MOP VACCUM MOTOR POWER CALCULATION

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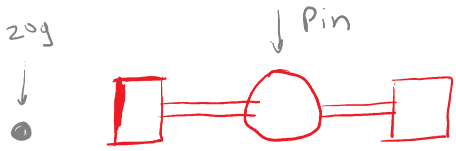
The mop should be able to suck the 20g object



Steady state flow process assumption

All the power/work done by motor fan goes in increasing the kinetic energy of air $\Delta H = 0$ (inlet and exit state variables are same)

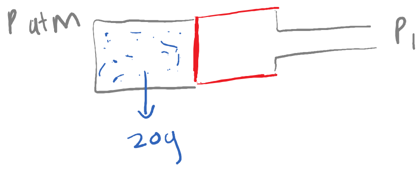
Suppose exit velocity of the air is v m/s

$V_{out} >> V_{in}$ (assumption)

$$W = \frac{1}{2}(m)v^2$$

$$m = (\rho A_{exit})$$

$$\therefore \quad W = \frac{1}{2}(\rho A_e)v^2$$



assuming friction to be 0.5 but it will be lower that this just a conservative estimate

$\therefore$

$$mgu = \Delta P A_i$$

$$P_1 = P_{atm} - \frac{mgu}{A_i}$$

Applying Bernoulli eqn

$$P_1 + \frac{V_1^2}{2g} = P_2 + \frac{V_2^2}{2g}$$

$P_1 \rightarrow P_{atm}$, $V_1 \rightarrow 0$, $P_2 \rightarrow P_1$, $\frac{V_2^2}{2g} \rightarrow \frac{V^2}{2g}$

$$P_{atm} = P_{atm} - \frac{mgu}{A_i} + \frac{V^2}{2g}$$

$$\frac{mgu}{A_i} = \frac{V^2}{2g}$$

$$\frac{2mug^2}{A_i} = V^2$$

$m = 20 \times 10^{-3}$ $\quad A_e = \pi/4 \, D^2 = 75.43 \times 10^{-4}$

$\frac{2mug}{Ai} = 0$

$$W = \frac{1}{2} \rho A_e \left(\frac{2mug^2}{Ai} \right)$$

$m = 20 \times 10^{-3}$

$u = 0.5$

$\rho = 1.3$

$A_e = \pi/4\, D^2 = 75.43 \times 10^{-4}$

$A_i = 1.5 \times 10 = 15 \times 10^{-4}$

$$W = \frac{1}{2} (1.3)(75.43 \times \cancel{10^{-4}}) \left(\frac{2 \times 20 \times 10^{-3}\, 0.5 \times (9.8)^2}{15 \times \cancel{10^{-4}}} \right)$$

$$= \frac{1.3}{2} \left(\frac{75.93}{15} \right) \left(20 \times (9.8)^2 \times 10^{-3} \right)$$

$$= 0.65\, (5.03)(20)(96.04) \times 10^{-3}$$

$$\approx 3.4 W$$

Say 50% of produced energy is lost in frictional and other losses

$= 51 W$

$\boxed{\text{Power of motor} = 51 W}$