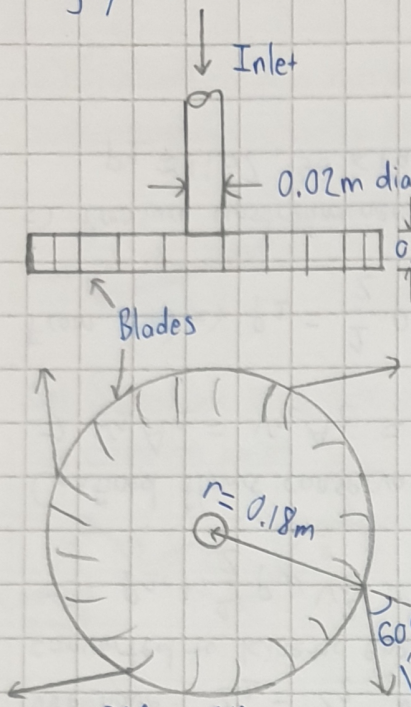
Nguyen Xuan Binh 887799 Round 3 Problem 1



Water flows out through a set of thin, closely spaced blades as shown in figure. with a speed of $V = 3 m/s$ around the entire circumference of the outlet. Determine the mass flowrate through the inlet pipe

- Time rate of change in system mass is 0

$$\Rightarrow \frac{dM_{sys}(t)}{dt} = 0$$

$$\Rightarrow \text{Conservation of mass}: \frac{\partial M_{cv}(t)}{\partial t} = \frac{\partial m_{in}}{\partial t} - \frac{\partial m_{out}}{\partial t}$$

Let control volume be this turbine. Since water flows in and flows out constantly with unchanged density

$\Rightarrow$ mass in the control volume doesn't change w.r.t time

$$\Rightarrow \frac{\partial M_{cv}(t)}{\partial t} = 0 \Rightarrow \frac{\partial m_{in}}{\partial t} = \frac{\partial m_{out}}{\partial t} \quad (\text{inlet mass flow rate} = \text{outlet mass flow rate})$$

V → Absolute velocity

$$\Rightarrow \frac{\partial m_{in}}{\partial t} = \rho_{out} V_{out} A_{out} = \rho_{out} V \cdot \cos 60^\circ A_{out}$$

V_{out} → Normal velocity vector to outlet

$$\Rightarrow \frac{\partial m_{in}}{\partial t} = \rho_{water} V \cos 60^\circ \, 2\pi r \cdot (w_{blade}) = 1000 \frac{kg}{m^3} \cdot 3 \frac{m}{s} \cos 60^\circ \cdot 2\pi \, 0.18m \cdot 0.03m$$

$$\Rightarrow \frac{\partial m_{in}}{\partial t} \approx 50.89 \frac{kg}{s} \quad (\text{answer})$$