Corrigé Type - Examen — 3CM
Transfert Thermique

Exercice 1. (06 Pts)

- Equation du Bilan.

$$m.C_p.\frac{dT}{dt} = -h.C_p.(T-T_F) \qquad (1)$$

$$\int_{T_0}^{T} \frac{1}{T-T_F}.dT = \int_{0}^{t} \frac{hS}{mC_p}.dt \qquad (1)$$

(1)

$$\ln\left(\frac{T_0-T_F}{T-T_F}\right) = \frac{1}{\tau}.t \quad , \quad \tau = \frac{mC_p}{hS} = \frac{\rho R C_p}{3h}$$

$$T(t) = T_F + (T_0 - T_F)\,Exp\left(-\frac{t}{\tau}\right) \qquad (1)$$

$T_F = 30°c$, $T_0 = 200°c$, $t = 2h = 7200s$

$$\tau = \frac{\rho.R.C_p}{3h} = \frac{7800.2.10^{-2}.450}{3.10} = 2340\ \frac{1}{s}$$

$$T(t) = 30 + (200-30).Exp\left(-\frac{7200}{2340}\right) \qquad (1)$$

$$= 30 + 7,84 = 37,84°c$$

- Température à $t = 7200s$.

$$T(t=7200) = 37,84°c. \qquad (1)$$

S. BOULAHROUZ

Exercice 2. (07) Conduction : $\phi = -\lambda\, 2\pi r L \frac{dT}{dr}$

- Tube :

$$\int_{R_1}^{R_2} \frac{\phi}{r}\, dr = -\int_{T_1}^{T_2} 2\pi L \lambda_a .\, dT$$

$$\frac{\phi}{2\pi L} = \lambda_a . \frac{T_1 - T_2}{\ln(R_2/R_1)} \quad \dots \quad (1) \qquad ①$$

- Isolant :

$$\int_{R_2}^{R_3} \frac{\phi}{r}.dr = -\int_{T_2}^{T_3} 2\pi L\, a\, T\, dT$$

$$\frac{\phi}{2\pi L} = \frac{a\,(T_2^2 - T_3^2)}{2\ln(R_3/R_2)} \quad \dots \quad (2) \qquad ①$$

(1) = (2) :

$$\frac{a}{2} . \frac{T_2^2 - T_3^2}{\ln(R_3/R_2)} = \frac{\lambda a (T_1 - T_2)}{\ln(R_2/R_1)} \qquad ①$$

$$\frac{a}{2} . \frac{1}{\ln\left(\frac{R_3}{R_2}\right)} . T_2^2 + \frac{2\lambda a}{\ln\left(\frac{R_2}{R_1}\right)} T_2 - 2\left[\frac{a T_3^2}{2\ln\left(\frac{R_3}{R_2}\right)} + \frac{\lambda a T_1}{\ln\left(\frac{R_2}{R_1}\right)}\right] = 0 \qquad ①$$

$a = 0.15$, $R_1 = 9$ cm, $R_2 = 11$ cm, $R_3 = 12$ cm, $\lambda = 1{,}52$, $L = 1$m

$T_1 = 85°c$, $T_3 = 20°c$

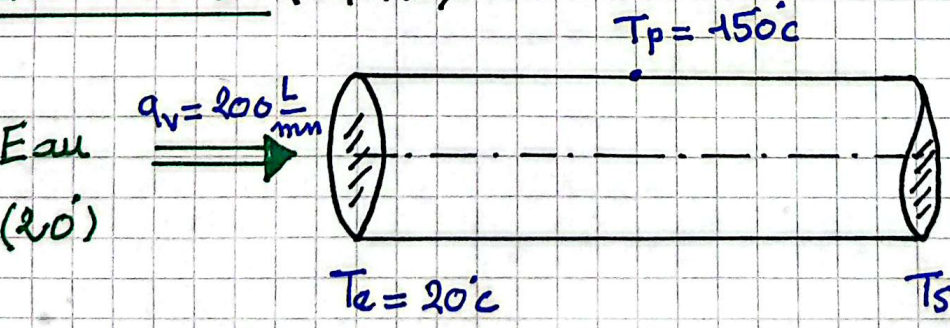
$T_2 = 64°c$. ②

- Le Flux thermique :

$$\phi = \frac{T_1 - T_2}{\frac{\ln(R_2/R_1)}{2\pi\lambda_a L}}$$

A.N. $\phi = 998{,}94$ ①

Exercice 3. (07 Pts)



$\phi = 5$cm

$L = 4{,}15$ m

1. Equation du bilan.

$$\rho . q_v . C_p . dT = h . \pi . D . dx . (T_p - T) \qquad ③$$

$$\frac{dT}{T_p - T} = \frac{h . \pi . D}{\rho . q_v . C_p} . dx .$$

$$\int_{T_E}^{T_S} \frac{dT}{T_p - T} = \int_0^L \frac{\pi h D}{\rho . q_v . C_p} . dx .$$

$$\ln\left[\frac{T_p - T_E}{T_p - T_S}\right] = \frac{h . \pi D}{\rho . q_v . C_p} . L \qquad (1)$$

2. Calcul de h.

- $Re = \frac{\rho . u . D}{\mu}$, $u = \frac{q_v}{S}$ (1)

$q_v = 200 \frac{l}{min} = 3{,}33 . 10^{-3} \frac{m^3}{s}$, $S = \frac{\pi D^2}{4}$

$u = \frac{4 . q_v}{\pi D^2} = 1{,}7 \frac{m}{s}$

$Re = 8{,}15 . 10^4 > 5000$, Ecoulement turbulent

- $Pr = \frac{\mu C_p}{\lambda} = 6{,}53$. (0,5)
- $Nu = 0{,}023 . Re^{0{,}8} . Pr^{0{,}4} = 428{,}15$ (0,5)
- $h = Nu . \lambda / D = 5480{,}32$. (1)

3. Température de l'eau à la sortie (T_S).

$$T_S = T_p - (T_p - T_E) . Exp\left[- \frac{h \pi D}{\rho q_v C_p} . L \right]$$

$T_S = 85°C$ (1)

4. Flux thermique. (ϕ)

$\phi = \rho . q_v . C_p . (T_S - T_E)$

$= 419 W$ (1)