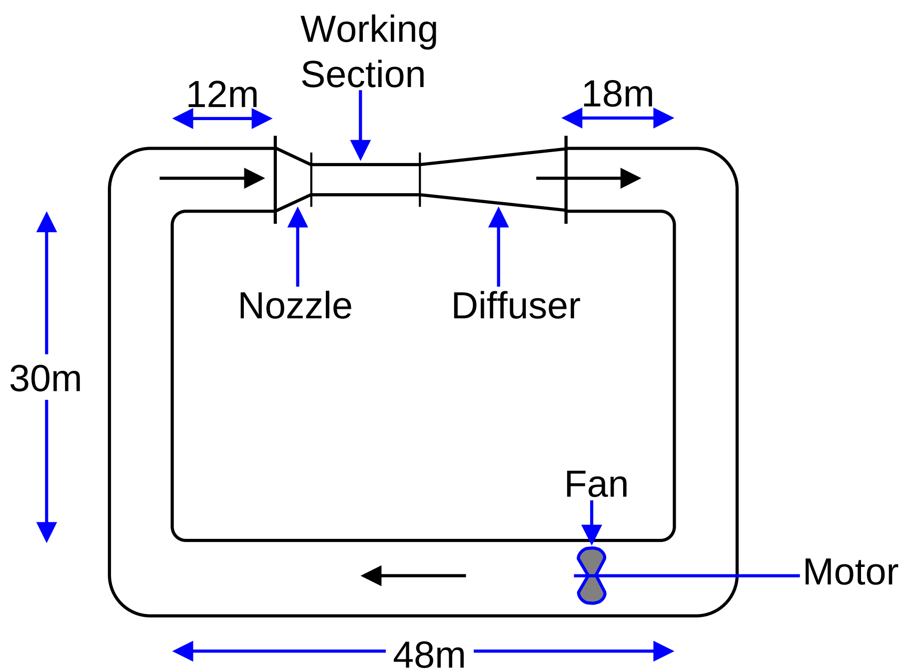
Solution to Problem 205D

The total pressure losses in the circuit are composed of several contributions:

- Total pressure loss due to length of pipe, Δp_{el}
- Total pressure loss due to the bends in the pipe, Δp_b
- Total pressure loss in nozzle, working section and diffuser, Δp_n

The power output of the fan must be increased to offset the losses Δp with power increase P.



The total pressure loss due to the length of the pipe will be due to the following total length of $6m$ pipe:

$$L^\star_{el} = 48 + 30 + 30 + 12 + 18 = 138\ m$$

The total pressure loss in the bends of the pipe can be taken into account by the addition of the following effective length of pipe:

$$L^\star_b = 4 \text{ bends} \cdot 20D_{pipe} = 80D_{pipe} = 480\ m$$

Consequently the total pressure loss due to the total effective length of the $6m$ pipe is:

$$\Delta p_{L^\star} = \Delta p_b + \Delta p_{el} = \frac{fL^\star}{D}\frac{1}{2}\rho U^2 = 1.03\rho U^2$$

with

$$L^\star = L^\star_{el} + L^\star_b = 618\ m$$

The total pressure loss in the nozzle, working section and diffuser is computed from:

$$\Delta p_n = \frac{1}{5}\frac{1}{2}\rho u^2$$

where the velocity in working section $u = 80\ m/s$. The volume flow rate, Q, is given by :

$$Q = uA_{workingsection} = UA_{pipe} = 180\pi\ m^3/s$$

so that the velocity in the $6m$ pipe U is:

$$U = \frac{D^2_{workingsection}}{D^2_{pipe}} u = \frac{u}{4}.$$

Then the total pressure loss in the nozzle, working section and diffuser is:

$$\Delta p_n = \frac{8}{5} \rho U^2 = 1.6 \rho U^2$$

and therefore the total total pressure loss in the circuit, Δp, is

$$\Delta p = (1.03 + 1.6) \rho U^2 = 2.63 \rho U^2$$

This must also be the total pressure rise across the fan.

The total power input P to the fan is then given by:

$$P = \frac{Q \Delta p}{\eta} = 8.923 \times 10^5\ kg\ m^2/s^2$$

with flow rate Q, total pressure loss Δp and given efficiency $\eta = 0.8$. Thus

$$P = 1.196 \times 10^3\ HP$$