8}} = \rho \frac{\bar{u}_8^2 - \bar{u}_1^2}{2\alpha}$$

mean velocity in the pipe at 1

What is $\bar{u}_8$ how is calculated?

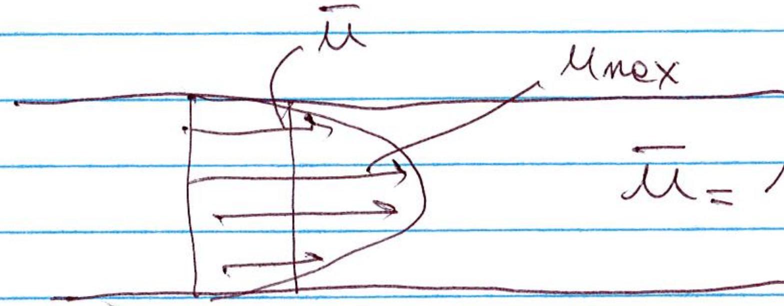
$$\bar{u}_8 = \frac{Q_8}{\underbrace{\pi R_8^2}_{\text{cross sectional area at 8}}}$$

α "CORRECTION FACTOR"

PARAMETER TO TAKE INTO ACCOUNT THAT THE LIQUID MAY NOT BE NEWTONIAN [TO BE DETERMINED !!]

$$\bar{u}_1 = \frac{Q_1}{\underbrace{\pi R_1^2}_{\text{cross sectional area at 1}}}$$

Assuming that the material is Newtonian



$$\bar{u} = \frac{u_{max}}{2}$$

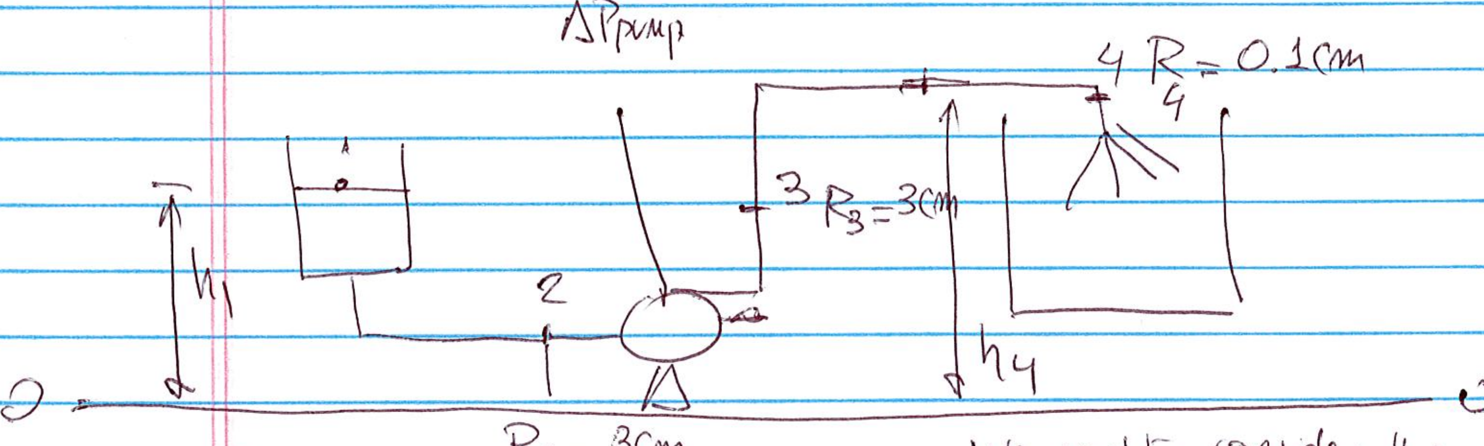
what happens if we have steady state (2)
and R_1 and R_8 are the same

if $Q_1 = Q_8$ = constant [steady state

and $R_1 = R_8$

$$\bar{u}_1 = \bar{u}_8 \Longrightarrow \Delta P_{K\,1\to 8} = 0$$

SLIDE 9



BALANCE 1 to 4

We need to consider the system

$$\Delta P_{pump} = (P_4 - P_1) + \Delta P_{S\,1\to 4} + \Delta P_{K\,1\to 4} + \Delta P_{f\,1,4}$$

$$\Delta P_{S\,1\to 4} = \rho g (h_4 - h_1) \qquad \Delta P_{K\,1\to 4} = \rho \frac{\bar{u}_4^2 - \bar{u}_1^2}{2\alpha}$$

We need to kno the rheology.

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$$\Delta P_{K\,4\to 8} = \rho \frac{\bar{u}_8^2 - \bar{u}_4^2}{2\alpha}$$

TO BE DETERMINED

~~BY~~ ASSUME KNOWN

FOR NOW

$\bar{u}_8 = 0$ Because under steady state the level of liquid does not change.

$$\bar{u}_4 = \frac{Q}{\pi R_4^2} = \frac{Q}{\pi R^2}$$

[Radius/diameter does not change]

what happens if we consider a balance between 4 and 7?

$$\Delta P_{K\,4\to 7} = \rho \frac{\bar{u}_7^2 - \bar{u}_4^2}{2\alpha} = 0 \quad \boxed{\bar{u}_7 = \bar{u}_4}$$

$$\bar{u}_7 = \frac{Q}{\pi R_7^2} = \frac{Q}{\pi R^2}$$

UNITS CONCERNS

$$\left.\begin{array}{l}\Delta P_{pump.} \\ \text{Pressures.}\end{array}\right\} \text{Pascal (Pa)}$$

$1\,atm = \underline{\underline{101\,KPa}}$

We are going to use $\underline{\underline{KPa}}$

Kinetic Energy [Newtonian fluid] $\alpha = 1$

$$\Delta P_{K\,1\to 2} = \frac{\rho\,[\bar{u}_2^2 - \bar{u}_1^2]}{2\alpha} \leftarrow 1$$

$\rho = 1000\,\frac{Kg}{m^3}$ $\quad \bar{u}_2 = 100\,\frac{m}{s}$

$\bar{u}_1 = 0\,m/s$

$$\Delta P_{K\,1\to 2} = \cancel{\frac{Kg}{m^3}}\;\cancel{10}\;1000\,\frac{Kg}{\cancel{m^3}} \times 10^4\,\frac{\cancel{m^2}}{s^2} = 10^7\,\frac{Kg}{m\,s^2}$$

$$\Delta P_{K\,1\to} = 10^7\,Pa = \underline{\underline{10^4\,KPa}} \qquad Pa$$

$$\Delta P_S = \rho g \Delta h = \frac{Kg}{m^3} \times \frac{\cancel{m}}{s^2} \times \cancel{m} = \frac{Kg}{m\,s^2} \equiv Pa$$

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KPa $\frac{m^3}{s}$

$$\text{PUMP POWER REQUIRED} = \frac{\Delta P_{pump} \times Q}{\eta_p \eta_m} = \underline{\underline{KW}}$$

Efficiency in Pump ≡ "FRICTION" [NO UNITS]

EFFICIENCY IN ELECTRICAL MOTOR DRIVING THE PUMP (NO UNITS)

$$KPa \times \frac{m^3}{s} = \frac{KN}{\cancel{m^2}} \times \frac{m^{\cancel{3}}}{s} = \frac{KJ}{s} = KWatts$$

FOR NEWTONIAN

$\Delta P \propto Q$ [50% change in Q will be a 50% in ΔP

For NON NEWTONIAN $n = 0.1$

50% change in Q
0.933% change in ΔP → measured
↑ measured

Binghom Fluid (6)

$$\sigma = \sigma_0 + \eta \dot{\gamma}$$

$$f(\sigma) = \dot{\gamma} = \frac{\sigma - \sigma_0}{\eta}$$