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17/ENG06/055

MECHANICAL ENGINEERING

 ASSIGNMENT 3

 Given µ= 0.9$Ns/m^{2}$, $ρ=1260kg/m^{3}$, $L=65m$, $D=10mm=0.01m$, $q=180lt/min=0.003m^{3}/s$

From continuity equation

q = A.u

where $A=\frac{πD^{2}}{4}=\frac{π×\left(0.01\right)^{2}}{4}=7.855×10^{-5}m^{2}$

$$∴ u=\frac{q}{A}=\frac{0.003}{7.855×10^{-5}}=38.19m/s$$

$$∴ Re=\frac{ρuD}{μ}=\frac{1260×38.19×0.01}{0.9}=534.66$$

Because Re < 2000, the flow is laminar

$$∆P=\frac{32μuL}{D^{2}}=\frac{32×0.9×38.19×65}{\left(0.01\right)^{2}}=\frac{71491.68}{0.0001}=7.15×10^{8}N/m^{2}$$

Given $μ=800cp=0.8Ns/m^{2}$, G = 0.85, $ρ=850kg/m^{3}$,

$dp=2000×10^{3}N/m^{3}$, D = 65mm = 0.065m , L = 95m

$$A=\frac{πD^{2}}{4}=\frac{π×\left(0.065\right)^{2}}{4}=3.319×10^{-3}m^{2}$$

$$\frac{dp}{dx}=\frac{-2000×10^{3}}{95}=-21.05×10^{3}$$

 Rate of flow, Q = A.u

 Where $u=\frac{-1}{8μ}\frac{dp}{dx}R^{2}$

 $=\left(\frac{-1}{8×0.8}\right)\left(-21.05×10^{3}\right)\left(0.0325\right)^{2}=3.474m/s$

$$∴Q=3.474×3.319×10^{-3}=0.0115m^{3}/s$$

Centre line velocity = $u\_{max}$

But, $u\_{max}=2 ×u$

 $=2×3.474=6.948m/s$

Total frictional drag, fD

$$f\_{D}=τ\_{0}πDL$$

Where $τ\_{0}=\frac{-∂p}{∂x}\frac{r}{2}=21.05×10^{3}×\frac{0.0325}{2}$

$$τ\_{0}=342.0625N/m^{2}$$

$$∴ f\_{D}=342.0625×π×0.065×95=6636.645N≅6.637kN$$

Power required to maintain flow

$$P=f\_{D}×u$$

 $=6636.645×3.474$

$$P=23055.7Watts$$

$$P=23kW$$

Velocity gradient at the pipe wall

$$τ\_{0}=\frac{μ∂u}{∂y} @ y=0$$

$$∴ \frac{∂u}{∂y}=\frac{τ\_{0}}{μ}=\frac{342.0625}{0.8}=427.584s^{-1}$$

Velocity and shear stress 60mm from wall

$$u=\frac{-1}{4μ}\frac{∂p}{∂x}\left(R^{2}-r^{2}\right)$$

$$but y=R-r and y=60mm=0.06m$$

$$∴ 0.06=0.065-r$$

$$r=0.005$$

$$∴u=\frac{-1}{(4×0.8)}\left(-21.05×10^{3}\right)\left(0.065^{2}-0.005^{2}\right)$$

$$ u=27.628m/s$$

The shear stress can be found as;

$$\frac{τ}{r}=\frac{τ\_{0}}{R}$$

$$∴τ=\frac{r×τ\_{0}}{R}=\frac{0.005×342.0625}{0.065}=26.3125N/m^{2}$$