Data measured during tests of a centrifugal pump at 3500 rpm are given in the table below:

| Parameter | Inlet Section | Outlet Section |
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| gage pressure, $p$ [kPa] | 85.2 | 412 |
| elevation above datum, $z$ [m] | 1.25 | 2.75 |
| avg speed of flow, $V$ [m/s] | 2.35 | 3.62 |

The flow rate is 11.5 $m^3$/hr and the torque applied to the pump shaft is 3.68 N·m. Evaluate the total heads at the pump inlet and outlet, the hydraulic power input to the fluid, and the pump efficiency. Specify the electric motor size needed to drive the pump. If the electric motor efficiency is 85%, calculate the electric power requirement.

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SOLUTION:

$$H_{inlet} = \left(\frac{p}{\rho g} + \alpha\frac{\bar{V}^2}{2g} + z\right)_{inlet} = \frac{85.2\times10^3\ Pa}{(1000\ kg/m^3)(9.81\ m/s^2)} + \frac{(2.35\ m/s)^2}{2(9.81\ m/s^2)} + 1.25\ m$$

$$\therefore H_{inlet} = 10.2\ m$$

$$H_{outlet} = \left(\frac{p}{\rho g} + \alpha\frac{\bar{V}^2}{2g} + z\right)_{outlet} = \frac{412\times10^3\ Pa}{(1000\ kg/m^3)(9.81\ m/s^2)} + \frac{(3.62\ m/s)^2}{2(9.81\ m/s^2)} + 2.75\ m$$

$$\therefore H_{outlet} = 45.4\ m$$

$$\dot{W}_{on\ fluid} = \rho Q g H = (1000\ kg/m^3)(11.5\ m^3/hr)\left(\frac{hr}{3600\ s}\right)(9.81\ m/s^2)\underbrace{(45.4\ m - 10.2\ m)}_{\Delta H}$$

$$\therefore \dot{W}_{on\ fluid} = 1100\ W$$

$$\eta = \frac{\dot{W}_{on\ fluid}}{\dot{W}_{shaft}\ (=\omega T)} = \frac{1100\ W}{(3500\ rpm)\left(\frac{2\pi\ rad}{rot}\right)\left(\frac{min}{60\ sec}\right)(3.68\ N\cdot m)} = \frac{1100\ W}{1350\ W}$$

$$\therefore \eta = 0.81 \Rightarrow \eta \approx 80\%$$

$$\dot{W}_{required} = 1350\ W\left(\frac{hp}{746\ W}\right) = 1.8\ hp \Rightarrow$$

Specify motor that can supply at least 1.8 hp (probably use a 2 hp motor)

- If motor is 85% efficient, then we need to supply the motor with $\dot{W}_{to\ motor} = \frac{\dot{W}_{required}}{\eta_{motor}} = \frac{1350\ W}{0.85} = 1590\ W \approx 2.1\ hp = \dot{W}_{to\ motor}$