Estimation of the Heat Dissipation Power of a Coolant Reservoir

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2024.12.22

1 Assumptions

The main factor affecting the total heat dissipation power of the reservoir is the heat exchange between the hot water and cold air. Therefore, the assumptions in this estimation are:

- Only the heat exchange at the interface between the water surface and the air is considered;
- Water and air are under natural convection conditions (no wind);
- The system is in a state of thermal equilibrium.

2 Parameters and Variables

Reservoir total surface area:

$$A = 40\,m \times 60\,m \times 4 \text{ units}$$

Water temperature:

$$T_1 = 30°\text{C} \quad \text{(assume 30 in winter, 38 in summer; we take the winter temperature)}$$

Ambient temperature:

$$T_\infty = -10°\text{C} \quad \text{(assume winter ambient temperature)}$$

Natural convection heat transfer coefficient for air:

$$h = 50 \left[W \cdot m^{-2} \cdot K^{-1}\right] \quad \text{(typical range: 10–100)}$$

Thermal generator efficiency:

$$\eta = 30\% \quad \text{(typical range: 30\%–50\%)}$$

3 Heat Conduction Theorem

Theorem 1. *According to the steady-state heat convection equation, the convective heat flux* $\dot{q}''\,(\mathrm{W/m^2})$ *is given by:*

$$\dot{q}'' = \frac{\Delta T}{1/h} \tag{1}$$

$$= \frac{T_1 - T_\infty}{1/h}. \tag{2}$$

4 Coolant Reservoir Cooling Power Calculation

Based on the above, the cooling power $\dot{q}\,(\mathrm{W})$ of the reservoir is:

$$\dot{q} = \dot{q}'' \cdot A \tag{3}$$

$$= h \cdot A \cdot (T_1 - T_\infty) \tag{4}$$

$$= 50 \times (40 \times 60 \times 4) \times (30 - (-10)) \tag{5}$$

$$= 1.9 \times 10^4\,\mathrm{kW}. \tag{6}$$

Over one day, the total cooling energy $Q\,(\mathrm{kW \cdot h})$ is:

$$Q = \dot{q} \cdot t \tag{7}$$

$$= 1.9 \times 10^4\,\mathrm{kW} \times 24\,\mathrm{h} \tag{8}$$

$$= 4.56 \times 10^5\,\mathrm{kW \cdot h}. \tag{9}$$

5 Conclusion

According to the above conservative estimation, if a thermal generator is installed and the recovered heat is used for production, the system can at least save the usable electrical energy 456,000 kWh.