2–58 A 75-hp (shaft output) motor that has an efficiency of 91.0 percent is worn out and is replaced by a high-efficiency 75-hp motor that has an efficiency of 95.4 percent. Determine the reduction in the heat gain of the room due to higher efficiency under full-load conditions.

Problem 2-58

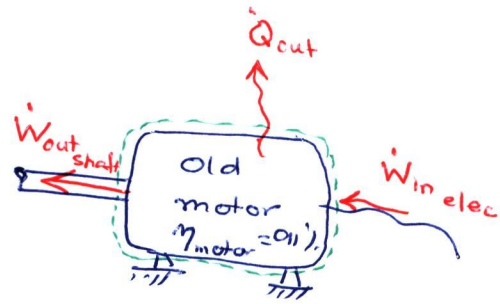
Old motor : $\dot{W}_{out_{shaft_{old}}} = 75$ hp

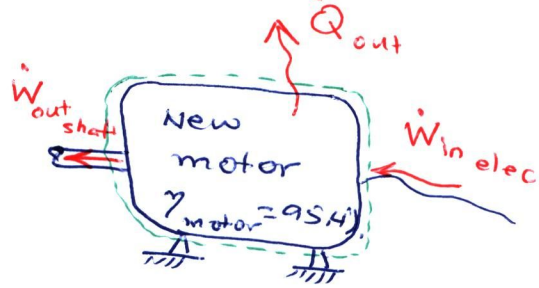
$\eta_{motor_{old}} = 91\%$

New motor : $\dot{W}_{out_{shaft_{new}}} = 75$ hp

$\eta_{motor_{new}} = 95.4\%$

Determine : reduction in heat gain of the room with the new motor





Solution : We need to calculate the heat dissipated to the room from the old motor ($\dot{Q}_{out_{old}}$) and the new motor ($\dot{Q}_{out_{new}}$) and find the difference ($\dot{Q}_{out_{old}} - \dot{Q}_{out,new}$)

To find $\dot{Q}_{out_{old}}$, apply the 1st law :

$$\left(\dot{Q}_{in} + \dot{W}_{in} + \dot{E}_{mass,in}\right) - \left(\dot{Q}_{out} + \dot{W}_{out} + \dot{E}_{mass_{out}}\right) = \frac{dU}{dt} + \frac{dKE}{dt} + \frac{dPE}{dt}$$

($\dot{Q}_{in} = 0$: no heat input; $\dot{E}_{mass,in} = 0$: closed system; $\dot{E}_{mass_{out}} = 0$: closed system; $\frac{dU}{dt} = 0$: assuming temperature is constant; $\frac{dKE}{dt} = 0$, $\frac{dPE}{dt} = 0$: stationary)

$$\rightarrow \dot{W}_{in_{elec_{old}}} - \dot{Q}_{out_{old}} - \dot{W}_{out_{old}} = 0$$

$$\rightarrow \dot{Q}_{out_{old}} = \dot{W}_{in_{elec_{old}}} - \dot{W}_{out_{old}} \quad \text{---- (1)}$$

We know $\dot{W}_{out_{old}} = 75$ hp $= 75 \times 0.746 = 55.95$ kW

To find $\dot{W}_{in_{elec_{old}}}$, use $\eta_{motor_{old}} = \frac{\dot{W}_{out_{old}}}{\dot{W}_{in_{elec_{old}}}} \rightarrow \dot{W}_{in_{elec_{old}}} = \frac{\dot{W}_{out_{old}}}{\eta_{motor_{old}}}$

$$\rightarrow \dot{W}_{in_{elec_{old}}} = \frac{55.95}{0.91} = 61.48 \text{ kW}$$

Substitute in Equation (1) : $\dot{Q}_{out_{old}} = 61.48 - 55.95 = \underline{5.53 \text{ kW}}$

Now, use the same procedure for the new motor;

$$\dot{Q}_{out_{new}} = \dot{W}_{in_{elec_{new}}} - \dot{W}_{out_{new}} = \frac{55.95}{0.954} - 55.95 = \underline{2.7 \text{ kW}}$$

So, reduction in heat loss to room is : $\dot{Q}_{out_{old}} - \dot{Q}_{out_{new}} = 5.53 - 2.7 = 2.83$ kW