تمرین سری ۱

Subject

Date

الف -

P	T	x	v	h	s	توضیحات
۱/۲ (MPa)	۱۸۷/۹۹°C	۰٪	۰/۰۰۱۱۴۴ $(\frac{m^3}{kg})$	۷۸۱/۹۶ $\frac{kJ}{kg}$	۲/۱۳۹۶ $(\frac{kJ}{kg.K})$	آب اشباع
۲۰۰۰ (psi)	۹۳۹°F	۱۰۰٪	۰/۱۸۸۱ $(\frac{ft^3}{lbm})$	۱۱۳۹/۲ $(\frac{Btu}{lbm})$	۱/۸۷۹۲ $(\frac{Btu}{lbm.R})$	بخار آب
۹/۸۵۶ (MPa)	۳۱۰(°C)	۱۰۰٪	۰/۰۱۸۵۰ $(\frac{m^3}{kg})$	۲۷۲۷/۲ $(\frac{kJ}{kg})$	۵/۹۲۲۹ $(\frac{kJ}{kg.K})$	بخار اشباع
۱۵۲۱ (psi)	۹۰۰(°F)	۰٪	۰/۰۲۲۹۲ $(\frac{ft^3}{lbm})$	۳۱۹/۹ $(\frac{Btu}{lbm})$	۰/۸۱۲۱ $(\frac{Btu}{lbm.R})$	آب اشباع
۱۰۰۰ (psi)	۸۰۰(°F)	۱۰۰٪	۰/۲۸۷۸ $(\frac{ft^3}{lbm})$	۱۴۸۸/۵ $\frac{Btu}{lbm}$	۱/۵۹۹۹ $(\frac{Btu}{lbm.R})$	super heat steam
۲۰ (MPa)	۵۵۰(°C)	۱۰۰٪	۰/۰۱۵۹ $(\frac{m^3}{kg})$	۳۳۹۳/۲ $(\frac{kJ}{kg})$	۶/۳۵۶۹ $(\frac{kJ}{kg.K})$	super heat steam
۲۰۰۰ (psi)	۱۲۰۰ (°F)	۱۰۰٪	۰/۴۶۸۵ $(\frac{ft^3}{lbm})$	۱۵۹۸/۹ $(\frac{Btu}{lbm})$	۱/۹۲۰۰ $(Btu/lb_m.R)$	super heat steam
۹۰۰ (psi)	۴۸۹/۲(F)	۹۰٪	۰/۰۹۹۵۲ $(\frac{ft^3}{lbm})$	۱۱۴۰/۱۵ $(\frac{Btu}{lbm})$	۱/۲۹۹۱۸ $(\frac{Btu}{lbm.R})$	مخلوط آب اشباع و بخار اشباع

ب -

الف) ۶.۱

$P = ۲۵\ (MPa) \quad T = ۵۴۰(°C)$

$\bar{V} = mv \rightarrow m = \frac{۲/۸}{۸۰۸۵ \times ۱۰^{-۵}} = ۳۴۶/۲۲$

$\rightarrow v = ۸۰۸۵ \times ۱۰^{-۵}\ (\frac{m^3}{kg})$

ب)

$R = ۰/۴۶۸\ (\frac{kJ}{kg.K}) \quad T_c = ۹۴۷/۴(K)$

$T_r = \frac{T}{T_c} = ۱/۲۵۹ \quad P_c = ۲۲/۱۲\ (MPa)$

Subject Date

$P_r = \frac{P}{P_c} = ۱/۵۸۳$ با توجه شکل: $Z = ۰/۷۵$

$m = \frac{PV}{ZRT} = ۳۵۰/۱۸۹ \ (kg)$

۱.۷. الف)

$P_1 = ۳ (MPa)$, $T_1 = ۴۰۰ °C$ $\rightarrow$ $v_1 = ۰/۰۹۹۳۶ \left(\frac{m^3}{kg}\right)$, $u_1 = ۲۹۳۳ \left(\frac{kJ}{kg}\right)$

$P_2 = ۰/۵ (MPa)$, $v_1 = v_2 = ۰/۰۹۹۳۶ \left(\frac{m^3}{kg}\right)$ $\rightarrow$ $u_2 = ۱۱۳۵ \left(\frac{kJ}{kg}\right)$

$T_2 = ۱۵۱/۹ \ (°C)$

ب) $Q - W = \Delta U$ $V = mv \longrightarrow m = \frac{۱۰}{۰/۰۹۹۳۶} = ۱۰۰/۶۴ (kg)$

حجم ثابت $W = ۰ \longrightarrow Q = \Delta U = m(u_2 - u_1) = ۱۰۰/۶۴ \times (۱۱۳۵ - ...$

$Q = -۱۷۹۹۴۴/۳۴ \ (kJ)$

۱.۸.

$P_1 = ۳ (MPa)$, $T_1 = ۴۰۰ \ (°C)$ $\rightarrow$ $u_1 = ۲۹۳۳ \left(\frac{kJ}{kg}\right)$

$P_2 = ۰/۵ (MPa)$, بخار اشباع $\rightarrow$ $u_2 = ۲۵۶۱ \left(\frac{kJ}{kg}\right)$, $v_2 = ۰/۳۷۴۹ \left(\frac{m^3}{kg}\right)$

Subject ..... Date .....

$V_2 = mv_2 = \frac{0.05}{0.0294} = 1.49V(kg)$

قانون اول ترمودینامیک برای سیستم بسته $\longrightarrow Q - W = \Delta U$

فرایند بی‌دررو $\longrightarrow Q = 0 \quad W = -\Delta U$

$W = -m(u_2 - u_1) = -1.49V(2541 - 2934) = 585.11(kJ)$

Year: Month: Date:

بامداد سالاری 91101934

تمرین سری دوم سیستم های تولید انرژی الکتریکی دکتر عباسپور

① طبق قانون اول: $Q_{in} = Q_{out} + W \Rightarrow \frac{Q_{out}}{t} = 250\,W$

$\eta = 75\%$

طبق قانون دوم: $\Delta S \geq \frac{Q_C}{T_C} - \frac{Q_H}{T_H}$

با فرض برگشت پذیری و ادیاباتیک بودن سیکل Q_{out} و Q_{in} تبادل

$\eta_{carnot} = 1 - \frac{T_C}{T_H} \overset{(I)}{\geq} 1 - \frac{Q_C}{Q_H}$ ✓

با فرض: $\Delta S = 0$, $\Delta P_S = 0$ $\Rightarrow (\eta_{carnot\,max}) \equiv \left(\begin{matrix} T_{C\,min} \\ T_{H\,max} \end{matrix}\right) \equiv \left(\frac{Q_H}{T_H} = \frac{Q_C}{T_C}\right)$

اما در اینجا اصطکاک داریم $\Rightarrow \Delta P_S > 0 \Rightarrow \Delta S > -\frac{Q_C}{T_C} + \frac{Q_H}{T_H} \overset{\Delta S = 0}{\Rightarrow} \frac{Q_C}{T_C} > \frac{Q_H}{T_H}$ (I)

② $Q = 0$

قانون اول: $h_{in} = h_{out} + W \Rightarrow W = -\Delta h \Rightarrow |W| = h_{in} - h_{out}$

بخار 1 kg/sec, 2 MPa, 400°C → T → 1 atm = 0.101 MPa, W

قانون دوم: $\begin{cases} \Delta P_S = \Delta S + \dot{M} S_{out} - \dot{M} S_{in} \\ \Delta P_S \geq 0 \Rightarrow S_{out} \geq S_{in} \end{cases}$

طبق جدول: 400°C, 20 bar → $h_{in} = 3247.6$, $S_{in} = 7.1271$, $v_{in} = 0.1512$

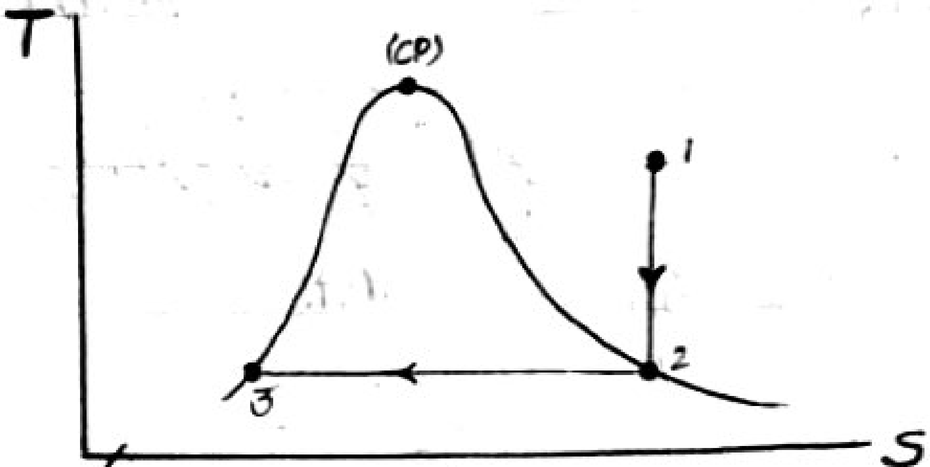
$|W| = max \Rightarrow h_{out} = min \Rightarrow S_{out} = min \Rightarrow S_{out} = S_{in}$

طبق جدول: $S_{out} \geq 7.1271$, $P = 0.101\,MPa \rightarrow 1\,bar$

بخار اشباع: $S_{out} = 7.3580$, $h_{out} = 2675$, $v_{out} = 1.694$

$\Rightarrow |W|_{max} = h_{in} - h_{out} = 3247.6 - 2675 = 572.6 \frac{kJ}{kg} = 5726 \frac{kJ}{sec}$

$\Rightarrow P_{max} = 5726\,kW$



تحول ① : ایزنتروپیک ⟹ $\Delta S_{1-2} = 0$

طبق جدول : $P_1 = 1000\ psi \simeq 70atm$ ⟹ $T = 900°F$

[illegible] : $v_1 = [illegible]$

80 , 60 [illegible] 70atm $h_1 = [illegible]$

$S_1 = 1.?25$

$S_1 = S_2 \cong 1.92$

$h_2 = 1116.2$

$v_2 = 173.76$

$T_2 = 126.07°F$

$P_2 = 2\ psi$

⟹ $\Delta h_{1-2} = -365.3$. $\Delta H_{1-2} = \Delta h \times 100\ lbm = -36530\ [illegible]$

تحول ② : $T_3 = 126.07°F$

$P_3 = 2\ psi$

$v_3 = 0.01623$

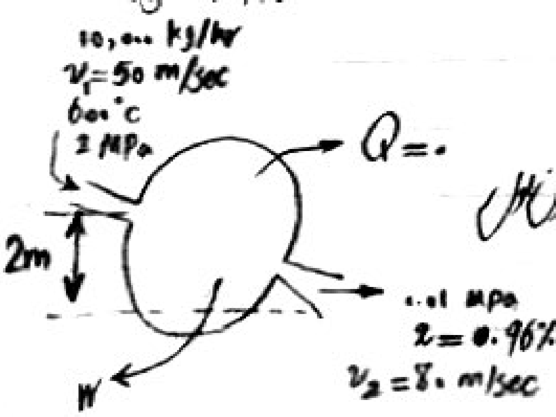
$h_3 = 94.03$

$S_3 = 0.1750$

⟹ $\Delta h_{2-3} = -1022.17\ btu/lbm$ ⟹ $\Delta H_{2-3} = -102217\ btu$

$\Delta S_{2-3} = -1.745\ btu/lbm\,°F$ ⟹ $\Delta S_{2-3} = -174.5\ btu/°F$

④



قانون اول: $KE_{in} + PE_{in} + H_{in} = W + KE_{out} + PE_{out} + H_{out}$

$ke_{in} = \frac{1}{2}v^2 = \frac{2500}{2} = 1250\ J/kg$. $\frac{PE_{in} - PE_{out}}{m} = g(h_{in} - h_{out}) = 20\ J/kg$

$ke_{out} = \frac{1}{2}v^2 = \frac{6400}{2} = 3200\ J/kg$. $h_{in} = 3690.1\ kJ/kg$

Subject:
Year: Month:

$h_{out} = h_f + x h_{fg} = 191.9 + 2392.3 \times 0.96 = 2488.51$ kJ/kg

$\rightarrow w = 1250 - 3200 + 20 + (3690.1 - 2488.51) \times 10^3$ J/kg

$\rightarrow w = 1199.66$ kJ/kg $\rightarrow \dot{P} = 1199.66 \times 10^5$ kJ/hr

$= 0.333239 \times 10^5$ kJ/sec

$\rightarrow P = 33323.89$ kW

با صرف نظر از k_E, P_E : $w = (3690.1 - 2488.51)$ kJ/kg

$= 1201.59$ kJ/kg $\rightarrow P = 33377.5$ kW

$\rightarrow \eta = \frac{33377.5 - 33323.89}{33323.89} \times 100 = 0.161\ \%$

طبق انتظار، خطای صرف نظر از k_E و P_E بسیار ناچیز است زیرا این موارد در مقایسه با آنتالپی بسیار کوچک هستند.

10000 kg/hr $\rightarrow 2.778$ kg/sec

$v_1 = 0.1996$ m³/kg

$v_2 = v_f + x v_{fg} = 0.001010 3 \times 0.04 + 0.96 \times 14.68 = 14.0928$ m³/kg

$0.1996 \frac{m^3}{kg} \times 2.778 \frac{kg}{sec} \times \frac{1}{50} \frac{sec}{m} = 0.0110898\ m^2 = \pi r^2$

$\rightarrow D_{(\text{خروجی})} = 0.1188$ m

$14.0928 \times 2.778 \times \frac{1}{80} = 0.4894\ m^2 = \pi r^2 \rightarrow$ شعاع ورودی $= 0.7894$ m

Subject:
Year: Month: Date:

۱-۱۲ کتاب نیروگاه حرارتی

$Q_H = 1000\ kJ$
$T_H = 500^\circ C$
$Q_C = 350\ kJ$
$T_C = 50^\circ C$

⇒ راندمان حرارتی چرخه کارنو: $\eta = 1 - \frac{T_C}{T_H} = 1 - \frac{50+273}{500+273}$

بازده این چرخه مفروض: $\eta = \frac{\Delta W_{net}}{Q_{in}} = \frac{Q_{in} - Q_{out}}{Q_{in}}$

بازده این چرخه مفروض بالاتر از چرخه کارنو میباشد زیرا بیشترین بازده ممکن است.

۱-۲۱ کتاب نیروگاه حرارتی

طبق جدول: $P_1 = 17\ MPa = 2500\ psi$ ⇒ $h_1 = 3399\ kJ/kg$
$t_1 = 1000^\circ F$
$S_1 = 6.407\ kJ/kg\,K$

حالت ایزوتروپ: $\begin{cases} S_2 = S_1 = 6.407 \\ P_2 = 7\ kpa \end{cases}$ ⇒ $h_{2s} = 1989\ kJ/kg$

$P_S = W_S \times \dot{m}$

$W_S = -\Delta h = (3399 - 1989) \cdot \frac{4.5 \times 10^6\ kg}{h} \times \frac{1h}{3600} = 1762.5\ MW$

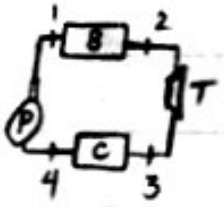
$P_{\substack{actual \\ output \\ turbine}} = 1762.5 \times 0.9 \times 0.95 = 1506.94\ MW$

$P_{\substack{output \\ G}} = 1506.94 \times 0.96 = 1446.66\ MW$

Subject:
Year Month Date

تمرین سری سوم تولید انرژی الکتریکی دکتر صابری

نام و نام خانوادگی 9110434



① $\eta = \frac{W_T - W_P}{Q_B}$

ورودی توربین: بخار اشباع ← $t_2 = 233.9^\circ C$ ، $v_2 = 0.0667\ m^3/kg$
$P_2 = 3\,MPa = 436.6\,psi \cong 435.11\,psi$ ، $h_2 = 2803.7\ kJ/kg$
، $S_2 = 6.1861\ kJ/kg$

ورودی کندانسور: بخار اشباع ← $t_4 = 39.03^\circ C$ ، $v_4 = 0.0010075\ m^3/kg$
$P_4 = 1.0188\,psi \cong 0.0153\,psi$ ، $h_4 = 163.43\ kJ/kg$
$S_4 = 0.5591$

خروجی توربین نقطه 3 با حفظ آنتروپی: $S_3 = S_2 = 6.1861 = 0.5591 + x\,7.7149 \Rightarrow x = 72.937\%$
$P_3 = P_4 = 1.0153\,psi$
$\rightarrow h_3 = 163.43 + 2409x = 1920.477\ kJ/kg$

خروجی پمپ نقطه 1 با حفظ آنتروپی در حالت پمپ ایده‌آل: $S_1 = S_4 = 0.5591$
$P_1 = P_2 = 435.11\,psi$

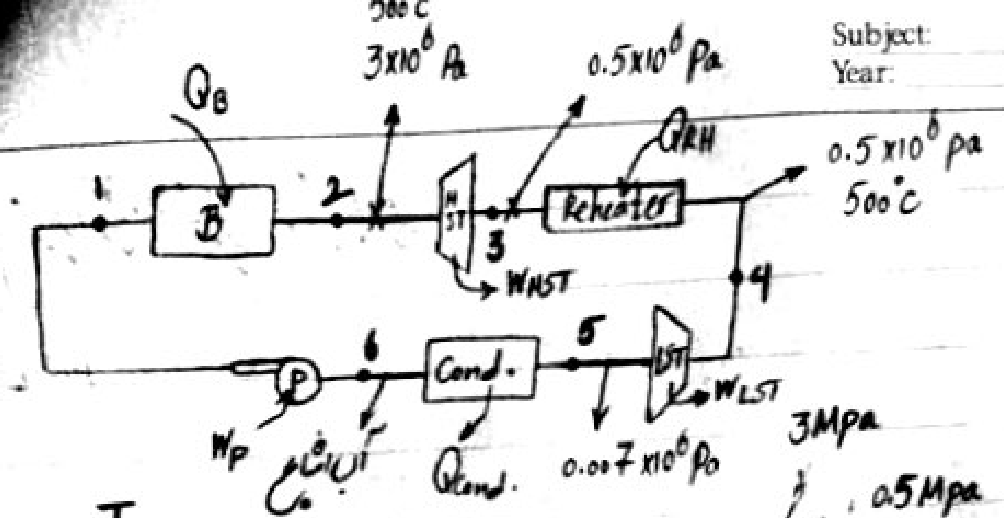
$W_{T_{ایده‌آل}} = \eta_{ST} W_{T_{ایده‌آل}} = (h_2 - h_3)0.8 = 706.578\ kJ/kg$

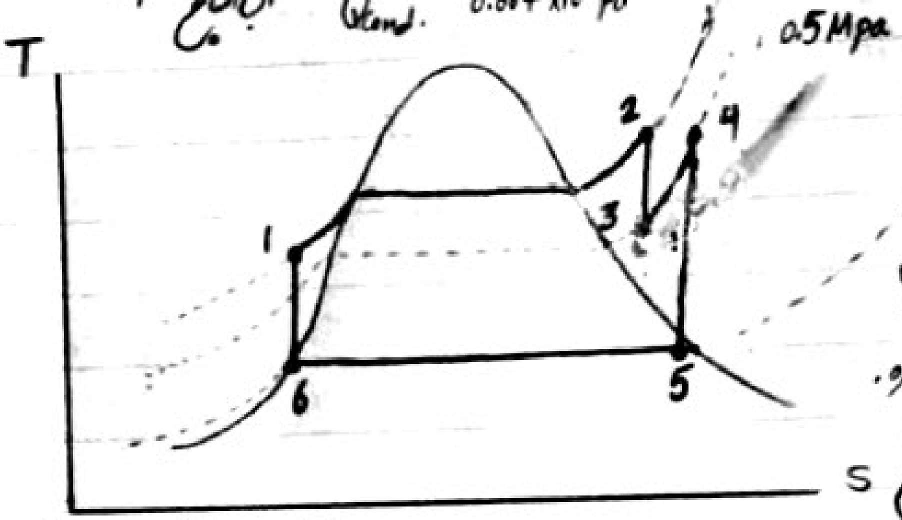
$|W_{P_{ایده‌آل}}| = \frac{|W_{P_{ایده‌آل}}|}{\eta_P} = \frac{h_1 - h_4}{0.6} = \frac{v_4(P_1 - P_4)}{0.6} = \frac{0.0010075(3\times10^6 - 7\times10^3)}{0.6} = 5.026\ kJ/kg$

$\rightarrow h_1 = h_4 + 3.0154 = 166.445\ kJ/kg \rightarrow Q_B = h_2 - h_1 = 2637.255\ kJ/kg$

$\rightarrow \eta = 26.6\%$

Subject:
Year: Month: Date:





این نمودار با فرض توربین و پمپ ایزنتروپیک و برگشت پذیر رسم شده.
در غیر این صورت افزایش آنتروپی در فرآیندهای 1-6 و 5-4 داریم.

$$\eta = \frac{W_{HST} + W_{LST} - W_P}{Q_B + Q_{RH}}$$

اطلاعات از جدو: ② $t_2 = 500°c$: $v_2 = 0.1162$ m^3/kg

$P_2 = 3Mpa$ $h_2 = 3456.5$ kJ/kg

$s_2 = 7.2338$ $kJ/(kg\,K)$

③ $s_3 = s_2 = 7.2338$: $v_3 = 0.4657$

$P_3 = 0.5 Mpa$ $h_3 = 2942.251$

$t = 241°c$

④ $p = 0.5 Mpa$: $v_4 = 0.7109$

$t = 500°c$ $h_4 = 3483.1$

$s_4 = 8.0873$

⑤ $s_5 = s_4 = 8.0873 = 0.5591 + 7.7149x \rightarrow x = 97.58\%$

$P_5 = 0.007 Mpa$ $t_5 = 39.03°c$

$\Rightarrow v_5 = 20.033$

$h_5 = 2514.13$

⑥ $t_6 = t_5 = 39.03°c$: $v_6 = 0.001075$

آب اشباع $h_6 = 163.43$

$s_6 = 0.5591$

$$W_{HST\,actual} = \eta_{ST} W_{HST\,ideal} = 0.8(h_2 - h_3) = 411.399 \ kJ/kg$$

$$W_{LST\,actual} = 0.8(h_4 - h_5) = 775.816 \ kJ/kg$$

$$|W_P|_{actual} = \frac{|W_{P\,ideal}|}{\eta_{SP}} = \frac{h_1 - h_6}{0.6} \cong \frac{v_6(P_1 - P_6)}{0.6} = 5.0257 \ kJ/kg$$

$$\Downarrow$$

$$h_1 = 166.445$$

$$Q_B = h_2 - h_1 = 3290.055 \ kJ/kg$$

$$Q_{RH} = h_4 - h_3 = 541.649 \ kJ/kg$$

$$\rightarrow \eta = 30.85\%$$

$$q + W + h_2 = h_1 \rightarrow W = -\Delta h - q$$

(3)

1000°F, 3500psi

X → 1000 psi, 666°F → 349°C → $\dot{m} = 7 \frac{Btu}{Lbm} = 16.282 \ kJ/kg$ → $v = 0.0343$, $h = 2998.25$, $S = 6.1892$ → $W = 281.271 \ kJ/kg$ → $\eta_{ST} = 94.5$

Y → 1000 psi, 635°F → 335°C → $\dot{m} = 12 \ Btu/lbm = 27.912$ → $v = 0.0329$, $h = 2950.295$, $S = 6.1116$ → $W = 317.516 \ kJ/kg$ → $\eta_{ST} = 91.92$

Z → 1000 psi, 680°F → 360°C → $\dot{m} = 2 \ Btu/lbm = 4.652$ → $v = 0.0354$, $h = 3030.22$, $S = 6.2409$ → $W = 260.931 \ kJ/kg$ → $\eta_{ST} = 98.25$

بخار ورودی کمپرسور

$v = 0.01539 \ m^3/kg$

$h = 3295.803$

$S = 6.138$

پیشنهاد به استفاده از توربین X است که بیشترین بازدهی را دارد.

Subject:
Year: Month: Date:

① $v = 0.001012$
35 in Hg: $h = 207.1$
$s = 0.6964$

② 350 psi

$$w_{ideal\,p} = v_1(P_2 - P_1) = 0.001012\,(2413 - 11.852)$$
$$= 2.42996 \text{ kJ/kg}$$

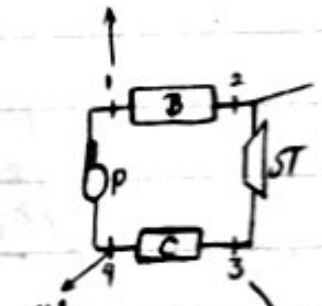
$$\rightarrow w_{actual\,p} = w_{ideal\,p} / \eta_{SP} = 3.0375 \text{ kJ/kg}$$

$$P = 3.0375 \text{ kJ/kg} \times \frac{3.79 \text{ kg}}{1 \text{ gallon}} \times \frac{5100}{1} \text{ gal/min} \times \frac{1 \text{ min}}{60 \text{ sec}}$$

$$= 978.515 \text{ kW} = 1312.212 \text{ hp}$$

مسئله 2.2 نیروگاه حرارتی:

$P_1 = P_{2+1} = 9.5631 \text{ MPa}$



125 kg/s
300°C
بخار آب

$P_2 = 1246.31 \text{ psi}$
$v_2 = 0.021649$ (SI)
$h_2 = 2751$
$s_2 = 5.7081$

$\eta_{ST} = 0.88$
$\eta_{SP} = 0.75$

40°C (SI)
$v_4 = 0.001\,0079$
$h_4 = 167.5$
$s_4 = 0.5723$
$P_4 = 1.0697 \text{ psi}$

$s_3 = s_2 = 5.7081$
$P_3 = P_4 = 1.0697 \text{ psi}$
$\downarrow$
$x = 66.84\%$
$\Rightarrow h_3 = 1775.696$

$$W_{net} = W_T - |W_P| = \eta_{ST} W_{ideal\,T} - \frac{|W_{ideal\,P}|}{\eta_{SP}}$$
$$= \eta_{ST}(h_2 - h_3) - \frac{v_4(P_1 - P_4)}{\eta_{SP}} = 845.4259 \text{ kJ/kg}$$

$845.4259 \text{ kJ/kg} \times 125 \frac{\text{kg}}{\text{s}} = 105.68 \text{ MW}$

$q_B = h_2 - h_1 = 2751 - 177.131 = 2573.869 \text{ kJ/kg}$

$\rightarrow \eta_{\%} = 32.85\%$

$w_{actual\,p} = h_1 - h_4 = 9.6312 \Rightarrow h_1 = 177.131$

مسئله 4-2 پیرو ۵ حرارتی :

(الف) $\eta_{ST} = 0.9$

$P_1 = 16.5\ MPa$, $t_1 = 540^\circ C$ $\Rightarrow$ $h_1 = 3398.91$, $S_1 = 6.4178$, $v_1 = 0.02023$

$W_{actual_T} = \eta_{ST} W_{ideal_T} = \eta_{ST}(h_1 - h_{2s}) = 0.9(3398.91 - 1992.82) =$

$P_2 = 7\ kPa$, $S_2 = S_1 = 6.4178 \Rightarrow h_{2s} = 1992.82$

$P_T = 1000\ MJ/s$ $\Downarrow$ $x = 0.7594$

$1000 \times 1000\ \frac{kJ}{s} \times \frac{1\ kg}{1265.481\ kJ} = 790.213\ kg/s$

$790.213\ kg/s \times 0.02023\ \frac{m^3}{kg} = 15.99\ m^3/s$

ب) $\eta_{ST} = 0.88$

$P_1 = 7\ MPa$, $t_1 = ?$ $\Rightarrow$ $v_1 = 0.0274$, $h_1 = 2771.7$, $S_1 = 5.8125$

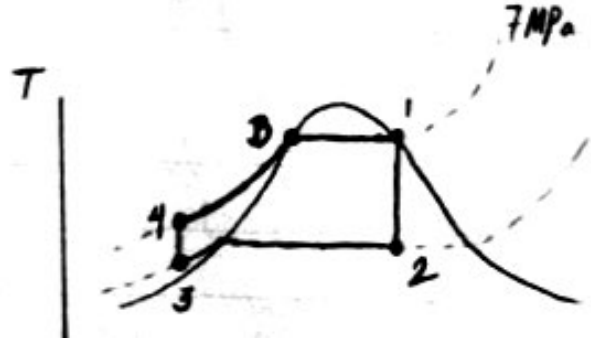
$W_{actual_T} = \eta_{ST} W_{ideal_T} = 0.9(h_1 - h_2) = 871.184$

$P_2 = 7\ kPa$, $S_2 = S_1 = 5.8125$ $\Downarrow$ $x = 68.09$ $\Rightarrow h_{2s} = 1803.718$

$1000 \times 1000\ \frac{kJ}{s} \times \frac{1\ kg}{871.184\ kJ} = 1147.863\ kg/s$

$1147.863 \times 0.0274 = 31.45\ m^3/s$

مسئله 2-8 پیرو ۵ حرارتی :



Year: Month:

① بخار اشباع $P_1 = 7\,MPa$ ⇒ $t_1 = 285.9^\circ C$, $v_1 = 0.0274$, $h_1 = 2771.7$, $S_1 = 5.8125$

بخار 68٪ رطوبت 32٪

(الف) ② $S_{2s} = S_1 = 5.8125$, $P_2 = 7\,kpa$ ⇒ $x_s = 0.6809$ ⇒ $h_{2s} = 1803.814$, $v_{2s} = 13.98$

$5.8125 = 0.5591 + x\,7.7149$

$S_2 = S_f + x S_{fg}$

$P_3 = 7\,kpa$ آب اشباع ⇒ $S_3 = 0.5591 = S_4$, $W_p = 0$ ⇒ $h_3 = h_4 = 163.4$

نزدیک

$P_B = 7\,MPa$ آب اشباع ⇒ $S_B = 3.121$, $h_B = 1267$

برای توربین: $S_1 + S_4 = S_2 + S_B$ ⇒ $S_2 = 3.2506$ ⇒ $h_2 = 1003.93$

$3.2506 = 0.5591 + 7.7149x$ ⇒ $x = 34.89\%$

ب) قانون اول: $W_T = h_1 - h_2 + h_4 - h_B$

$= 664.17\ kJ/kg$

ج) $q_B = h_1 - h_B = 1504.7\ kJ/kg$

د) $\eta = \frac{W_T + W_P}{q_B} = 0.441$ or 44.14%

بدون پمپ: $W_T = h_1 - h_{2s} = 967.886$

$q_B = h_1 - h_4 = 2608.3$ ⇒ $\eta = 0.371$ or 37.11%

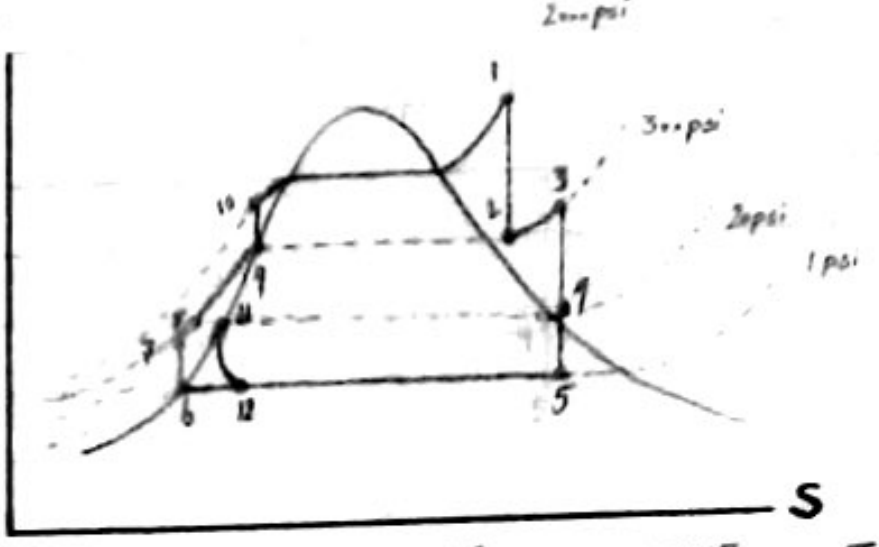
کارنو: $\eta = 1 - \frac{T_C}{T_H} = 1 - \frac{39.03 + 273}{285.9 + 273} = 0.4417$ or 44.17%

تمرین سری چهارم سیستم های تبدیل انرژی گرمایی ۲

نام و نام خانوادگی: 9110439

①

(الف)



① $\frac{2000psi}{100°F}$ ← بخار فوق گرم : $v_1 = 0.02461$ $h_1 = 3428.9$. $S_1 = 6.5327$ (در جدول استاندارد واحد SI نوشته شده است.)

② $300psi$. $S_{2S} = S_1 = 6.5327$ ← بخار فوق گرم : $h_2 = 2813.97$. $v_2 = 0.1103$. $t_2 = 246.3°C$

③ $300psi$. $900°F$ ← بخار فوق گرم : $h_3 = 3427.59$. $S_3 = 7.365$

④ $20psi$. $S_{45} = S_3 = 7.365$ ← $h_4 = 2725.404$: بخار فوق گرم

⑤ $1psi$. $S_{5S} = S_3 = 7.365$ ← $x = 0.8821$. $h_5 = 2278.30$. $v_5 = 18.136$

⑥ $1psi$. آب اشباع ← $t_6 = 99.63°C$. $v_6 = 0.001075$. $h_6 = 163.43$. $S_6 = 0.5591$

⑦ $S_{7S} = S_6 = 0.5591$. $P_7 = P_2 = 300\ psi$ ← آب مایع - سرد

⑧ $P_8 = P_7 = 300\ psi$. $t_8 = 108.87°C$ ← $h_8 = 117.091$. $S_8 = 1.39$

⑨ آب اشباع . $P_9 = P_8 = 300\ psi$ ← $t_9 = 214.3°C$. $v_9 = 0.001179$. $h_9 = 916.444$. $S_9 = 2.4627$

⑩ $2000psi$. $S_{10S} = S_9 = 2.4627$ ← آب مایع - سرد

(11) آب شیر ، $P = 20\,psi \rightarrow v_{11} = 0.001051$

$h_{11} = 458.6$

$S_{11} = 1.4115$

(12) $P_{12} = P_5 = 1\,psi$

$h_{12} = h_{11} = 458.6$ ← $x = 0.1226$ ، $v_{12} = 2.5215$ ، $S_{12} = 1.5049$

ب) توازن انرژی حول تبدیل CFWH :

$$h_4 \dot{m}_4 + h_2 (\dot{m}_1 - \dot{m}_2) = h_8 (\dot{m}_1 - \dot{m}_2) + \dot{m}_4 h_{11}$$

$$\rightarrow 2725.469\,\dot{m}_4 + 165.507 (\dot{m}_1 - \dot{m}_2) = 197.091 (\dot{m}_1 - \dot{m}_2) + 458.6\,\dot{m}_4 \quad (I)$$

کار پمپ اول $= W_{P_1} = v_6 (P_7 - P_6) = h_7 - h_6 \rightarrow h_7 = 165.507$

کار پمپ دوم $= W_{P_2} = v_9 (P_{10} - P_9) = h_{10} - h_9 \rightarrow h_{10} = 930.263$

توازن انرژی حول تبدیل CFWH :

$$\dot{m}_2 h_2 + h_7 (\dot{m}_1 - \dot{m}_2) = \dot{m}_1 h_9$$

$$\leftarrow 2893.47\,\dot{m}_2 + 197.091 (\dot{m}_1 - \dot{m}_2) = 916.4444\,\dot{m}_1 \rightarrow \frac{\dot{m}_2}{\dot{m}_1} = 0.2668$$

$$(II) \Rightarrow \frac{\dot{m}_4}{\dot{m}_1} = 0.0102$$

ج) $W_{LPT} = (h_3 - h_4)(\dot{m}_1 - \dot{m}_2) + (h_4 - h_5)(\dot{m}_1 - \dot{m}_2 - \dot{m}_4)$

$$? = \frac{W_{LPT}}{\dot{m}_1} = 762.186 (1 - 0.2668) + 437.109 (1 - 0.2668 - 0.0102)$$

$$= 830.869\ kJ/kg$$

$$W_{HPT} = \dot{m}_1 (h_1 - h_2) \Rightarrow \frac{W_{HPT}}{\dot{m}_1} = h_1 - h_2 = 535.43\ kJ/kg$$

د) $Q_B = \dot{m}_1 (h_1 - h_{10}) \rightarrow \frac{Q_B}{\dot{m}_1} = 2998.637\ kJ/kg$

ه) $Q_{Reh} = (\dot{m}_1 - \dot{m}_2)(h_3 - h_2) \Rightarrow \frac{Q_{Reh}}{\dot{m}_1} = 391.617\ kJ/kg$

AVA

$$= \left(1 - \frac{\dot{m}_2}{\dot{m}_1}\right)(h_7 - h_6) = 1.5229 \quad , \quad \frac{W_{P_2}}{\dot{m}_1} = 13.819$$

Subject:
Year: Month

$$\eta = \frac{W_{HPT} + W_{LPT} - W_{P_1} - W_{P_2}}{Q_B + Q_{RH}} \times \frac{\frac{1}{\dot{m}_1}}{\frac{1}{\dot{m}_3}} \times 100 = 46.78\%$$

(2)

(الف) $P_1 = 1700\ psi$, $\eta_{is} = 80\%$, $T_1 = 750^\circ F$ ← بخار ورودی توربین

$v_1 = 0.02157$, $h_1 = 3050.2$, $s_1 = 6.0817$ ← از جدول اشباع یا سوپرهیت

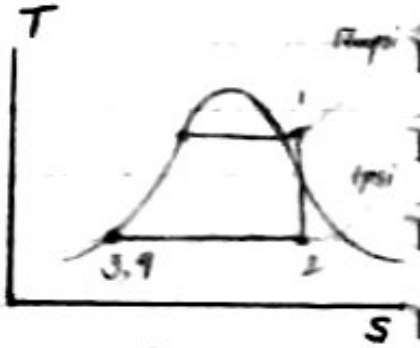
$s_{2s} = s_1 = 6.0817$, $\frac{h_1 - h_2}{h_1 - h_{2s}} = 0.8 \rightarrow h_2 = 2120.279$

$P_2 = 1\ psi \rightarrow x_{2s} = 0.7158$, $h_{2s} = 1887.792$, $v_2 = 14.696 \rightarrow x_2 = 0.8124$

$P_3 = P_2 = 1\ psi$, گی اشباع ← $v_3 = 0.01\ldots75$, $h_3 = 163.43$, $s_3 = 0.5591$

$W_p \simeq 0 \rightarrow h_4 = h_3 = 163.43$

$P_4 = P_3 = 1\ psi$

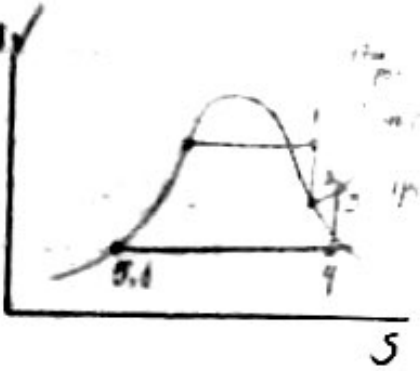


$$\eta_{کل} = \frac{W_T}{Q_B} = \frac{h_1 - h_2}{h_1 - h_4} = 0.3221 \simeq 32.21\%$$

(ب) $P_1 = 1700\ psi$, $T_1 = 750^\circ F \rightarrow h_{2s} = 1357 \rightarrow \eta_T = \ldots$

$P_2 = 410\ psi$ سطر اشباع ← $v_2 = 0.0\ldots$, $h_2 = 1202$, $s_2 = 6.2063$

$P_3 = 410\ psi$, $T_3 = 750^\circ F$ ← $v_3 = 0.\ldots$, $h_3 = 3255.71$, $s_3 = 6.\ldots$

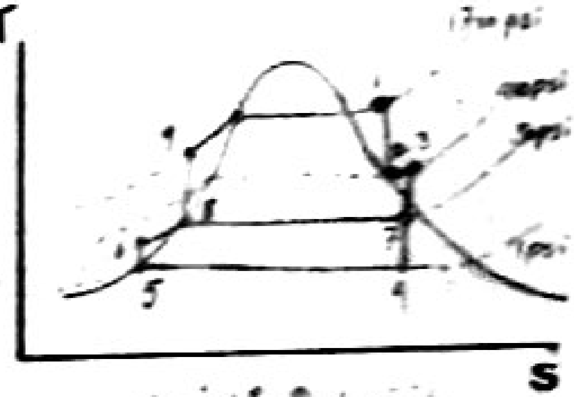


$P_4 = 1\ psi$, $s_{4s} = s_3 = 6.9403$ ← $x_{4s} = 0.8271$, $h_{4s} = 2155.91$, $0.8 = \frac{h_3 - h_4}{h_3 - h_{4s}} \rightarrow h_4 = 2371.486$ ↓ $x_4 = 0.9166$

$P_5 = P_4 = 1\ psi$ آب اشباع ← $v_5 = 0.01\ldots75$, $h_5 = 163.43$, $s_5 = 0.5591$

$$\eta = \frac{w_{T_H} - w_P + w_{T_L}}{q_B + q_{RH}} = \frac{(h_1 - h_2) + (h_3 - h_4)}{(h_1 - h_5) + (h_3 - h_2)} = \frac{1110.569}{3317.53} = 0.3348 \;;\; 33.48\ \%$$

c)



[illegible]

$$(1 - \dot m_7)\, h_6 + \dot m_7 h_7 = h_8$$

$P_6 = 30\,psi$

$s_{6_S} = s_5 = 0.5591$

$$\cdot\ 0.8 = v_5 (P_6 - P_5) = h_6 - h_5 \Rightarrow h_6 = 163.631$$

$P_8 = 30\,psi$ ← $v_8 = 0.001062$

مایع اشباع

$h_8 = 509.1614$

$s_8 = 1.5416$

$s_{7_S} = s_1 = 6.0817 \Rightarrow h_{7_S} = 2299.868 \Rightarrow h_7 = 2449.93$

$P_7 = 30\,psi$

$$(1 - \dot m_7)\,163.631 + \dot m_7\, 2449.93 = 509.1614 \Rightarrow \dot m_7 = 0.1511$$

$$\eta = \frac{W_{TH} + W_{TL} - W_{P_1} - W_{P_2}}{Q_B + Q_{RE}} = \frac{(h_1 - h_2) + (h_3 - h_7) + (1 - \dot m_7)(h_7 - h_4) - (h_6 - h_5) - (h_9 - h_8)}{(h_3 - h_2) + (h_1 - h_9)}$$

برای بازدهی بهتر، بهتر است تا فشار 170psi پیش رود تا گرمایی [illegible] بیشتر [illegible]

$$\eta = \frac{1086.252}{2960.6} = 0.3669 \;;\; 36.69\ \%$$

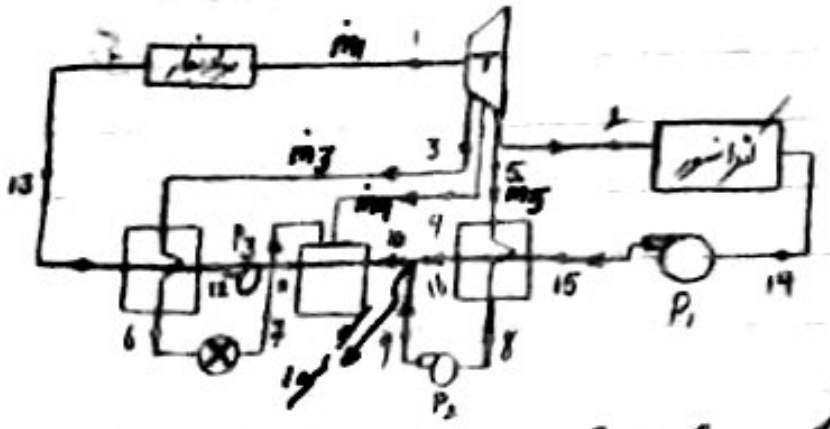
$$v_8 (P_9 - P_8) = h_9 - h_8 \Rightarrow h_9 = 521.39$$

Subject
Year Month

مسئله 13.2 نیروگاه حرارتی :

$\eta_{ST} = 90\%$
$\eta_{SP} = 80\%$

$P_1 = 8\,MPa$
$t_1 = 540^\circ C$
$P_2 = 7\,kpa$



(الف) ① $P_1 = 8\,MPa$, $t_1 = 540^\circ C$ → $v_1 = 0.04452$, $h_1 = 3495.78$, $S_1 = 6.8426$

② $P_2 = 7\,kpa$, $S_{2s} = S_1 = 6.8426$ → $h_{2s} = 2125.208$, $x_{2s} = 0.8144$

$\eta_t = \frac{h_1 - h_2}{h_1 - h_{2s}} \Rightarrow h_2 = 2262.267$

⑭ $P_{14} = 7\,kpa$ (فشار آب اشباع) → $v_{14} = 0.001\,0075$, $h_{14} = 163.32$, $S_{14} = 0.5589$, $t_{14} = 39^\circ C$

$\Delta T_{opt} = \frac{t_1 - t_{14}}{4} = \frac{295.06 - 39}{4} = 64.015$ (8MPa فشار بخار)

⑦ $t_7 = t_c + 64.015 = 103.015^\circ C$ (اشباع) → $P_7 = 112.679\,kpa$, $h_7 = 432.79$, $S_7 = 1.3607$

⑪ $t_{11} = 103.015 + 64.015 = 167.03^\circ C$ (اشباع) → $P_{11} = 735.248\,kpa$, $v_{11} = 0.001\,1061$, $v_{11} = 0.001\,1038$, $h_{11} = 700.121$

⑥ $t_6 = 167.03 + 64.015 = 231.045^\circ C$, $S_6 = 2.6233$

(آب اشباع) → $P_6 = 2.848\,MPa$, $v_6 = 0.001\,2083$, $h_6 = 995.216$, $S_6 = 2.6198$

W_{P_1}

⑫ $v_{11}(P_{12} - P_{11}) = h_{12} - h_{11} \Rightarrow h_{12} = 714.198$

$P_{11} = P_9 = P_{10} = P_{11}$, $P_{12} = P_1 = 8\,MPa$

$W_{P_1} = v_{14}(P_{15} - P_{14}) = 0.001\,0075\,(735.248 - 7) = 0.7337 = h_{15} - h_{14}$

⑮ $h_{15} = 164.054$

$P_{15} = 735.248\,kpa$

$W_{P_2} = v_8(P_9 - P_8) = 0.8513 = h_9 - h_8 \Rightarrow$ ⑨ $h_9 = 432.4413$, $P_9 = 735.248\,kpa$

$P_3 = P_2 = 2.848\,MPa$

$S_{3s} = S_4 = 6.8426$ ⇒ $h_{3s} = 3116.302$ ⑬ $h_3 = 3199.25$, $P_3 = 2.848\,MPa$

Subject
Year Month Date

$P_4 = P_{10} = 735.248$ kpa $\rightarrow h_{4s} = 2852.241$

$S_{4s} = S_1 = 6.8926$ $\xrightarrow[\eta_T]{④}$ $h_4 = 2916.585$, $P_4 = 735.248$ kpa

$P_5 = 112.679$ kpa

$S_{5s} = S_1 = 6.8926$ $\rightarrow h_{5s} = 2501.185$ $\xrightarrow[\eta_T]{⑤}$ $h_5 = 2600.645$, $P_5 = 112.679$ kpa

$TTD = 2.5°C$: $t_7 - t_{16} = 2.5 \rightarrow t_{16} = 100.515°C$

$P_{16} = 735.248$ kpa $\rightarrow$ ⑯ $h_{16} = 422.056$

: $t_6 - t_{13} = 2.5 \rightarrow t_{13} = 228.545°C$

$P_{13} = 8$ Mpa $\rightarrow$ ⑬ $h_{13} = 987.521$

: $h_6(\dot{m}_1 - \dot{m}_5 - \dot{m}_3 - \dot{m}_4) + h_9\dot{m}_5 = h_{10}(\dot{m}_1 - \dot{m}_3 - \dot{m}_4)$

: $h_5\dot{m}_5 + h_{15}(\dot{m}_1 - \dot{m}_5 - \dot{m}_3 - \dot{m}_4) = h_8\dot{m}_5 + h_{16}(\dot{m}_1 - \dot{m}_5 - \dot{m}_3 - \dot{m}_4)$

: $\dot{m}_1 h_{12} + h_3\dot{m}_3 = \dot{m}_1 h_{13} + h_6\dot{m}_3$

$\rightarrow h_6 = 995.216$

: $h_{10}(\dot{m}_1 - \dot{m}_3 - \dot{m}_4) + \dot{m}_4 h_4 + h_2\dot{m}_3 = h_{11}\dot{m}_1$

$$W_{net} = W_T - W_{P_1} - W_{P_2} - W_{P_3} = \dot{m}_1(h_1 - h_2) + (\dot{m}_1 - \dot{m}_3)(h_2 - h_4) + (\dot{m}_1 - \dot{m}_3 - \dot{m}_4)(h_4 - h_5) + (h_8 - h_7)(\dot{m}_1 - \dot{m}_3 - \dot{m}_4 - \dot{m}_5) - 0.7357(\dot{m}_1 - \dot{m}_3 - \dot{m}_4 - \dot{m}_5) - 0.6513\dot{m}_5 - \dot{m}_1(h_{12} - h_{11})$$

: $(h_{10}, h_6, \dot{m}_1)$ ... 5 ... 5 —

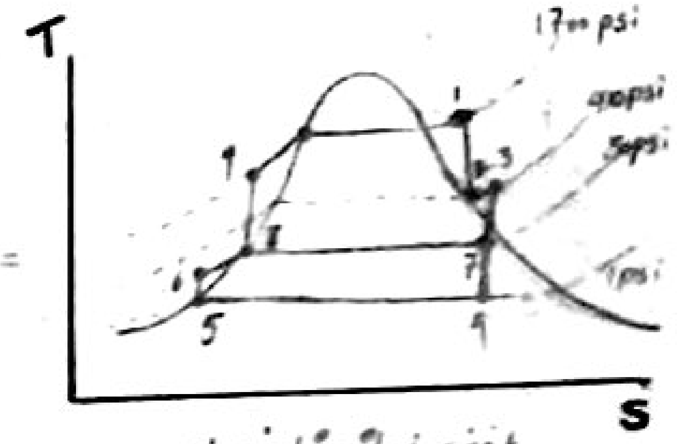
$\dot{m}_1 = 829.69$ kg/s , $\dot{m}_3 = 102.88$, $\dot{m}_4 = 70.545$, $\dot{m}_5 = 69.759$

$h_{10} = 423.16$

: $\dot{m}_1 - \dot{m}_3 - \dot{m}_4 - \dot{m}_5 = 587.469$

$$\eta = \frac{w_{T_1} - w_P - w_{T_2}}{q_B + q_{RH}} = \frac{(h_1 - h_2) + (h_3 - h_4)}{(h_1 - h_5) + (h_3 - h_2)} = \frac{1110.504}{3318.53} = 0.3346 \Rightarrow 33.46\%$$

ج)



منحنی نمودار دمای تر از دبی بالا

$$(1-\dot{m}_7) h_6 + \dot{m}_7 h_7 = h_8$$

$P_6 = 30\ psi$
$S_{6s} = S_5 = 0.559$

$$v_5 (P_6 - P_5) = h_6 - h_5 \Rightarrow h_6 = 163.631$$

$P_8 = 30\ psi$ → $v_8 = 0.001062$
مایع اشباع
$h_8 = 509.1614$
$S_8 = 1.5416$

$S_{7s} = S_1 = 6.0817$ $\Rightarrow h_{7s} = 2299.868 \Rightarrow h_7 = 2449.93$
$P_7 = 30\ psi$

$$(1-\dot{m}_7)\,163.631 + \dot{m}_7\,2449.93 = 509.1614 \Rightarrow \dot{m}_7 = 0.1511$$

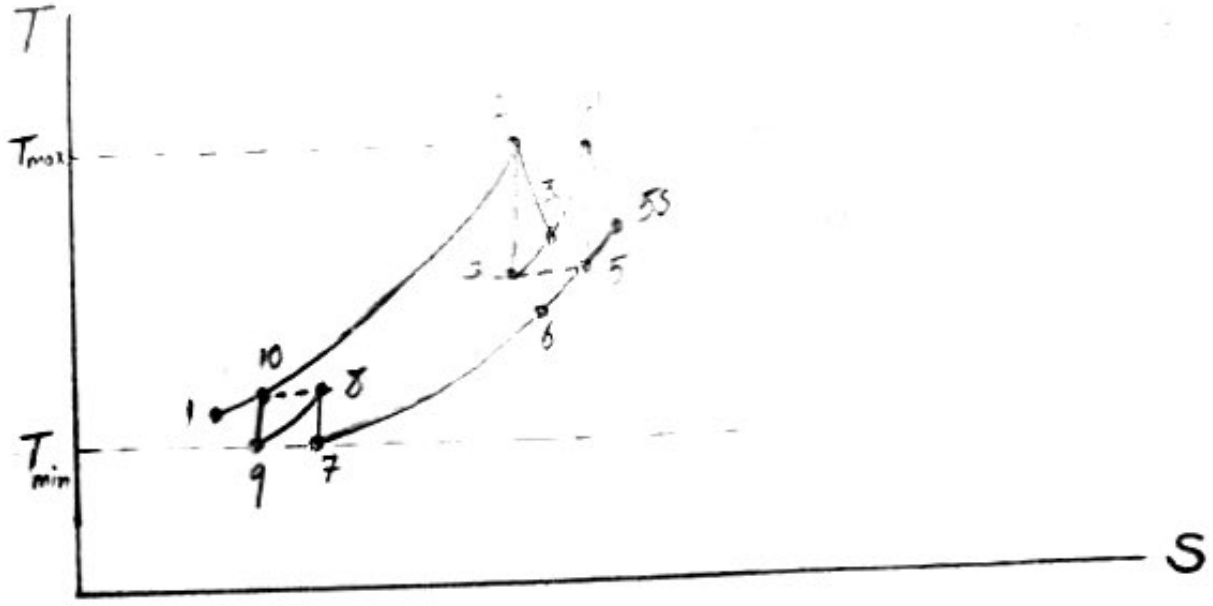
$$\eta = \frac{W_{TH} + W_{TL} - W_{P_1} - W_{P_2}}{Q_B + Q_{RH}} = \frac{(h_1 - h_2) + (h_3 - h_7) + (1-\dot{m}_7)(h_7 - h_4) - (1-\dot{m}_7)(h_6 - h_5) - (h_9 - h_8)}{(h_3 - h_2) + (h_1 - h_9)}$$

برای بدست آوردن h_9 باید تا فشار 1700psi پیش رود تا آنتالپی مایع متراکم بدست آید

$$\eta = \frac{1086.252}{2960.6} = 0.3669 \Rightarrow 36.69\%$$

$$v_8 (P_9 - P_8) = h_9 - h_8 \Rightarrow h_9 = 521.39$$

①



ي) $W_T = \dot{m}(h_2 - h_3) + \dot{m}(h_4 - h_5) = \dot{m}\eta_T(h_2 - h_{3s}) + \dot{m}\eta_T(h_4 - h_{5s})$

$\eta_T = \frac{\text{actual}}{\text{ideal}}$

$\rightarrow W_T = \dot{m}\eta_T c_p(T_2 - T_{3s}) + \dot{m}\eta_T c_p(T_4 - T_{5s}) = \dot{m}\eta_T T_2 c_p\left(1 - \frac{T_{3s}}{T_2}\right) + \dot{m}\eta_T T_4 c_p\left(1 - \frac{T_{5s}}{T_4}\right)$

$= \dot{m}\eta_T T_2 c_p\left(1 - \left(\frac{P_{3s}}{P_2}\right)^{\frac{k-1}{k}}\right) + \dot{m}\eta_T T_4 c_p\left(1 - \left(\frac{P_{5s}}{P_4}\right)^{\frac{k-1}{k}}\right)$

$= \dot{m}\eta_T T_2 c_p\left(1 - \frac{1}{\rho}\right) + \dot{m}\eta_T T_4 c_p\left(1 - \frac{1}{\rho}\right) = 2\dot{m}\eta_T\left(1 - \frac{1}{\rho}\right) T_{max} c_p$

$W_C = \dot{m}(h_8 - h_7) + \dot{m}(h_{10} - h_9) = \frac{\dot{m}c_p}{\eta_C}(T_{8s} - T_7) + \frac{\dot{m}c_p}{\eta_C}(T_{10s} - T_9)$

$\eta_C = \frac{\text{ideal}}{\text{actual}}$

$\rightarrow W_C = \frac{\dot{m}c_p}{\eta_C}\left(\frac{T_{8s}}{T_7} - 1\right) T_7 + \frac{\dot{m}c_p}{\eta_C} T_9\left(\frac{T_{10s}}{T_9} - 1\right)$

$= \frac{\dot{m}c_p}{\eta_C}(\rho - 1) T_7 + \frac{\dot{m}c_p}{\eta_C} T_9(\rho - 1) = 2\frac{\dot{m} T_{min}}{\eta_C}(\rho - 1) c_p$

$Q_{in} = \dot{m}(h_2 - h_1) + \dot{m}(h_4 - h_3) = \dot{m}c_p(T_2 - T_1) + \dot{m}(T_4 - T_3)c_p$

$\eta_r = \varepsilon_r = \frac{T_1 - T_{10}}{T_5 - T_{10}} \rightarrow T_1 = T_{10} + (T_5 - T_{10})\varepsilon_r$ ①

AUA

$\frac{T_{10s}}{T_9} = \rho \cdot \eta_C = \frac{T_{10s} - T_9}{T_{10} - T_9} \rightarrow T_{10s} = \eta_C(T_{10} - T_{min}) + T_{min}$ ②

$$\eta_T = \frac{T_2 - T_3}{T_2 - T_{3S}} \Rightarrow T_3 = T_2 - \eta_T (T_2 - T_{3S}) = T_2 - \eta_T T_2 \left(1 - \frac{1}{\rho}\right)$$

$$\therefore \text{مثلاً: } T_5 = T_4 - \eta_T T_4 \left(1 - \frac{1}{\rho}\right) \quad ③$$

$$①②③ \Rightarrow T_1 = T_{min}\left(\frac{\rho-1}{\eta_c} + 1\right) + \gamma_r \left(T_{max}\left(1 - \eta_T\left(1 - \frac{1}{\rho}\right)\right) - T_{min}\left(\frac{\rho-1}{\eta_c} + 1\right)\right)$$

$$\Rightarrow Q_{in} = \dot{m} c_p \left(2T_{max} - T_1 - T_3\right)$$

$$\Rightarrow \eta = \frac{W_T - W_C}{Q_{in}} = \frac{2\eta_T T_{max}\left(1 - 1/\rho\right) - \frac{2T_{min}}{\eta_c}(\rho-1)}{2T_{max} - T_{max} + \eta_T T_{max}\left(1 - \frac{1}{\rho}\right) - T_{min}\left(\frac{\rho-1}{\eta_c} + 1\right)(1-\gamma_r) - T_{max}\gamma_r \left(1 - \eta_T\left(1 - \frac{1}{\rho}\right)\right)}$$

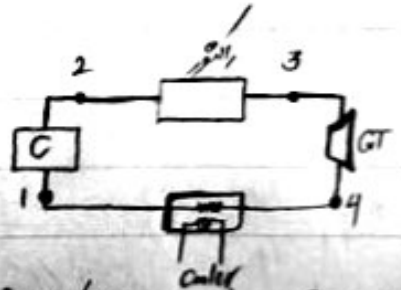
$$\Rightarrow \eta_{th} = \frac{2\eta_T \frac{T_{max}}{T_{min}}\left(1 - \frac{1}{\rho}\right) - \frac{2}{\eta_c}(\rho-1)}{\frac{T_{max}}{T_{min}} + \eta_T\left(1 - \frac{1}{\rho}\right)\frac{T_{max}}{T_{min}} - (1-\gamma_r)\left(\frac{\rho-1}{\eta_c} + 1\right) - \frac{T_{max}}{T_{min}}\gamma_r\left(1 - \eta_T\left(1 - \frac{1}{\rho}\right)\right)}$$

ج)

$$\eta_{th} = \frac{1.8 \times 3\left(1 - \frac{1}{1.3}\right) - \frac{2}{0.9}(1.3-1)}{3 + 0.9\left(1 - \frac{1}{1.3}\right)3 - (1-0.85)\left(\frac{0.3}{0.9} + 1\right) - 3 \times 0.85\left(1 - 0.9\left(1 - \frac{1}{1.3}\right)\right)}$$

$$= 41.31\ \%$$

② (ii)



$$\frac{k-1}{k} = 0.286 \qquad c_p = 1.004\ \frac{kJ}{kg\,k}$$

$$W_T = \dot{m} c_p (T_3 - T_4) = \dot{m} c_p \eta_T (T_3 - T_{4S}) = \dot{m} c_p \eta_T T_3 \left(1 - \frac{1}{5^{(k-1/k)}}\right)$$

$$\frac{W_T}{\dot{m}} = c_p \eta_T T_3 \left(1 - \frac{1}{5^{0.286}}\right) = 395.174\ kJ/kg$$

1.004 0.85 $1255.222\ k$

$$W_C = \dot{m} c_p (T_2 - T_1) = \frac{\dot{m} c_p (T_{2S} - T_1)}{\eta_c} = \frac{T_1 \dot{m} c_p}{\eta_c}\left(5^{0.286} - 1\right)$$

$$\Rightarrow \frac{W_C}{\dot{m}} = 206.906\ kJ/kg$$

AVA

$\frac{W_{net}}{\dot{m}} = 188.268 \frac{kJ}{kg}$ → $188.268 \times \dot{m} = 50000$

→ $\dot{m} = 265.579$ kg/s

$Q_{in} = \dot{m} c_p (T_3 - T_2)$

$\frac{T_{2s}}{T_1} = 5^{0.286}$

$\eta_c = \frac{T_{2s} - T_1}{T_2 - T_1} \Rightarrow T_2 = \frac{T_{2s} - T_1}{\eta_c} + T_1$ → $T_2 = 1.6$

→ $\frac{Q_{in}}{\dot{m}} = 1.004 (1255.222 - 55.747) = 752.473$ kJ/kg

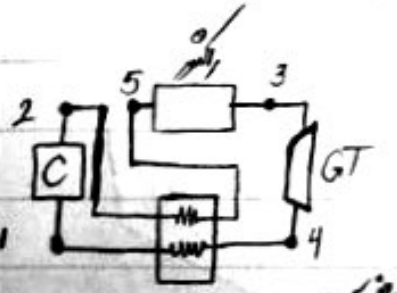
→ $\eta = 0.2502$ ≈ 25.02%

$\dot{m} \times W_{T/m} = 395.174 \times 265.579 = 104949.92$ kW = 140683.5 hp

$\dot{m} \times W_{C/m} = 73659.37$ hp

0.746 kW = 1 hp

ب)



$W_T = \dot{m} c_p (T_3 - T_4) \xrightarrow{\dot{m}} \frac{W_T}{\dot{m}} = 395.174$ kJ/kg

$\frac{W_C}{\dot{m}} = 206.906$ kJ/kg

$\frac{W_{net}}{\dot{m}} = 188.268$ kJ/kg

→ $\dot{m} = 265.579$ kg/s

$Q_{in} = \dot{m} c_p (T_3 - T_5)$ ② $\frac{Q_{in}}{\dot{m}} = 466.633$ kJ/kg

$\eta_r = \frac{T_5 - T_2}{T_4 - T_2} = 0.8$ ① $T_5 = 790.448$ K ②

$\eta_T = \frac{T_3 - T_4}{T_3 - T_{4s}} \Rightarrow T_4 = T_3 - \eta_T (T_3 - T_{4s}) = T_3 - T_3 \eta_T \left(1 - \frac{1}{5^{0.286}}\right)$

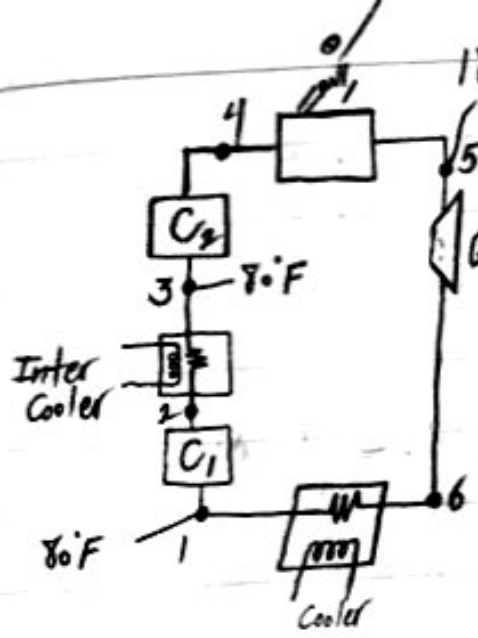
$= 861.623$ K ①

$\eta = 0.4035$ ≈ 40.35%

$\dot{m} \times W_{T/m}$ = 140683.5 hp

$\dot{m} \times W_{C/m}$ = 73659.37 hp

ب)



$W_T = \dot{m} c_p (T_5 - T_6) \xrightarrow{\text{ای}} \frac{W_T}{\dot{m}} = 395.174$ kJ/kg

$W_{C_1} = W_{C_2} \Rightarrow W_C = 2\dot{m} c_p (T_2 - T_1)$

$\Rightarrow \frac{W_C}{\dot{m}} = 2c_p (T_2 - T_1)$

$\eta_C = \frac{T_{2S} - T_1}{T_2 - T_1} \Rightarrow T_2 = \frac{T_{2S} - T_1}{\eta_C} + T_1$

$\Rightarrow T_2 = T_1 \left(\frac{\left(\frac{T_{2S}}{T_1} - 1\right)}{\eta_C} + 1 \right)$, $\frac{T_{2S}}{T_1} = \left(\frac{P_{2S}}{P_1}\right)^{0.286} = \sqrt{15}$

$\Rightarrow T_2 = T_1 \left(\frac{\sqrt{15}^{0.286} - 1}{0.85} + 1 \right) = 390.903\ ^\circ k$

$\Rightarrow \frac{W_C}{\dot{m}} = 183.202$ kJ/kg

$Q_{in} = \dot{m} c_p (T_5 - T_4) \Rightarrow \frac{Q_{in}}{\dot{m}} = 867.776$ kJ/kg

$W_{C_2} = \dot{m}\, 91.601 = \dot{m} c_p (T_4 - T_3) \Rightarrow T_4 = 390.903\ ^\circ k$

$\eta = 0.2443 \text{ یا } 24.43\%$

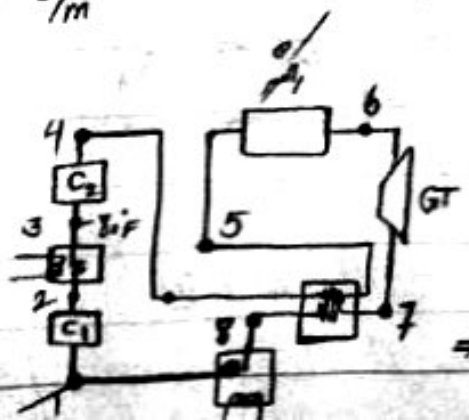
$50000 = 211.972 \times \dot{m}_{ای} \Rightarrow \dot{m}_{ای} = 235.88$ kg/s

$\frac{W_{net}}{\dot{m}} = 211.972$ kJ/kg

$\dot{m}_{ای} \times W_{T/\dot{m}} = 124951.26$ hp

$\dot{m}_{ای} \times W_{C/\dot{m}} = 57927.195$ hp $\Rightarrow$ توان خالص $= 28163.598$ hp

ج)



$\frac{W_T}{\dot{m}} = c_p (T_6 - T_7) = c_p \eta_T (T_6 - T_{7S}) \xrightarrow{\text{ای}} 395.174$ kJ/kg

$\frac{W_C}{\dot{m}} \xrightarrow{\text{ای}} 183.202$ kJ/kg

$\Rightarrow \dot{m}_{ای} = 235.88$ kg/s

$\dot{W}_{net} = 211.972$ kJ/kg

توان خالص $\rightarrow$ 28163.598 hp

$$Q_{in} = \dot{m} c_p (T_6 - T_5) \overset{②}{\Rightarrow} \frac{Q_{in}}{\dot{m}} = 489.695 \text{ kJ/kg}$$

$$\eta_r = \frac{T_5 - T_4}{T_7 - T_4} = 0.8 \overset{①}{\Rightarrow} T_5 = 767.478\,K \;②$$

$$\frac{W_T}{\dot{m}} = 395.174 \text{ kJ/kg} = c_p (T_6 - T_7) \Rightarrow T_7 = 861.622\,K \;①$$

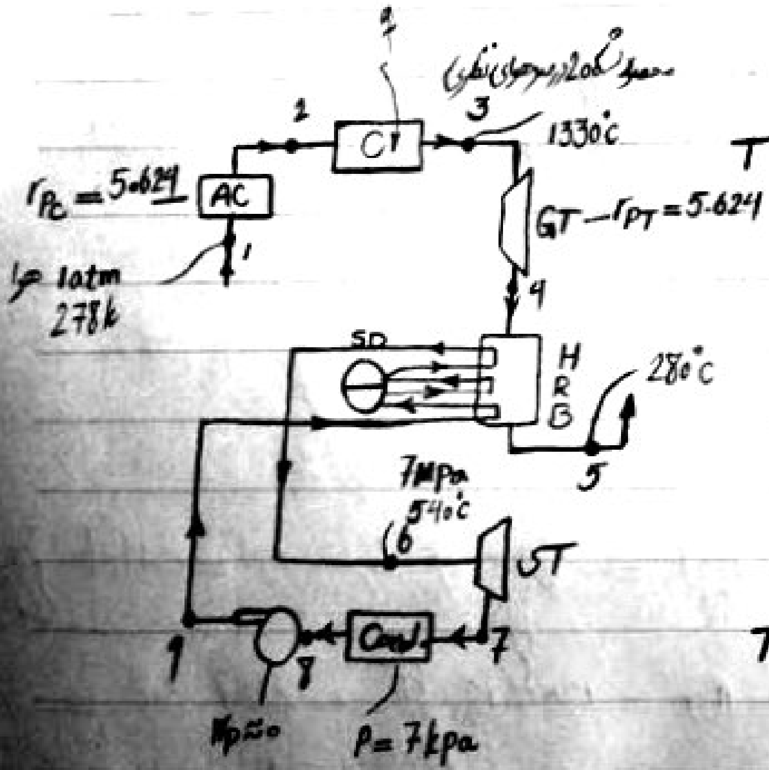
$$\Rightarrow \eta = 0.4329 \text{ یا } 43.29\%$$

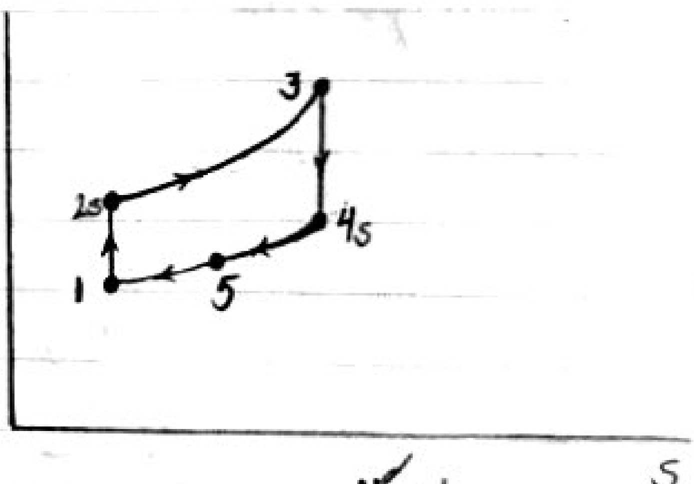
① برگرداندن تنهای Regenerator : $\downarrow Q_{in} \rightarrow \eta \uparrow$ ، W_{net} ثابت.

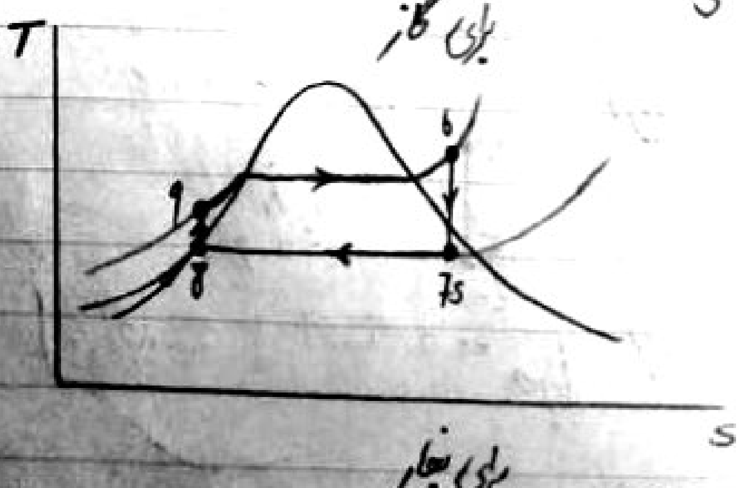
② تنها Intercooler : $W_c \downarrow \rightarrow W_{net} \uparrow$ اما $\eta \downarrow$.

③ ① & ② باهم: می‌توان طوری طراحی کرد که W_{net} و η هر دو زیاد شوند.

مسائل 3.8 کتاب نیروگاه حرارتی







Subject:
Year: Month: Date:

ا) هوا → 1 atm → $h_1 = 278.466 \frac{kJ}{kg\ هوا}$
278 k = 501 R
$P_{r_1} = 1.0666 \Rightarrow P_{r_2} = 5.9986 \Rightarrow h_2 = 456.744 \frac{kJ}{kg\ هوا}$

③ $h_3 = 53404.49 \frac{kJ}{kmol\ سوخت}$
$Pr_3 = 1066.22 \Rightarrow Pr_4 = 189.584 \Rightarrow \bar{h}_4 = 34328.05 \frac{kJ}{kg\ mol\ سوخت}$

(ii) $\bar{h}_3 = 1849.169 \frac{kJ}{kg\ سوخت} \times 1.0335 = 1911.116 \frac{kJ}{kg\ هوا}$

$\Rightarrow q = h_3 - h_2 = 1454.372 \frac{kJ}{kg\ هوا}$

ب) ⑤ 280 c → $h_5 = 16583.729 \frac{kJ}{kg\ mol\ سوخت} \rightarrow 573.15 \frac{kJ}{kg\ هوا}$

⑥ 7Mpa , 540°c $\Rightarrow h_6 = 3503.7 \frac{kJ}{kg\ بخار}$, $s_6 = 6.9174 \frac{kJ}{kg\ K}$

⑦ $s_7 = s_6 = 6.9174$ (ideal)
$P_7 = 7kpa \Rightarrow x = 0.8241 \Rightarrow h_7 = 2148.58 \frac{kJ}{kg\ بخار}$
کیفیت = صفر

⑧ $P_8 = 7kpa$ (ایزنتالپی) → $h_8 = 163.32 = h_9$
$s = 0.5589$

$h_4 - h_5 = 634.999 \frac{kJ}{kg\ هوا}$, $h_6 - h_9 = 3340.38 \frac{kJ}{kg\ بخار}$

$\rightarrow \frac{m_{بخار}}{m_{هوا}} = \frac{634.999}{3340.38} = 0.1901 \rightarrow$ دبی جرمی هوا / دبی جرمی بخار $= 0.1901 \frac{kg}{kg}$

ج) $W_{GT} = 682.652 \frac{kJ}{kg\ هوا}$, $W_{ST} = 1355.12 \frac{kJ}{kg\ بخار} = 257.608 \frac{kJ}{kg\ هوا}$
$W_c = 178.278 \frac{kJ}{kg\ هوا} \rightarrow W_{net} = 761.982 \frac{kJ}{kg\ هوا}$

د) $\eta_{بازده} = 0.5239 \approx 52.39\%$

ه) $\eta = \frac{W_{ST}}{q} = 0.4694 \approx 46.94\%$