



eta_t1=0.85

eta_t2=0.8

eta_p=0.7

{do mass balances for 1 unit mass leaving steam generator, calculate actual turbine inlet flow at end}

m1=1

{state properties - reactor coolant}

pa=17900

Ta=327

ha=enthalpy(STEAM_NBS,p=pa,T=Ta)

pb=17200

Tb=288

hb=enthalpy(STEAM_NBS,p=pb,T=Tb)

sb=entropy(STEAM_NBS,p=pb,T=Tb)

pc=18600

hc=enthalpy(STEAM_NBS,p=pc,s=sb)

Tc=temperature(STEAM_NBS,p=pc,s=sb)

{state properties - turbine to condenser}

p1=6870

T1=316

h1=enthalpy(STEAM_NBS,p=p1,T=T1)

s1=entropy(STEAM_NBS,p=p1,T=T1)

p2=2750

h2i=enthalpy(STEAM_NBS,p=p2,s=s1)

$(h1-h2)/(h1-h2i)=\eta_{t1}$

s2=entropy(STEAM_NBS,p=p2,h=h2)

p3=2060

h3i=enthalpy(STEAM_NBS,p=p3,s=s2)

$(h2-h3)/(h2-h3i)=\eta_{t1}$

p4=1920

T4=288

h4=enthalpy(STEAM_NBS,p=p4,T=T4)

s4=entropy(STEAM_NBS,p=p4,T=T4)

p19=p1

T19=232

h19=enthalpy(STEAM_NBS,p=p19,T=T19)

p5=68.7

h5i=enthalpy(STEAM_NBS,p=p5,s=s4)

$(h4-h5)/(h4-h5i)=\eta_{t1}$

x5=quality(STEAM_NBS,p=p5,h=h5)

h5f=enthalpy(STEAM_NBS,p=p5,x=0)

h5g=enthalpy(STEAM_NBS,p=p5,x=1)

s5g=entropy(STEAM_NBS,p=p5,x=1)

p6=3.44

h6i=enthalpy(STEAM_NBS,p=p6,s=s5g)

$(h5g-h6)/(h5g-h6i)=\eta_{t1}$

p7=p6

h7i=enthalpy(STEAM_NBS,p=p7,s=s5g)

$(h5g-h7)/(h5g-h7i)=\eta_{t2}$

{state properties - condensate and feedwater}

p9=p6

T9=21

h9=enthalpy(STEAM_NBS,p=p9,T=T9)

s9=entropy(STEAM_NBS,p=p9,T=T9)

p10=68.7

h10i=enthalpy(STEAM_NBS,p=p10,s=s9)

$(h10-h9)=(h10i-h9)/\eta_{tp}$

{mass and energy balance on LP heater}

$m10+m17+m18=m11$

$m10*h10+m17*h17+m18*h18=m11*h11$

{mass balance at moisture separator}

$m51=m4$

m53=m51-m52
m54=(1-x5)*m53
m55=x5*m53
m56=m55-m57
m7=m57
m6=m56
m52+m54=m17
m52*h5+m54*h5f=m17*h17

{state properties - feedwater}

p11=68.7
T11=82
h11=enthalpy(STEAM_NBS,p=p11,T=T11)
s11=entropy(STEAM_NBS,p=p11,T=T11)
p12=8240
h12i=enthalpy(STEAM_NBS,p=p12,s=s11)
(h12-h11)=(h12i-h11)/eta_p
p13=8240
T13=216
h13=enthalpy(STEAM_NBS,p=p13,T=T13)
p14=p2
T14=93
h14=enthalpy(STEAM_NBS,p=p14,T=T14)

{mass and energy balance on reheater and throttling valve}

m3=m1-z-y
m3=m4
m19=z
qr=-24
m3*h3+z*h1+qr*m3=m4*h4+m19*h19
m16=m19
m19*h19=m16*h16

{mass and energy balance on HP heater and associated streams}

m2=y
m2+m16=m15
m2*h2+m16*h16=m15*h15
m12=m11
m13=m12
m13=m1
m15=m14
m15*h15+m12*h12=m13*h13+m14*h14

{mass and energy balance on throttling valve}

m14=m18
m14*h14=m18*h18

{equate work output of feedpump turbine to work input to feedpump}

m7*(h5g-h7)=m11*(h12-h11)

{turbine and pump work per unit m1}

w_hp=((m1-z)*h1-y*h2-m3*h3)/m1

```
w_ip=(m4*h4-m4*h5)/m1
w_lp=(m6*(h5g-h6))/m1
w_p=(m10*(h9-h10))/m1
w_rp=ma/m1*(hb-hc) {reactor coolant pump}
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```
{power output and massflows}
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```
P_gross_turbine=1000000
P_gross_turbine=m_dot*(w_hp+w_ip+w_lp)
P_net=m_dot*(w_hp+w_ip+w_lp+w_p+w_rp)
m_eng=m_dot*K2
K2=2.2*3600
```

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{energy balance on steam generator}
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```
q_sg=-36
ma*ha+m1*h13+m1*q_sg=ma*hb+m1*h1
```

```
{thermal efficiency based on reactor coolant enthalpy rise}
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```
eta_th=(w_hp+w_ip+w_lp+w_p+w_rp)/(ma/m1*(ha-hc))
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SOLUTION

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Unit Settings: [kJ]/[C]/[kPa]/[kg]/[degrees]
```

$\eta_p = 0.7$	$\eta_{t1} = 0.85$	$\eta_{t2} = 0.8$	$\eta_{th} = 0.3472 \text{ [kJ}^2/\text{kg}^2]$
$h1 = 2906 \text{ [kJ/kg]}$	$h10 = 88.11 \text{ [kJ/kg]}$	$h10i = 88.09 \text{ [kJ/kg]}$	$h11 = 343.3 \text{ [kJ/kg]}$
$h12 = 355.3 \text{ [kJ/kg]}$	$h12i = 351.7 \text{ [kJ/kg]}$	$h13 = 927 \text{ [kJ/kg]}$	$h14 = 391.6 \text{ [kJ/kg]}$
$h15 = 2142 \text{ [kJ/kg]}$	$h16 = 1000 \text{ [kJ/kg]}$	$h17 = 1536 \text{ [kJ/kg]}$	$h18 = 391.6 \text{ [kJ/kg]}$
$h19 = 1000 \text{ [kJ/kg]}$	$h2 = 2748 \text{ [kJ/kg]}$	$h2i = 2720 \text{ [kJ/kg]}$	$h3 = 2701 \text{ [kJ/kg]}$
$h3i = 2693 \text{ [kJ/kg]}$	$h4 = 2997 \text{ [kJ/kg]}$	$h5 = 2479 \text{ [kJ/kg]}$	$h5f = 374.6 \text{ [kJ/kg]}$
$h5g = 2659 \text{ [kJ/kg]}$	$h5i = 2388 \text{ [kJ/kg]}$	$h6 = 2300 \text{ [kJ/kg]}$	$h6i = 2237 \text{ [kJ/kg]}$
$h7 = 2321 \text{ [kJ/kg]}$	$h7i = 2237 \text{ [kJ/kg]}$	$h9 = 88.02 \text{ [kJ/kg]}$	$ha = 1491 \text{ [kJ/kg]}$
$hb = 1272 \text{ [kJ/kg]}$	$hc = 1274 \text{ [kJ/kg]}$	$K2 = 7920 \text{ [(lbm/hr)/(kg/s)]}$	$m1 = 1 \text{ [kg]}$
$m10 = 0.5657 \text{ [kg]}$	$m11 = 1 \text{ [kg]}$	$m12 = 1 \text{ [kg]}$	$m13 = 1 \text{ [kg]}$
$m14 = 0.3265 \text{ [kg]}$	$m15 = 0.3265 \text{ [kg]}$	$m16 = 0.1131 \text{ [kg]}$	$m17 = 0.1078 \text{ [kg]}$
$m18 = 0.3265 \text{ [kg]}$	$m19 = 0.1131 \text{ [kg]}$	$m2 = 0.2134 \text{ [kg]}$	$m3 = 0.6735 \text{ [kg]}$
$m4 = 0.6735 \text{ [kg]}$	$m51 = 0.6735 \text{ [kg]}$	$m52 = 0.05951 \text{ [kg]}$	$m53 = 0.614 \text{ [kg]}$
$m54 = 0.04831 \text{ [kg]}$	$m55 = 0.5657 \text{ [kg]}$	$m56 = 0.5301 \text{ [kg]}$	$m57 = 0.03559 \text{ [kg]}$
$m6 = 0.5301 \text{ [kg]}$	$m7 = 0.03559 \text{ [kg]}$	$ma = 9.225 \text{ [kg]}$	$\dot{m} = 1407 \text{ [kg/s]}$
$m_{eng} = 1.114E+07 \text{ [lbm/hr]}$	$p1 = 6870 \text{ [kPa]}$	$p10 = 68.7 \text{ [kPa]}$	$p11 = 68.7 \text{ [kPa]}$
$p12 = 8240 \text{ [kPa]}$	$p13 = 8240 \text{ [kPa]}$	$p14 = 2750 \text{ [kPa]}$	$p19 = 6870 \text{ [kPa]}$
$p2 = 2750 \text{ [kPa]}$	$p3 = 2060 \text{ [kPa]}$	$p4 = 1920 \text{ [kPa]}$	$p5 = 68.7 \text{ [kPa]}$
$p6 = 3.44 \text{ [kPa]}$	$p7 = 3.44 \text{ [kPa]}$	$p9 = 3.44 \text{ [kPa]}$	$pa = 17900 \text{ [kPa]}$
$pb = 17200 \text{ [kPa]}$	$pc = 18600 \text{ [kPa]}$	$P_{gross_turbine} = 1000000 \text{ [kW]}$	$P_{net} = 975817 \text{ [kJ/s]}$
$qr = -24 \text{ [kJ/kg]}$	$q_{sg} = -36 \text{ [kJ/kg]}$	$s1 = 6.054 \text{ [kJ/kg-k]}$	$s11 = 1.099 \text{ [kJ/kg-k]}$
$s2 = 6.11 \text{ [kJ/kg-k]}$	$s4 = 6.738 \text{ [kJ/kg-k]}$	$s5g = 7.486 \text{ [kJ/kg-k]}$	$s9 = 0.3104 \text{ [kJ/kg-k]}$
$sb = 3.106 \text{ [kJ/kg-k]}$	$T1 = 316 \text{ [C]}$	$T11 = 82 \text{ [C]}$	$T13 = 216 \text{ [C]}$
$T14 = 93 \text{ [C]}$	$T19 = 232 \text{ [C]}$	$T4 = 288 \text{ [C]}$	$T9 = 21 \text{ [C]}$
$Ta = 327 \text{ [C]}$	$Tb = 288 \text{ [C]}$	$Tc = 288.5 \text{ [C]}$	$w_{hp} = 172 \text{ [kJ/kg]}$
$w_{ip} = 348.9 \text{ [kJ/kg]}$	$w_{lp} = 190 \text{ [kJ/kg]}$	$w_p = -0.05284 \text{ [kJ/kg]}$	$w_{rp} = -17.14 \text{ [kJ/kg]}$
$x5 = 0.9213 \text{ [-]}$	$y = 0.2134 \text{ [kg]}$	$z = 0.1131 \text{ [kg]}$	

No unit problems were detected.

Purple units were automatically set. Right click on the variable to confirm or change the units.