K.L.G

David Beck

Purpose

Compute forces in the horizontal and vertical direction.

Design consideration

- Incompressible fluid
- Isothermal process
- steady state

Data and variables

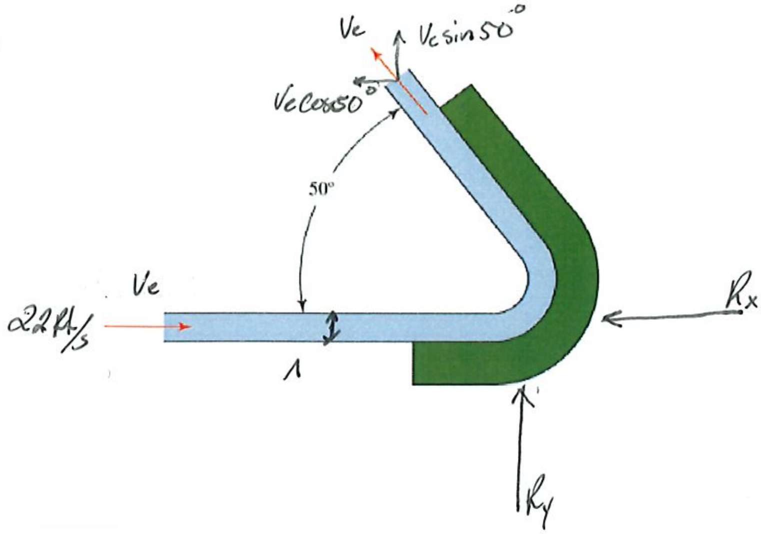
$T_{water} \doteq 180°F$

$Area_{pipe} = 2.95 in^2 = 0.0205 ft^2$

Flow rate $= 22 ft/s$

Water at 180°F

Density $= 1.88 \, slugs/ft^3$



$Q_e = A_1 V_e$

$= 0.0205(22)$

$= 0.451$

$R_x = \rho Q_e V_e (1 + \cos\theta)$

$= 1.88(0.451)(22)(1 + \cos(50))$

$= 30.64 \, lbf$

$R_y = \rho Q_e V_e (\sin\theta)$

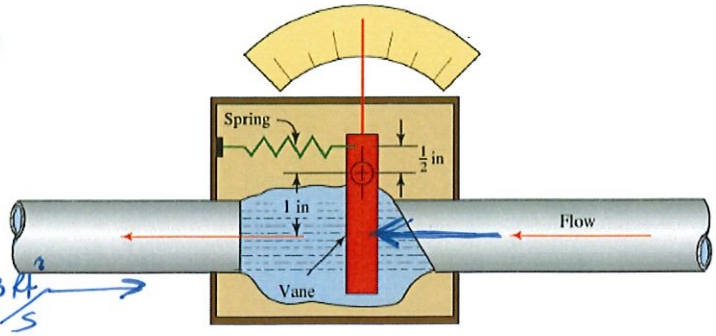
$= 1.88(0.451)(22)(\sin(50))$

$= 14.29 \, lbf$

16.11)

Purpose

Calculate spring force required to hold the Vane in a vertical Position.



0.223 ft³/s (inflow, right) 0.223 ft³/s (outflow, left)

Design Considerations

- Incompressible fluid
- Isothermic process
- Steady state

Data and Variables

Flow rate = 100 gal/min = 0.223 ft³/s

Pipe = 1in sch. 40

A = 0.006 ft²

ID = 0.0874 ft

Water at 70°F

Density = 1.94 slug/ft³

need to find force using Force Equation

$$F_x = \rho Q V$$

need to find velocity by rearranging the Volumetric flow rate equation.

$$Q = AV$$

$$V = \frac{Q}{A}$$

$$= \frac{0.223\ ft^3/s}{0.006\ ft^2}$$

$$= 37.167\ ft/s$$

$$F_x = \left(1.94\ \frac{slug}{ft^3}\right)\left(0.223\ ft^3/s\right)\left(37.167\ ft/s\right)$$

$$= 16.08\ lbf$$

- now we find the force the spring needs to stay vertical

$$F_x \times 1in = F_{spring} \times .5in$$

$$F_{spring} = \frac{F_x \times 1in}{.5in}$$

$$= \frac{16.08 \times 1}{.5}$$

$$= 32.16\ lbf$$

17.11

Purpose

Calculate torque when cups are in
air at 80°C
gasoline at 20°C

Design considerations

- Incompressible fluid
- Isothermal process
- steady state

Data and variables

Cup = 25mm = 0.025m
20rpm

Water at 30°C
Density = 1.164 Kg/m³

gasoline at 20°C
Density = 680 Kg/m³

$C_{D\,open\,front}$ = 1.35 from
$C_{D\,open\,back}$ = 0.41

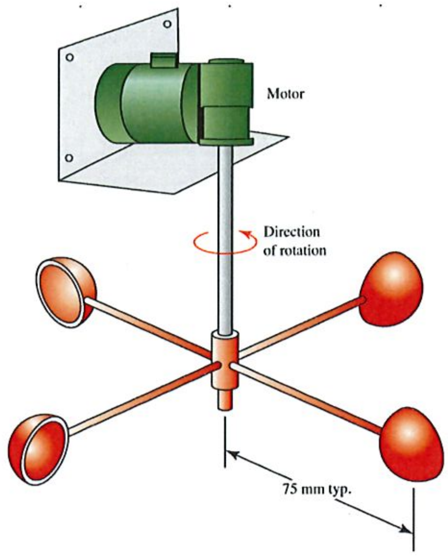
$A = \frac{\pi (0.025)^2}{4}$

$= 0.000491 m^2$

$V = 2\pi \times r \times \frac{rpm}{60}$

$= 2\pi \times 0.075 \times \frac{20}{60}$

$= 0.1571$ m/s



- first we need to find forces on cups in air

$F_{open\,front} = C_D\left(\frac{\rho v^2}{2}\right)A$

$= 1.35\left(\frac{(1.164\ Kg/m^3)(0.1571\ m/s)^2}{2}\right)(0.000491 m^2)$

$= 9.52 \times 10^{-6} N$

$F_{open\,back} = 0.41\left(\frac{(1.164\ Kg/m^3)(0.1571\ m/s)^2}{2}\right)(0.000491 m^2)$

$= 2.89 \times 10^{-6} N$

T_q = Force x length

$= ((9.52 \times 10^{-6})(.075) - (2.89 \times 10^{-6})(.075))$

$= 4.9725 \times 10^{-7}$ N-m — air

- now Torque when cup are in gasoline

$F_{open\,front} = 1.35\left(\frac{(680\ Kg/m^3)(0.1571\ m/s)^2}{2}\right)(0.000491 m^2)$

$= 5.56 \times 10^{-3} N$

$$F_{open\ back} = 0.41\left(\frac{(680\ kg/m^3)(0.1571\ m/s)^2}{2}\right)(0.000491\ m^2)$$

$$= 1.69\times10^{-3}$$

$$T_q = (5.56\times10^{-3})(.075) - (1.69\times10^{-3})(.075)$$

$$= 2.9\times10^{-4}\ N\text{-}m$$

17.14)

Purpose

Compute drag force exerted on car due to vertical rods.

Design Considerations

- Incompressible fluid
- Isothermal process
- steady state

Data and variable

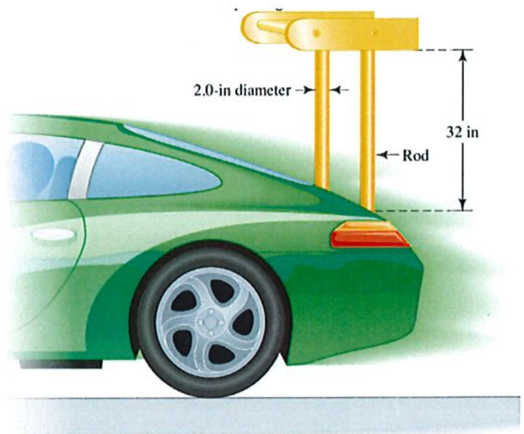
air temp = -20°F

Speed = 150mph
= 220 ft/s

air at -20F

Density = 2.80×10^{-3} slugs/ft³
= 2.80×10^{-3} lb-s²/ft⁴

$\nu = 1.17\times10^{-4}$



- First we find total area of the rod

$$A_{total} = 2\left(\frac{2}{12}\times\frac{32}{12}\right)$$
$$= 0.889\ ft^2$$

- now we find the drag coefficient of the cylinders

$$R_e = \frac{vD}{\nu}$$
$$= \frac{220\left(\frac{2}{12}\right)}{1.17\times10^{-4}}$$
$$= 313390$$

$$C_D = 0.80$$

- now we calculate force

$$F = C_D\left(\frac{\rho V^2}{2}\right)A$$
$$= 0.80\left(\frac{(0.0028\ \ldots)(220\ ft/s)^2}{2}\right)(0.889\ ft^2)$$
$$= 48.2\ lbf$$