1. Suatu pembangkit tenaga uap berdaya 80.000 kW beroperasi dengan boiler yang menghasilkan uap bertekanan 10.000 kPa dan suhunya 600°C. Uap keluar turbin pada tekanan 10 kPa. Efisiensi **turbin = 0,8** dan **pompa** sebesar **0,75**. Hitunglah:
   a. Laju alir uap, dalam kg/s
   b. Laju transfer panas pada boiler, dalam kJ/s
   c. Laju transfer panas pada kondenser, dalam kJ/s
   d. Daya pompa (kW)
   e. Efisiensi termal pembangkit

$kJ := 1000 \cdot J$

a) $P_2 := 10000 \cdot 10^3 \cdot Pa$ $\quad T_2 := (600 + 273.15) \cdot K$

$H_2 := 3622.7 \cdot \frac{J}{gm}$ $\quad S_2 := 6.9013 \cdot \frac{J}{gm \cdot K}$

Turbin

Jika Turbin isentropik:

$P_3 := 10 \cdot 10^3 \cdot Pa$ $\quad S_3 := S_2$ $\quad S_3 = 6.9013 \frac{J}{gm \cdot K}$

$T_3 := (45.83 + 273.15) \cdot K$ $\quad H_{v3} := 2584.8 \cdot J \cdot gm^{-1}$ $\quad H_{L3} := 191.832 \cdot J \cdot gm^{-1}$

$S_{L3} := 0.6493 \cdot J \cdot gm^{-1} \cdot K^{-1}$ $\quad S_{v3} := 8.1511 \cdot J \cdot gm^{-1} \cdot K^{-1}$

$x_{v3} := 0.7$ (tebakan)

Given

$S_3 = S_{v3} \cdot x_{v3} + S_{L3} \cdot (1 - x_{v3})$

$x_{v3} := \text{Find}(x_{v3})$ $\quad x_{v3} = 0.8334$

$H_{3s} := H_{v3} \cdot x_{v3} + H_{L3} \cdot (1 - x_{v3})$ $\quad H_{3s} = 2186.1315 \frac{J}{gm}$ $\quad \eta_t := 0.8$

$\Delta H_s := H_{3s} - H_2$ $\quad \Delta H_s = -1436.5685 \frac{J}{gm}$

Kondisi aktual

$W_{s\_act\_turbin} := \eta_t \cdot \Delta H_s$ $\quad W_{s\_act\_turbin} = -1149.2548 \frac{J}{gm}$ $\quad \Delta H := W_{s\_act\_turbin}$

$H_3 := \Delta H + H_2$ $\quad H_3 = 2473.4452 \frac{J}{gm}$

Given

$H_3 = H_{v3} \cdot x_{v3} + H_{L3} \cdot (1 - x_{v3})$

$x_{v3} := \text{Find}(x_{v3})$ $\quad x_{v3} = 0.9535$

$S_3 := S_{v3} \cdot x_{v3} + S_{L3} \cdot (1 - x_{v3})$ $\quad S_3 = 7.802\ K^{-1} \frac{J}{gm}$

CONDENSER

$T_4 := T_3$ $T_4 = 318.98\ K$ $P_4 := P_3$ $P_4 = 10000\ Pa$

cair jenuh $H_4 := H_{L3}$ $H_4 = 191.832\ \frac{J}{gm}$

$S_4 := S_{L3}$ $S_4 = 0.6493\ K^{-1}\ \frac{J}{gm}$

$Q_C := H_4 - H_3$ $Q_C = -2281.6132\ \frac{J}{gm}$

POMPA

$P_4 = 10000\ Pa$ $T_4 = 318.98\ K$

Jika isentropik:

$S_1 := S_4$ $P_1 := P_2$ $V_4 := 1.010 \cdot cm^3 \cdot gm^{-1}$ $\Delta P := P_1 - P_4$

$\Delta H_s := V_4 \cdot \Delta P$ $\Delta H_s = 10.0899\ \frac{J}{gm}$ $\eta_p := 0.75$

Kondisi aktual

$\Delta H := \frac{\Delta H_s}{\eta_p}$ $W_{s\_act\_pompa} := \Delta H$ $W_{s\_act\_pompa} = 13.4532\ \frac{J}{gm}$

$H_1 := \Delta H + H_4$ $H_1 = 205.2852\ \frac{J}{gm}$

BOILER

$Q_H := H_2 - H_1$ $Q_H = 3417.4148\ \frac{J}{gm}$

$W_{s\_net} := W_{s\_act\_pompa} + W_{s\_act\_turbin}$

$\eta_{cycle} := \frac{|W_{s\_net}|}{Q_H}$ $\eta_{cycle} = 0.3324$

$W_{s\_net} = -1135.8016\ \frac{J}{gm}$ $W_{s\_net\_rate} := -80000 \cdot kW$

steam rate (laju alir massa steam): $m_s := \frac{W_{s\_net\_rate}}{W_{s\_net}}$ $m_s = 70.4348\ \frac{kg}{s}$

$Q_{H\_rate} := m_s \cdot Q_H$ $Q_{H\_rate} = 240705.0515\ kW$ (pada boiler)

$Q_{C\_rate} := m_s \cdot Q_C$ $Q_{C\_rate} = -160705.0515\ kW$ (pada condenser)

cek : $Q_{H\_rate} + Q_{C\_rate} = 80000\ kW$ (cocok)

$$W_{s\_act\_pompa\_rate} := W_{s\_act\_pompa} \cdot m_s$$

$$\boxed{W_{s\_act\_pompa\_rate} = 947.5739\,\text{kW}}$$