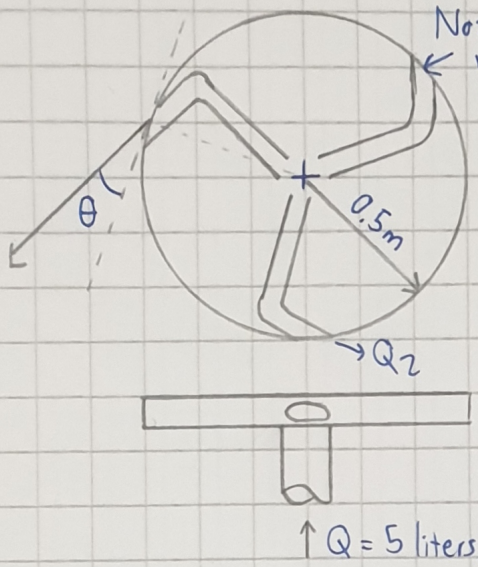
Nguyen Xuan Binh 887799 Round 3 Problem 3



How fast will the rotor spin steadily if the resisting torque is reduced to 0 and
a) $\theta = 0°$? b) $\theta = 30°$ c) $\theta = 60°$

How fast the rotor spins => find angular velocity ω

We have $Q_1 = 5$ litters/s. Since Q_2 is flown out at the three nozzles, let Q_2 be volume of water passing for each nozzle => $Q_2 = \frac{Q_1}{3} = 5/3$ liters/s

We have $Q_2 = A_{nozzle} \cdot V_{r,2}$

$$\Rightarrow V_{r,2} = \frac{Q_2}{A_{nozzle}} = \frac{5/3 \times 10^{-3}}{18 \times 10^{-6}} \simeq 92.592 \text{ (m/s)}$$

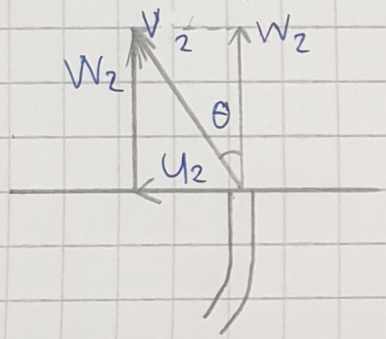
We also have: $\dot{m}(r_2 V_{\theta,2} - r_1 V_{\theta,1}) = T_{shaft}$.

Since V_1 is perpendicular to the rotor and resisting torque is reduced to 0

=> $V_{\theta,1} = 0$, $T_{shaft} = 0$ => $\dot{m}(r_2 V_{\theta,2} - 0) = 0$

$\dot{m}$ and r_2 are non-zero => $V_{\theta,2} = 0$ => $V_2 = V_{r,2} = 92.592$ m/s

Velocity triangle at outlet



$$\Rightarrow U_2 = V_2 \cos\theta = r_2 \omega$$

$$\Rightarrow \omega = \frac{V_2 \cos\theta}{r_2} \text{ (formula)}$$

a) $\theta = 0° \Rightarrow \omega = \frac{92.592 \cdot \cos 0°}{0.5} = 185.184$ rad/s

b) $\theta = 30° \Rightarrow \omega = 92.592 \cdot \cos 30° / 0.5 = 160.374$ rad/s

c) $\theta = 60° \Rightarrow \omega = 92.592 \cdot \cos 60° / 0.5 = 92.592$ rad/s