Problem: 9-11

Given: Three high pressure turbines, each with inlet state of 1000 $^\circ F$, 3500 psia steam
Turbine x Exit: 1000 psia, 660 $^\circ F$, $Q_{loss} = 7$ Btu/lbm
Turbine y Exit: 1000 psia, 635 $^\circ F$, $Q_{loss} = 12$ Btu/lbm
Turbine z Exit: 1000 psia, 680 $^\circ F$, $Q_{loss} = 2$ Btu/lbm
compare to Mollier chart.

Find: Work output and isentropic efficiency and give a purchase recommendation

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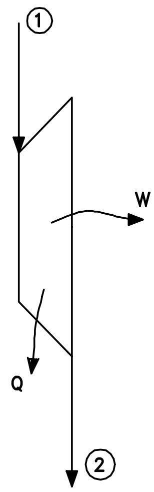

Energy Balance:

$$\dot{m}h_1 = \dot{m}h_2 + \dot{Q} + \dot{W}$$

or

$$W = (h_1 - h_2) - Q$$

$$T_1 = 1000\ ^\circ F \qquad P_1 = 3500\ psia$$

From steam tables

$$\begin{aligned} h_1 &= 1421.1\ Btu/lbm \\ s_1 &= 1.471\ Btu/lbm \cdot R \end{aligned}$$

Isentropic case:

From steam tables

$$h_{2s}(P_2 = 1000\ psia, s_{2s} = s_1 = 1.471\ Btu/lbm \cdot R) = 1277.3\ Btu/lbm$$

Therefore

$$W_s = h_1 - h_{2s} = 1421.1 - 1277.3 = 143.8\ Btu/lbm$$

Turbine x

$$\begin{aligned} h_2(1000\ psia, 660\ ^\circ F) &= 1294.2\ Btu/lbm \\ W_{T_x} &= h_1 - h_2 - Q = 1421.1 - 1294.2 - 7 = \boxed{119.9\ Btu/lbm} \\ \eta_{T_x} &= W_{T_x}/W_s = 119.9/143.8 = \boxed{83.4\%} \end{aligned}$$

Turbine y

$$\begin{aligned} h_2(1000\ psia, 635\ ^\circ F) &= 1275.3\ Btu/lbm \\ W_{T_y} &= h_1 - h_2 - Q = 1421.1 - 1275.3 - 12 = \boxed{133.8\ Btu/lbm} \\ \eta_{T_y} &= W_{T_y}/W_s = 133.8/143.8 = \boxed{93.1\%} \end{aligned}$$

Turbine z

$$\begin{aligned} h_2(1000\ psia, 680\ ^\circ F) &= 1309.4\ Btu/lbm \\ W_{T_z} &= h_1 - h_2 - Q = 1421.1 - 1309.4 - 2 = \boxed{109.7\ Btu/lbm} \\ \eta_{T_z} &= W_{T_z}/W_s = 109.7/143.8 = \boxed{75.6\%} \end{aligned}$$

Turbine y is recommended as it has the highest output and efficiency.