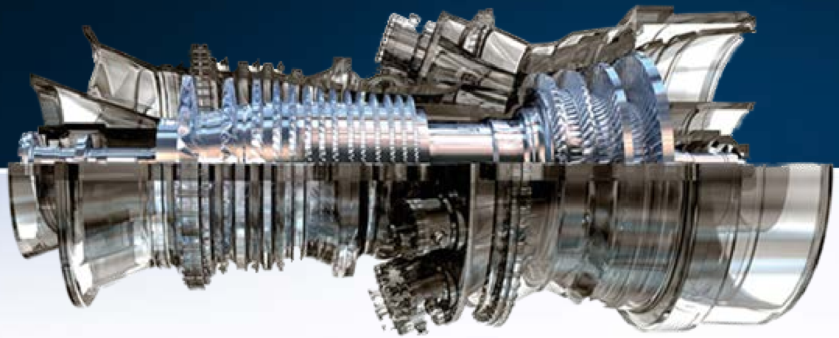
Production de puissance



NRJ EN ROTATION

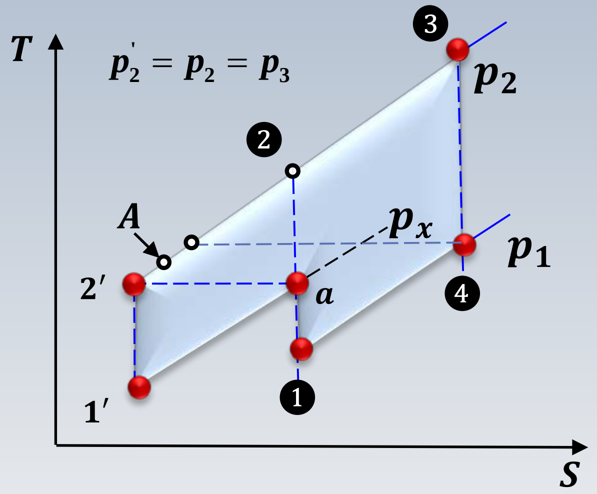
Problème

Une turbine à gaz opère avec 2 compresseurs et un régénérateur. Les paramètres de l'air à l'entrée du système sont $\boldsymbol{p_1 = 101.3kPa}$ et $\boldsymbol{T_1 = 290K}$, la température à l'entrée de la turbine est $\boldsymbol{T_3 = 973K}$. Le rapport de compression total est $\boldsymbol{r_p = 5, \gamma = 1.4}$, $\boldsymbol{c_p = 1005\, J/kg\, K}$. Calculer le rendement de l'installation si: $\boldsymbol{a)\eta_C = 1 = \eta_T, \sigma = 0.7}$ $\boldsymbol{b)\, \eta_C = 0.85 = \eta_T, \sigma = 0.7}$

Ce problème sera d'abord regardé étape par étape et par la suite, au moyen d'une formule abrégée

Problème

$p_1 = 101.3kPa,\ T_1 = 290K, T_3 = 973K$
$r_p = 5, \gamma = 1.4,\ c_p = 1005 J/kg \cdot K$
$\boldsymbol{a)\eta_C = 1 = \eta_T, \sigma = 0.7}$



Pression intermédiaire p_x (optimisée)

$$p_x = \sqrt{p_1 p_2} = \sqrt{5p_1^2} = 2.236 p_1$$

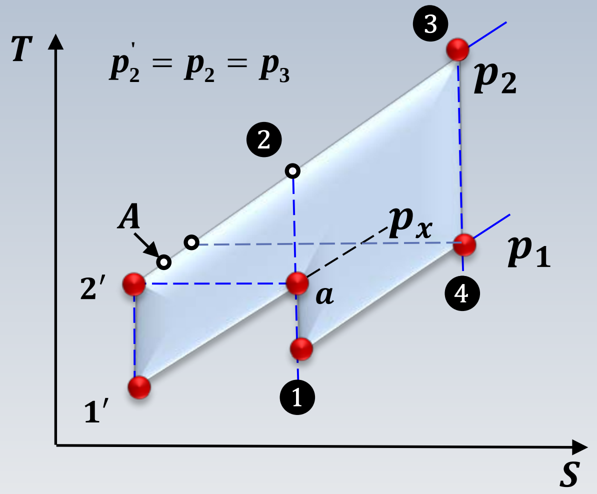
$$\Delta = \left(\frac{p_2}{p_1}\right)^{\frac{\gamma-1}{\gamma}} = (5)^{\frac{1.4-1}{1.4}} = 1.5838$$

Compression 1-a

$$\Delta^* = \left(\frac{p_x}{p_1}\right)^{\frac{\gamma-1}{\gamma}} = (2.236)^{\frac{0.4}{1.4}} = 1.2584$$

Problème

$p_1 = 101.3kPa,\ T_1 = 290K, T_3 = 973K$
$r_p = 5, \gamma = 1.4,\ c_p = 1005 J/kg \cdot K$
$\boldsymbol{a)\eta_C = 1 = \eta_T, \sigma = 0.7}$



$$\boldsymbol{T_a} = T_1\left(\frac{p_x}{p_1}\right)^{\frac{\gamma-1}{\gamma}} = T_1\ \Delta^*$$

$$= 290 \times 1.2584 \ = \boldsymbol{365K}$$

$$\boldsymbol{W_C} = c_P(T_a - T_1) + c_p(T_{2'} - T_{1'})$$

$$(T_1' = T_1, \quad T_2' = T_a)$$

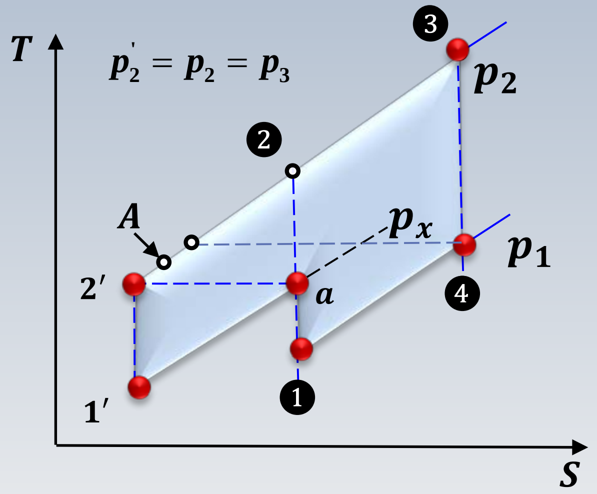
$$\boldsymbol{W_C} = 2c_P T_1(\Delta^* - 1)$$

$$= 2 \times 1.005 \times 290 \times (1.2584 - 1)$$

$$= \boldsymbol{150.6(kJ/kg)}$$

Problème

$p_1 = 101.3kPa,\ T_1 = 290K, T_3 = 973K$
$r_p = 5, \gamma = 1.4,\ c_p = 1005 J/kg \cdot K$
$\boldsymbol{a)\eta_C = 1 = \eta_T, \sigma = 0.7}$



$$\Delta = \left(\frac{p_2}{p_1}\right)^{\frac{\gamma-1}{\gamma}} = \left(\frac{T_2}{T_1}\right) = \left(\frac{T_3}{T_4}\right)$$

$$= 1.5838$$

Travail produit par la turbine

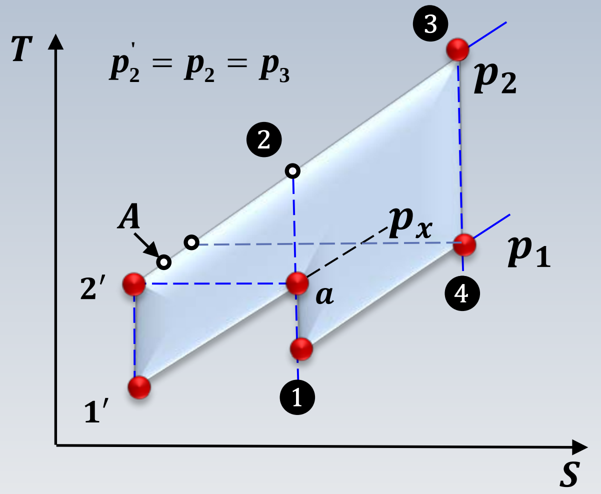
$$W_T = c_P(T_3 - T_4) \quad = c_P T_3 \left(1 - \frac{1}{\Delta}\right)$$

$$\boldsymbol{W_T} = 1.005 \times 973 \times \left(1 - \frac{1}{1.5838}\right)$$

$$= \boldsymbol{360.4(KJ/kg)}$$

Problème

$p_1 = 101.3kPa,\ T_1 = 290K, T_3 = 973K$
$r_p = 5, \gamma = 1.4,\ c_p = 1005 J/kg\cdot K$
$\boldsymbol{a)\eta_C = 1 = \eta_T, \sigma = 0.7}$



Chaleur fournie $(\Delta = 1.5838)$

$$T_4 = T_3/\Delta = 973/1.5838 = 614.3K$$

point A

$$T_2' = T_a = 365K$$

$$T_A = T_2' + \sigma(T_4 - T_2')$$

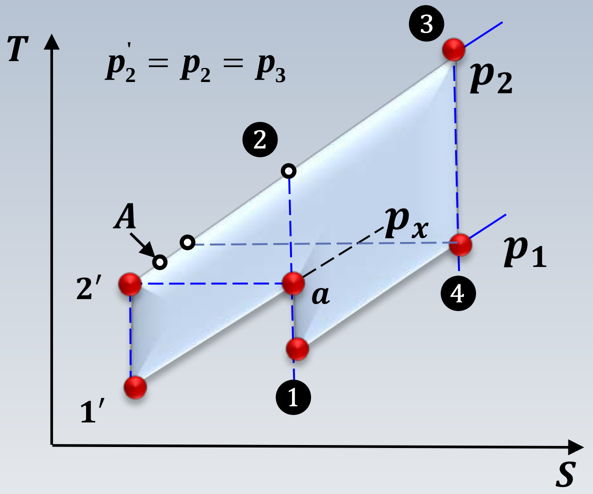
$$= 365 + 0.7(614.3 - 365) = 539.5\,K$$

$$Q = c_p(T_3 - T_A) = 1.005(973 - 539.5)$$

$$= \mathbf{435.6\ kJ/kg}$$

Problème

$p_1 = 101.3kPa,\ T_1 = 290K, T_3 = 973K$
$r_p = 5, \gamma = 1.4,\ c_p = 1005 J/kg \cdot K$
$\boldsymbol{a)\eta_C = 1 = \eta_T, \sigma = 0.7}$



Le rendement

$$\eta = \frac{W_T - W_C}{Q}$$

$W_T = 360.4 (KJ/kg)$
$W_C = 150.6 (kJ/kg)$
$Q = 435.6\ kJ/kg$

$$\boldsymbol{\eta = 0.482}$$

Formule abrégée

$p_1 = 101.3kPa,\ T_1 = 290K, T_3 = 973K$
$r_p = 5, \gamma = 1.4,\ c_p = 1005 J/kg\cdot K$
$\boldsymbol{a)\eta_C = 1 = \eta_T, \sigma = 0.7}$

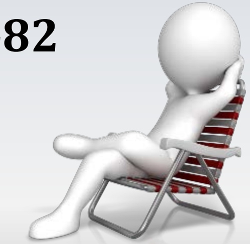
$$\eta = \frac{\frac{\Delta-1}{\Delta}\Phi\eta_T - \frac{2(\sqrt{\Delta}-1)}{\eta_C}}{\frac{\Delta-1}{\Delta}\sigma\,\Phi\eta_T + (1-\sigma)\left[\Phi - 1 - \frac{\sqrt{\Delta}-1}{\eta_C}\right]}$$

$$\Delta = \left(\frac{p_2}{p_1}\right)^{\gamma-1/\gamma} = 1.5838$$

$$\Phi = \left(\frac{T_3}{T_1}\right) = \left(\frac{973}{290}\right) = 3.35$$

$$\eta_c = \eta_T = 1, \quad \sigma = 0.7$$

$$\boldsymbol{\eta} = \frac{\frac{1.5838-1}{1.5838}\times 3.35\times 1 - \frac{2(\sqrt{1.5838}-1)}{1}}{\frac{1.5838-1}{1.5838}\times 0.7\times\ 3.35\times 1 + (1-0.7)\left[3.35 - 1 - \frac{\sqrt{1.5838}-1}{1}\right]} = \boldsymbol{0.482}$$



Problème

$p_1 = 101.3kPa,\ T_1 = 290K, T_3 = 973K$
$r_p = 5, \gamma = 1.4,\ c_p = 1005 J/kg\cdot K$
$\boldsymbol{b)\eta_C = 0.85 = \eta_T, \sigma = 0.7}$

$W_{Ts} = 360.4(kJ/kg)$

$W_{Cs} = 150.6(kJ/kg)$

$$\Delta = \left(\frac{p_2}{p_1}\right)^{\gamma-1/\gamma} = 1.5838, \quad \Phi = \left(\frac{T_3}{T_1}\right) = \left(\frac{973}{290}\right) = 3.35$$

$$\boldsymbol{W_C} = 150.6/0.85 = \boldsymbol{177.2(kJ/kg)} \qquad \boldsymbol{W_T} = 0.85(360.4) = \boldsymbol{306.3(kJ/kg)}$$

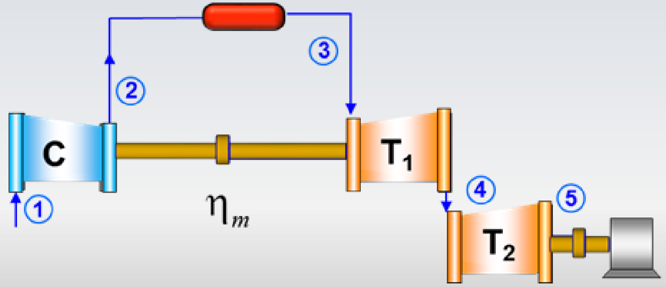
$$\boldsymbol{\eta} = \frac{\frac{1.5838-1}{1.5838}\times 3.35\times 0.85 - \frac{2\left(\sqrt{1.5838}-1\right)}{0.85}}{\frac{1.5838-1}{1.5838}\times 0.7\times 3.35\times 0.85 + (1-0.7)\left[3.35-1-\frac{\sqrt{1.5838}-1}{0.85}\right]} \boldsymbol{= 0.326}$$

$$\eta = \frac{\frac{\Delta-1}{\Delta}\Phi\eta_T - \frac{2(\sqrt{\Delta}-1)}{\eta_C}}{\frac{\Delta-1}{\Delta}\sigma\,\Phi\eta_T + (1-\sigma)\left[\Phi - 1 - \frac{\sqrt{\Delta}-1}{\eta_C}\right]}$$

Problème

Les conditions pour l'installation ci-dessous sont les suivantes: $\mathbf{p_{01}= 101.3\ kPa}$ et $\mathbf{T_{01}=288\ K}$. Le rapport de compression est $\mathbf{r_c =9}$, $\mathbf{T_{03}=1380K}$, $\mathbf{\eta_C =0.87}$, $\mathbf{\eta_{T1} =0.89}$, $\mathbf{\eta_{T2} =0.89}$. Le pouvoir calorifique est **LHV=43000kJ/kg** et la pression à la sortie de la turbine de puissance $\mathbf{T_2}$ est $\mathbf{p_{05}=120\ kPa}$. Considérez $\mathbf{\eta_m =1}$ $\mathbf{\gamma_c=1.4}$ et $\mathbf{\gamma_t =1.333}$ et calculez:

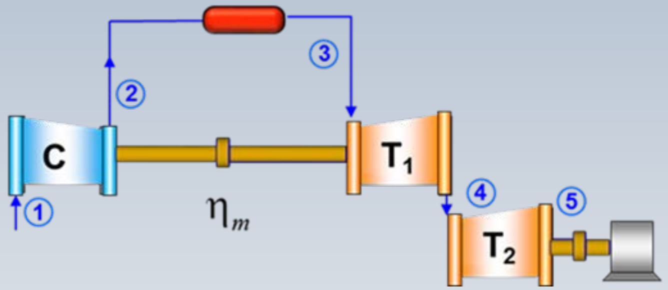
- Le rapport débit massique de carburant /débit massique d'air: $\mathbf{f}$
- La température $\mathbf{T_{05}}$ à la sortie de la turbine de puissance ($\mathbf{T_2}$)
- Le travail spécifique utile $\mathbf{W_e}$
- La rendement thermique du système $\mathbf{\eta_{th}}$



Problème f?

p_{01}= 101.3 kPa, T_{01}=288K, r_c =9, T_{03}=1380K, η_C=0.87, η_{T1} =0.89, η_{T2} =0.89, LHV=43000kJ/kg , p_{05}=120 kPa. γ_c=1.4 , γ_t =1.333, η_m=1, c_{pt}=1.148kJ/kg, c_{pc}=1.004kJ/kg

Compresseur



$$p_{02} = r_c p_{01} = 9 \times 101.3 = \mathbf{911.7}\boldsymbol{kPa}$$

$$T_{02} = T_{01}\left[1 + \frac{r_c^{(\gamma_c - 1)/\gamma_c} - 1}{\eta_c}\right]$$

$$= 288\left[1 + \frac{9^{(1.4-1)/1.4} - 1}{0.87}\right] = \mathbf{577.53}\boldsymbol{K}$$

Chambre de combustion f

$$\boldsymbol{f} = \frac{c_{p|t}T_{03} - c_{p|c}T_{02}}{LHV - c_{p|t}T_{03}} = \frac{1.148 \times 1380 - 1.004 \times 577.53}{43000 - 1.148 \times 1380} = \mathbf{0.0243}$$

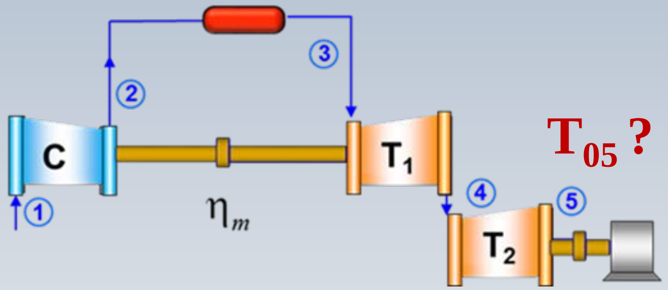
Problème $T_{05}?$

$f = 0.0243, \quad T_{02} = 577.53K$

p_{01}= 101.3 kPa, T_{01}=288K, r_c =9, T_{03}=1380K, η_C=0.87, η_{T1} =0.89, η_{T2} =0.89, LHV=43000kJ/kg , p_{05}=120 kPa. γ_c=1.4 , γ_t =1.333, η_m=1, c_{pt}=1.148kJ/kg, c_{pc}=1.004kJ/kg

$$p_{03} = p_{02} = \mathbf{911.7kPa}$$

Turbine liée ❸ T_1 ❹



$$T_{04} = T_{03} - \frac{1}{\eta_m(1+f)}\frac{c_{p|c}}{c_{p|t}}(T_{02} - T_{01})$$

$$= 1380 - \frac{1}{(1+0.0243)}\frac{1.004}{1.148}(577.53 - 288) = \mathbf{1132.5K}$$

$$p_{04} = p_{03}\left(1 - \frac{T_{03} - T_{04}}{\eta_{T1}T_{03}}\right)^{\gamma_t/(\gamma_t-1)} = 911.7\left(1 - \frac{1380 - 1132.5}{0.89 \times 1380}\right)^{1.333/(0.333)} = \mathbf{370.8kPa}$$

Problème

$p_{04} = 370.8kPa \quad T_{04} = 1132.5K \quad f = 0.0243,$

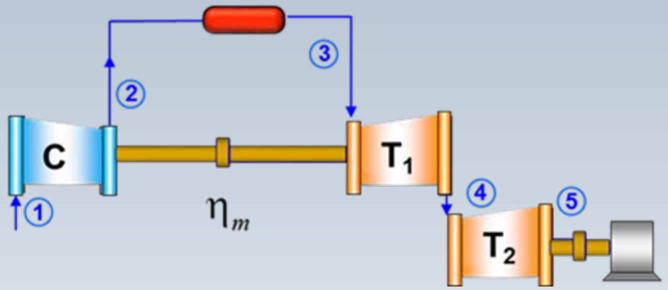
$T_{05}?\ W_e?\ \eta_{th}?$

p_{01}= 101.3 kPa, T_{01}=288K, r_c =9, T_{03}=1380K, η_C=0.87, η_{T1} =0.89, η_{T2} =0.89, LHV=43000kJ/kg , p_{05}=120 kPa. γ_c=1.4 , γ_t =1.333, η_m=1

Turbine de puissance ❹ T_2 ❺

$$T_{05} = T_{04}\left[1 - \eta_{T2}\left(1 - \left(\frac{p_{05}}{p_{04}}\right)^{(\gamma_t - 1)/\gamma_t}\right)\right] \qquad T_{04} = 1132.5K \quad p_{04} = 370.8kPa$$

$$= 1132.5\left[1 - 0.89\left(1 - \left(\frac{120}{370.8}\right)^{(.333)/1.333}\right)\right] = \mathbf{884.8K}$$



$$\eta_{th} = \frac{W_e}{f \times LHV} \qquad f = 0.0243$$

$$W_e = (1 + f)c_{pt}(T_{04} - T_{05})$$

$$= (1.0243) \times 1.148(1132.5 - 884.8) = \mathbf{292.27kJ / kg}$$

$$= \frac{292.27}{0.0243 \times 43000} = \mathbf{0.279}$$

Problème: raccourci

p_{01}= 101.3 kPa, T_{01}=288K, r_c =9, T_{03}=1380K, η_C=0.87, η_{T1} =0.89, η_{T2} =0.89, LHV=43000kJ/kg , p_{05}=120 kPa. γ_c=1.4 , γ_t =1.333, η_m=1

$$\eta = \frac{\frac{\Delta - 1}{\Delta}\Phi\eta_T - \frac{2\left(\sqrt{\Delta} - 1\right)}{\eta_C}}{\frac{\Delta - 1}{\Delta}\sigma\Phi\eta_T + (1-\sigma)\left[\Phi - 1 - \frac{\sqrt{\Delta} - 1}{\eta_C}\right]}$$

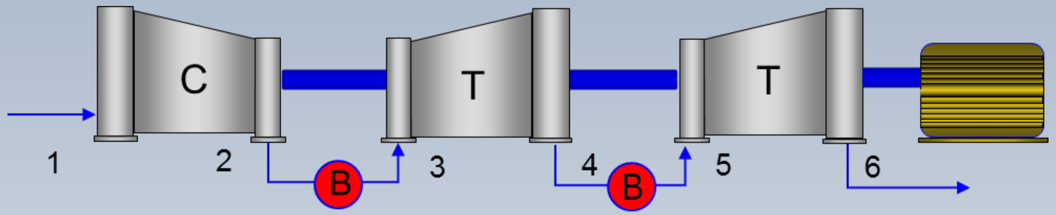
$$\Phi = \frac{T_{03}}{T_{02}} = 4.792$$

$$\Delta = \left(\frac{p_{02}}{p_{01}}\right)^{\gamma-1/\gamma} = 1.873$$

$$\sigma = 0$$

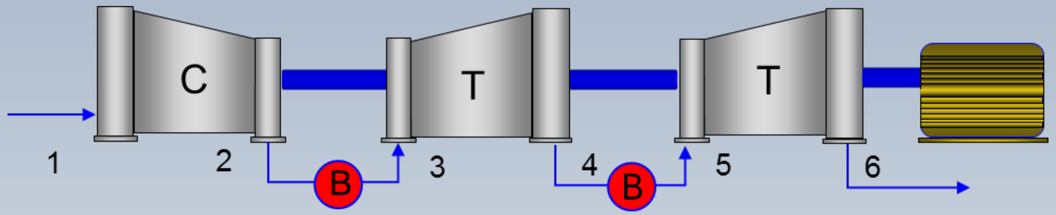
$$\boldsymbol{\eta = 0.339}$$

Problème



- La température et la pression à l'entrée du compresseur C sont T_{01} = 288 K et p_{01} = 101.3 kPa
- Le rendement du compresseur (C) η_c =87 %
- La pression à la sortie du compresseur p_{02} = 1216 kPa
- Le rendement des turbines η_t =89 %
- La température à la sortie des chambres de combustion $T_{03} = T_{05}$ =1400 K
- Le pouvoir calorifique : LHV=43000 kJ/kg

Problème



Considérez $\boldsymbol{c_p} = \boldsymbol{cnste}$ et calculez:

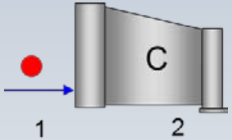
- Le travail de compression
- La pression $p_{05} = p_{04}$
- La travail utile produit par la seconde turbine
- L'efficacité thermique
- La consommation spécifique

Problème w_c?

p_{01}= 101.3 kPa, T_{01}=288K, T_{03}=1400K, η_C=0.87, η_{T1} =0.89, η_{T2} =0.89, LHV=43000kJ/kg , p_{02}=1216 kPa. γ_c=1.4 η_m=1, c_p=1.004 kJ/kg-K

Entrée du compresseur :

$$T_{01} = 288\,K$$

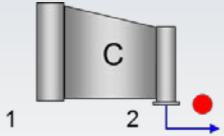


$$\frac{T_{02s}}{T_{01}} = \left(\frac{p_{02}}{p_{01}}\right)^{\frac{\gamma-1}{\gamma}}$$

“ Pont isentropique ”

$$= (r_p)^{\frac{\gamma-1}{\gamma}} = (12)^{0.2857}$$

Sortie du compresseur



$$T_{02} = T_{01} + \frac{T_{02s} - T_{01}}{\eta_c} = 630.3K$$

$$T_{02s} = 585.8K$$

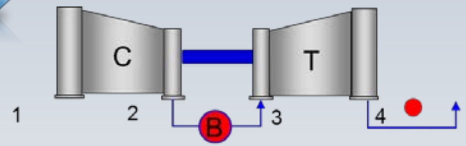
$$T_{02} = 630.3K$$

Problème w_c?

p_{01}= 101.3 kPa, T_{01}=288K, T_{03}=1400K, η_C=0.87, η_{T1} =0.89, η_{T2} =0.89, LHV=43000kJ/kg , p_{02}=1216 kPa. γ_c=1.4 η_m=1 , c_p=1.004 kJ/kg-K

$$w_{cs} = c_p(T_{02s} - T_{01}) = 1.0045(585.8 - 288) = \mathbf{299.1\, kJ/kg}$$

$$w_{cr} = \frac{w_{cs}}{\eta_c} = \frac{299.1}{0.87} = \mathbf{343.83\, kJ/kg}$$



$$\mathbf{w_{tr} = w_{cr} = 343.83\, kJ/kg}$$

" Pont isentropique "

$$w_{ts} = \frac{w_{tr}}{\eta_t} = \frac{343.83}{0.89} = \mathbf{386.34\, kJ/kg}$$

Problème p_{04}?

p_{01}= 101.3 kPa, T_{01}=288K, T_{03}=1400K, η_C=0.87, η_{T1} =0.89, η_{T2} =0.89, LHV=43000kJ/kg , p_{02}=1216 kPa. γ_c=1.4 η_m=1 , c_p=1.004 kJ/kg-K

$$T_{03} = 1400\text{K}$$

Processus **isentropique** 3-4

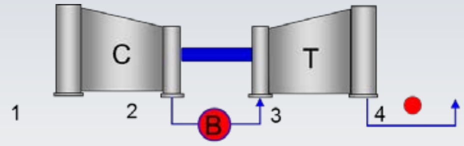
$$\boldsymbol{T_{04s}} = T_{03} - \frac{w_{ts}}{c_p} = \mathbf{1015.4K}$$

$$w_{ts} = 386.34\, kJ/kg$$

$$w_{tr} = 343.83\, kJ/kg$$

Processus réel 3-4

$$\boldsymbol{T_{04}} = T_{03} - \frac{w_{tr}}{c_p} = \mathbf{1057.7K}$$



$$\frac{\boldsymbol{p_{04}}}{p_{03}} = \left(\frac{T_{04s}}{T_{03}}\right)^{\gamma/\gamma-1}$$

$$\boldsymbol{p_{04} = 395.8\, kPa} \quad (p_{03} = p_{02})$$

Problème w_{t2r}?

p_{01}= 101.3 kPa, T_{01}=288K, T_{03}=1400K, η_C=0.87, η_{T1} =0.89, η_{T2} =0.89, LHV=43000kJ/kg , p_{02}=1216 kPa. γ_c=1.4 η_m=1 , c_p=1.004 kJ/kg-K

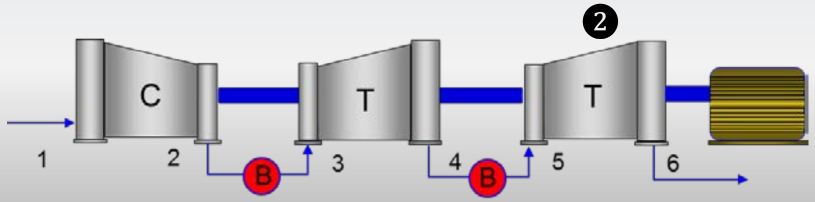
$$p_{04} = p_{05} = 395.82\,kPa \qquad p_{06} = p_{01} = 101.3\,kPa$$

$$T_{03} = T_{05} = 1400\,K$$

$$\frac{p_{06}}{p_{05}} = \left(\frac{T_{06s}}{T_{05}}\right)^{\gamma/\gamma-1} \Longrightarrow \quad \boldsymbol{T_{06s} = 948.5K}$$

Processus 5-6

$$w_{t2r} = c_p(T_{05} - T_{06s})\eta_t = \mathbf{403.7kJ/kg}$$



Problème

p_{01}= 101.3 kPa, T_{01}=288K, T_{03}=1400K, η_C=0.87, η_{T1} =0.89, η_{T2} =0.89, LHV=43000kJ/kg , p_{02}=1216 kPa. γ_c=1.4 η_m=1 , c_p=1.004 kJ/kg-K

Efficacité thermique

$w_{t2r} = 403.7 kJ/kg$

$T_{03} = 1400$ K $T_{02} = 630.3$K

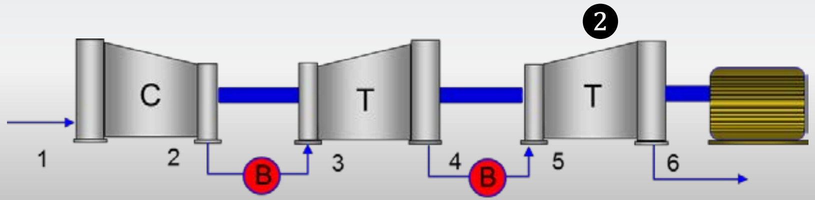
$T_{04} = 1057.1$K $T_{05} = 1400$K

$$q_{c.c} = c_p\left[(T_{05} - T_{04}) + (T_{03} - T_{02})\right] = \mathbf{1159.5\, kJ/kg}$$

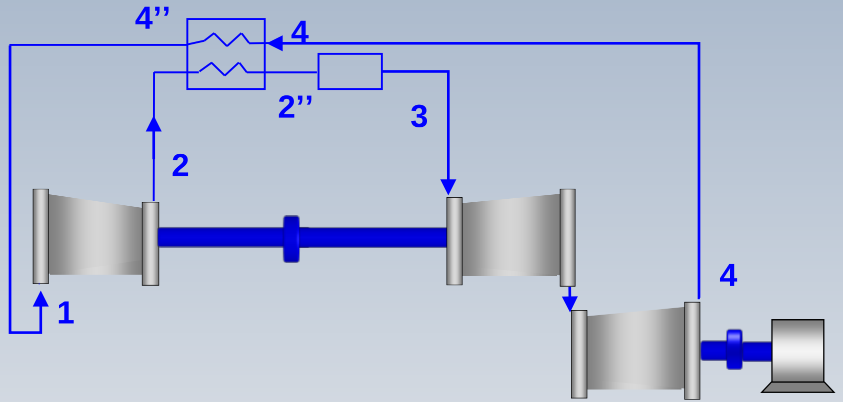
$$\eta_{th} = \frac{w_{t2r}}{q_{c.c}} = \frac{403.7}{1159.5} = \mathbf{0.348}$$

$$\boldsymbol{SFC} = \frac{3600}{\eta_{th} \times LHV}$$

$$= \frac{3600}{0.348 \times 43000} = \mathbf{0.24 \frac{kJ}{kW\,h}}$$

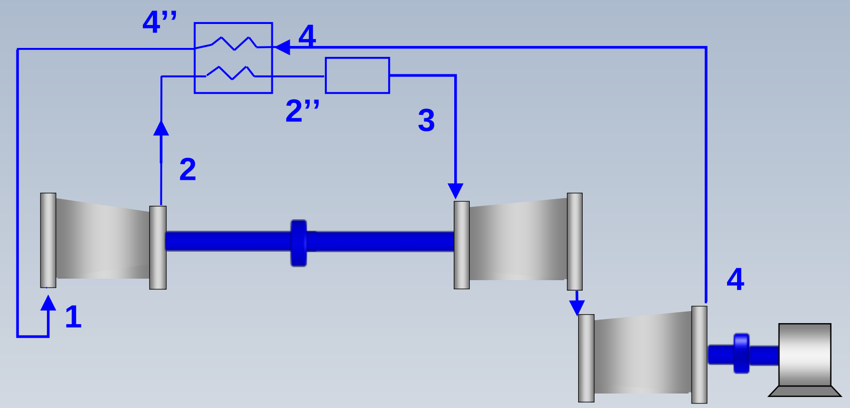


Problème



Les conditions pour ce cycle régénératif sont les suivantes: $\mathbf{p_{01} = p_{04} = 8}$ **bar** et $\mathbf{T_1 = 30^oC}$. Le rapport de compression est $\mathbf{r_c = 4}$, $\mathbf{T_3 = 850^oC}$, $\eta_C = 0.85 = \eta_T$, $\sigma = 0.7$, et le débit massique $\dot{m} = 30\ kg/s$. Considérez $c_p = cnste$ (air) et calculez:

Problème $c_p = cnste$



- La température à la sortie de la turbine de puissance (T libre)
- La température à l'entrée de la chambre de combustion $T_{2''}$.
- La température à l'entrée du régénérateur T_2
- La température à la sortie du régénérateur $T_{4''}$
- La puissance consommée par le compresseur
- La puissance générée par les turbines

Problème

$p_{01}=p_{04}=8$ bar $T_{01}=30\ ^0C$, $T_{03}=850\ ^0C$, $r_C=4$, $\eta_C=0.85$, $\eta_T=0.85$, LHV=43000kJ/kg , $\sigma=0.7$. $\gamma_c=1.4$ $\eta_m=1, \dot{m}=30$ kg/s

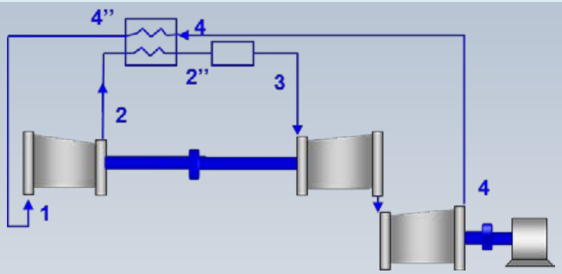
$T_{01}=303$ K

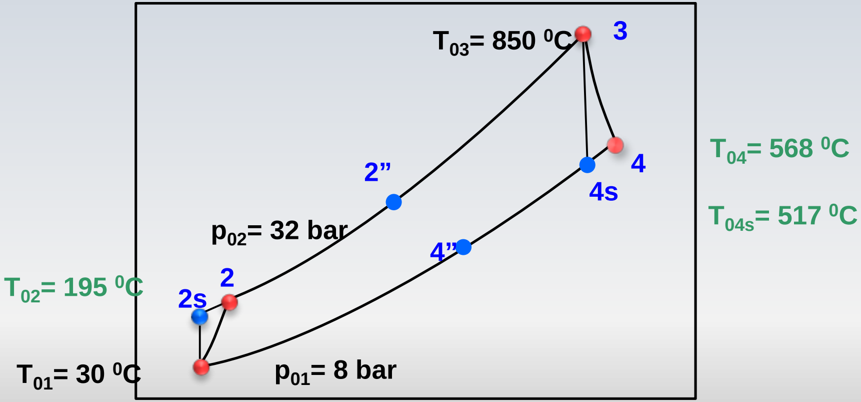
$$\frac{T_{02s}}{T_{01}}=\left(\frac{p_{02}}{p_{01}}\right)^{\frac{\gamma-1}{\gamma}}$$

$$=(r_p)^{\frac{\gamma-1}{\gamma}}=(4)^{0.2857}$$

$T_{02S}=450.2$ K

" Pont isentropique "

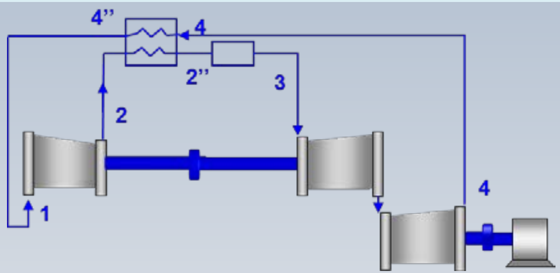




Problème

p_{01}= p_{04}= 8 bar T_{01}=30 ^{0}C, T_{03}=850 ^{0}C, r_C =4, η_C=0.85, η_T =0.85, LHV=43000kJ/kg , σ=0.7. γ_c=1.4 η_m=1, $\dot{m}$=30 kg/s

- $T_{02} = T_{01} + \dfrac{T_{02s} - T_{01}}{\eta_c} = 303 + \dfrac{450.2 - 303}{0.85} = \mathbf{476.2K}$



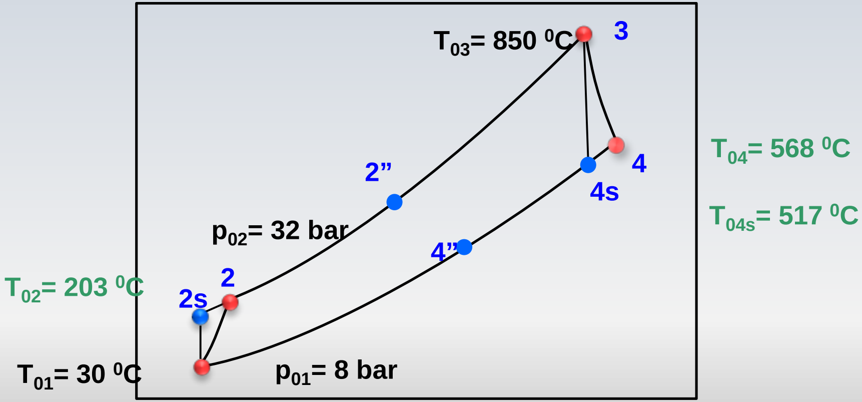
$T_{03} = 1123K \rightarrow$

" Pont isentropique "

$$\frac{p_{04}}{p_{03}} = \left(\frac{T_{04s}}{T_{03}}\right)^{\gamma/\gamma-1}$$

$$\frac{1}{4} = \left(\frac{T_{04s}}{1123}\right)^{\gamma/\gamma-1}$$

- $T_{04S} = 755.7K$



Problème

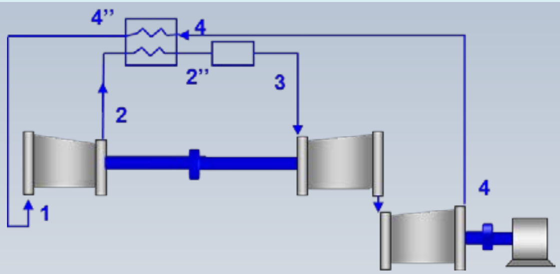
$p_{01}= p_{04}=$ 8 bar T_{01}=30 ^{0}C, T_{03}=850 ^{0}C, r_C =4, η_C=0.85, η_T =0.85, LHV=43000kJ/kg , σ=0.7. γ_c=1.4 η_m=1,$\dot{m}$=30 kg/s

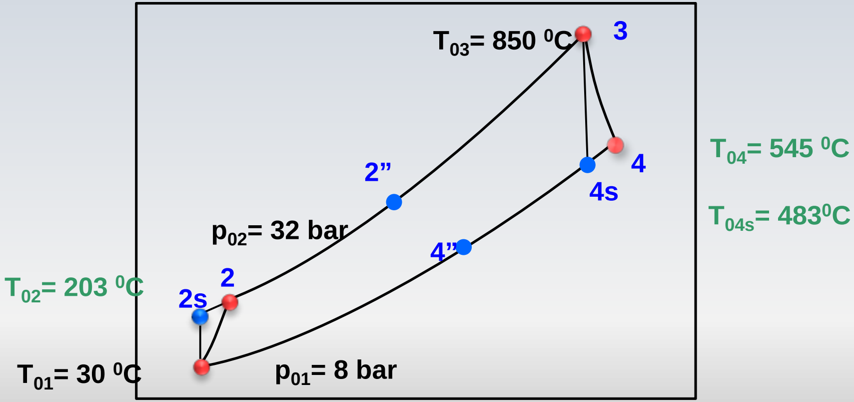
$$\rightarrow T_{04s} = 755.7K$$

$$\boldsymbol{T_{04}} = T_{03} - \eta_T(T_{03} - T_{04S})$$

$$\boldsymbol{T_{04}} = 1123 - 0.85\,(1123 - 755.7) = 817.7\text{K}$$

$$\boldsymbol{T_{04} = 817.7K}$$





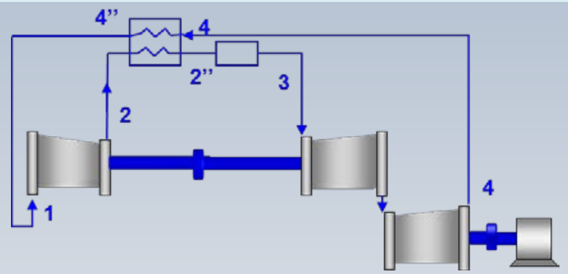
Problème

$$T_{04} = 817.7K$$
$$T_{02} = 476.2K$$

$p_{01}= p_{04}= 8$ bar $T_{01}=30\ ^0C$, $T_{03}=850\ ^0C$, $r_C=4$, $\eta_C=0.85$, $\eta_T=0.85$, LHV=43000kJ/kg, $\sigma=0.7$. $\gamma_c=1.4$ $\eta_m=1$, $\dot{m}=30$ kg/s

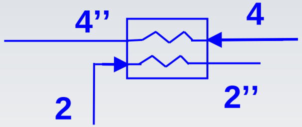
$$\sigma = \frac{T_{02}'' - T_{02}}{T_{04} - T_{02}} = 0.7 \qquad T_{02}'' = T_{02} + \sigma(T_{04} - T_{02})$$

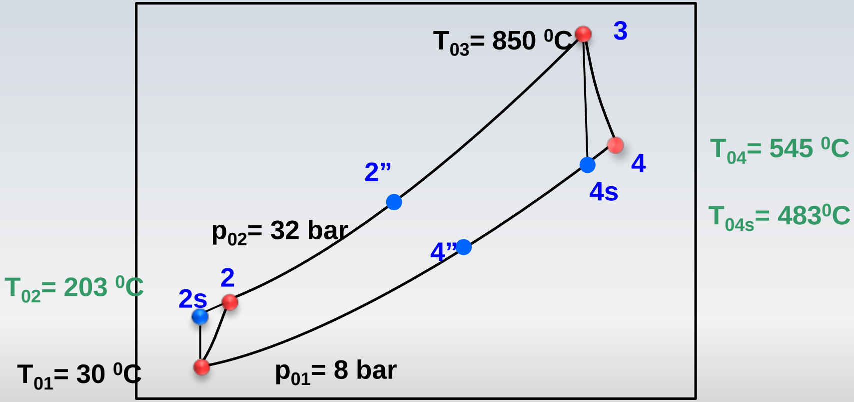
$$T''_{02} = 476.2 + 0.7(817.7 - 476.2) = 715.2K$$



$$T_{02}'' - T_{02} = T_{04} - T_{04}''$$

$$T_{04}'' = T_{04} + T_{02} - T_{02}''$$





Problème

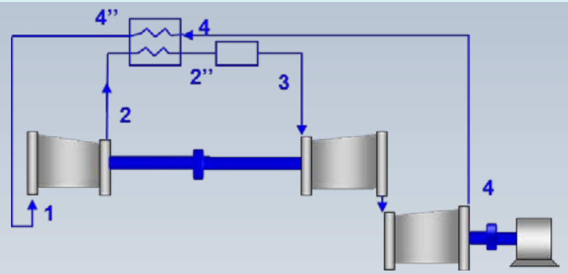
$$\rightarrow T_{02}'' = 715.2K \quad T_{02} = 476.2K \quad T_{04} = 817.7K \quad T_{01} = 303\ K$$

p_{01}= p_{04}= 8 bar T_{01}=30 ^{0}C, T_{03}=850 ^{0}C, r_C =4, η_C=0.85, η_T =0.85, LHV=43000kJ/kg , σ=0.7. γ_c=1.4 η_m=1,$\dot{m}$=30 kg/s

$$T_{04} \qquad T_{02} \qquad T_{02}''$$

$$T_{04}'' = 817.7 + 476.2 - 715.2 = 578.6K$$

$$\rightarrow \mathbf{T_{04}'' = 578.6K}$$

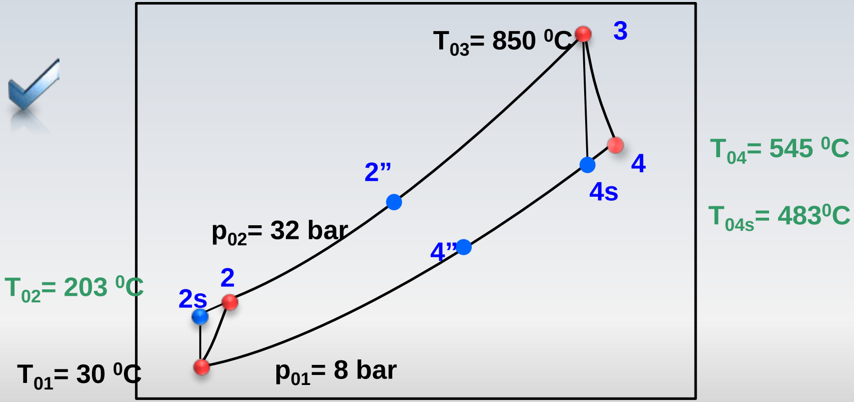


$$\dot{W}_c = \dot{m}c_P(T_{02} - T_{01}) = 30 \times 1.004(476.2 - 303)$$

$$\mathbf{\dot{W}_c = 5216.8kW}$$

$$\dot{W}_t = \dot{m}c_p(T_{03} - T_{04}) = 30 \times 1.004(1123 - 817.7)$$

$$\mathbf{= 9196kW}$$



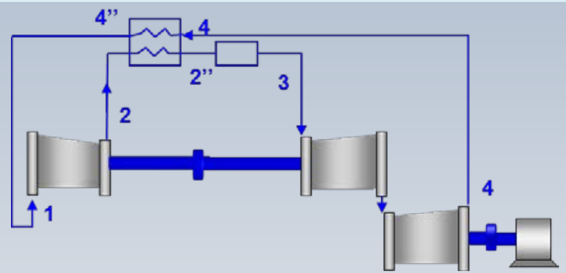
Problème

$\rightarrow T_{02}'' = 714.2K \quad T_{02} = 476.2K \quad T_{04} = 867.1K \quad T_{01} = 303\text{ K}$

p_{01}= p_{04}= 8 bar T_{01}=30 ^{0}C, T_{03}=850 ^{0}C, r_C =4, η_C=0.85, η_T =0.85, LHV=43000kJ/kg , σ=0.7. γ_c=1.4 η_m=1,$\dot{m}$=30 kg/s

$$\dot{W}_t = 9196kW \qquad \dot{W}_c = 5216kW$$

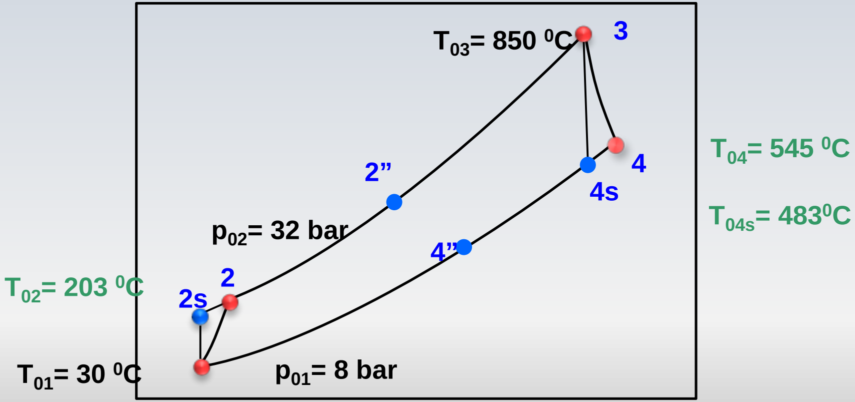
$$W_e = (\dot{W}_t - \dot{W}_c)/\dot{m} = 132.7\ kJ/kg$$



$$T_{03} = 1123K \quad T_{02}'' = 715.2K$$

$$q = c_P(T_{03} - T_{02}'') = 407.8\ kJ/kg$$

$$\eta = \frac{W_e}{q} = \frac{132.7}{407.8} = 0.32$$



Problème

$\rightarrow T_{02}'' = 714.2K \quad T_{02} = 476.2K \quad T_{04} = 867.1K \quad T_{01} = 303\ \mathrm{K}$

p_{01}= p_{04}= 8 bar T_{01}=30 ^{0}C, T_{03}=850 ^{0}C, r_C =4, η_C=0.85, η_T =0.85, LHV=43000kJ/kg , σ=0.7. γ_c=1.4 η_m=1, $\dot{m}$=30 kg/s

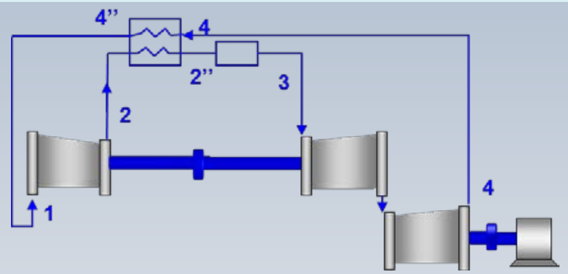
$$\Delta = 4^{\frac{\gamma-1}{\gamma}} = 1.4886$$

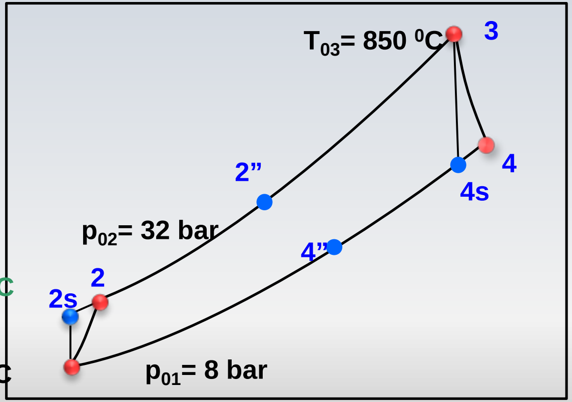
$$\Phi = \frac{T_3}{T_1} = \frac{1123}{303} = 3.706$$

$$c_p = 1.004\, kJ/kg.K$$

$$W_e = c_p T_1 \left(\frac{\Delta - 1}{\Delta}\right)\left(\eta_T \Phi - \frac{\Delta}{\eta_C}\right)$$

$$= 139.88\, kJ/kg.K$$

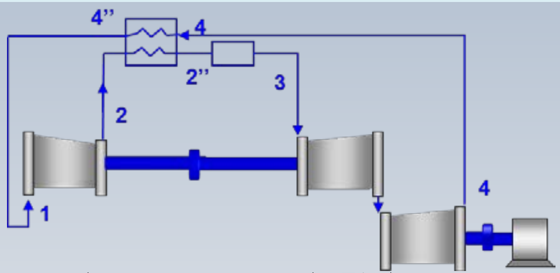




Problème

$\rightarrow T_{02}'' = 714.2K \quad T_{02} = 476.2K \quad T_{04} = 867.1K \quad T_{01} = 303\ K$

p_{01}= p_{04}= 8 bar T_{01}=30 ^{0}C, T_{03}=850 ^{0}C, r_C =4, η_C=0.85, η_T =0.85, LHV=43000kJ/kg , σ=0.7. γ_c=1.4 η_m=1, $\dot{m}$=30 kg/s



$$\Delta = 1.4886 \quad \Phi = 3.706 \quad c_p = 1.004\, kJ/kg.K$$

$$W_e = 139.88\, kJ/kg.K$$

$$Q = c_p T_1 \left(\Phi - \left\{ \left(1 + \frac{\Delta - 1}{\eta_C}\right) + \sigma \left[\Phi \left(1 - \eta_T \frac{\Delta - 1}{\Delta}\right) - \left(1 + \frac{\Delta - 1}{\eta_C}\right) \right] \right\} \right)$$

$$Q = 411.81 kJ/kg$$

$$\eta = \frac{W_e}{q} = \frac{139.88}{411.81} = 0.34$$