Termodinamica - Formulario per trasmissione del calore

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Materiale fornito da:
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Formulario veloce

CONDUZIONE

$\dot{Q}_{12} = K A \frac{(T_1 - T_2)}{L}$ $\quad a = \frac{K}{\rho c}$

- Lastra piana $T(x) = \frac{T_2 - T_1}{L} x + T_1$ $\quad \dot{Q} = K(T_1 - T_2)$ $\quad K = \frac{1}{R} = \frac{KA}{L}$

- Cilindro $\dot{Q} = K \Delta T$ $\quad K = \frac{1}{R} = \frac{2\pi K \ell}{\log(r_2/r_1)}$ $\quad \boxed{\dot{Q} = UA \Delta T \quad UA = \frac{1}{\sum_i R_i}}$

- Transitorio $Bi = \frac{h_c L_c}{K} \rightarrow Bi \le 0{,}1$ $\quad \frac{T - T_\infty}{T_i - T_\infty} = e^{-\frac{t}{\tau}}$ $\quad \tau = \frac{\rho c V}{\bar{h}_c A}$

IRRAGGIAMENTO

$A_1 = A_2$

NERA/NERA	NERA/GRIGIA	GRIGIA/GRIGIA
$A \sigma (T_1^4 - T_2^4)$	$A \sigma \varepsilon_2 (T_1^4 - T_2^4)$	$\frac{\sigma_0 A (T_1^4 - T_2^4)}{\frac{1}{\varepsilon_1} + \frac{1}{\varepsilon_2} - 1}$

sup. parallele

$A_1 \neq A_2$ $\quad \frac{\sigma (T_1^4 - T_2^4)}{\frac{1-\varepsilon_1}{\varepsilon_1 A_1} + \frac{1}{A_1 F_{12}} + \frac{1-\varepsilon_2}{\varepsilon_2 A_2}}$ sia sup. parallele che inclinate

- $A_i F_{ij} = A_j F_{ji}$
- $\sum_j F_{ij} = 1$
- $F_{ij} = F_{iu} + F_{iw}$

CONVEZIONE $\quad \dot{Q}_c = \bar{h}_c A (T_p - T_\infty)$

- Forzata $Re = \frac{v_\infty L}{\nu}$ $\quad Pr = \frac{\mu c}{K} = \frac{\nu}{a}$ $\quad \bar{N}u = f(Re, Pr) \rightarrow \frac{\bar{h}_c L}{K} = \bar{N}u$

  $T_{rif} = T_\infty$

  → Flussi esterni $Re_c = 3{,}5 \cdot 10^5$

  → Flussi interni $Re_c = 2300$

- Naturale $Gr = \frac{g \beta \Delta T L^3}{\nu^2}$ $\quad Pr =$ Come prima $\quad \bar{N}u = f(Gr, Pr) = f(Ra) \rightarrow \frac{\bar{h}_c L}{K} = \bar{N}u$

  $Ra = Gr \cdot Pr$ $\quad Ra_c = 10^9$

  $T_{rif} = \frac{T_p + T_\infty}{2}$

TABELLINE $\times\ \bar{h}_c$

Naturale

$T_{rif} \rightarrow Pr \rightarrow L_c \rightarrow Gr \rightarrow K \rightarrow Ra \rightarrow Nu \rightarrow h_c$

Forzata

$T_{rif} \rightarrow Pr \rightarrow L_c \rightarrow Re \rightarrow K \rightarrow Nu \rightarrow h_c$

TRASMISSIONE CALORE

CONDUZIONE

- Fourier
$$\begin{cases} \dot{Q} = KA\,\dfrac{T_1 - T_2}{L} \\ \dot{q} = \dfrac{\dot{Q}}{A} = -K\,\dfrac{\partial T}{\partial n}\,\hat{n} \end{cases} \longrightarrow \text{in 3D} \quad \dot{q} = -K\,\nabla T$$

- Eq. fondamentale
$$\frac{\dot{u}'''}{K} + \nabla^2 T = \frac{1}{a}\frac{\partial T}{\partial t} \qquad \frac{1}{a} = \frac{\rho c}{K} \quad a = \text{diffusività termica}$$

Equazione diff. con transitorio

1) Cond. al contorno

A) I tipo $T(P,t) = T_0$

B) II tipo $\dfrac{\partial T}{\partial x} = f(x,t)$

C) III tipo Bilancio di flusso

Tipi di casi:

1) regime stazionario $\dfrac{\partial T}{\partial t} = 0$ $\quad \dfrac{\dot{u}'''}{K} + \nabla^2 T = 0$ (POISSON)

2) regime stazionario senza generazione $\dfrac{\partial T}{\partial t} = 0$ $\quad \dot{u}''' = 0$ $\quad \nabla^2 T = 0$ (LAPLACE)

3) flusso monodimensionale $\quad \dfrac{d^2 T}{dx^2} + \dfrac{\dot{u}'''}{K} = \dfrac{1}{a}\dfrac{\partial T}{\partial t}$

[x coordinate cilindriche:
$$\frac{d^2T}{dx^2} \longrightarrow \frac{1}{r}\frac{\partial}{\partial r}\left(r\,\frac{\partial T}{\partial r}\right)$$
]

- Lastra piana

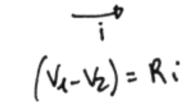
$$T(x) = \frac{T_2 - T_1}{L}\,x + T_1 \qquad \dot{Q} = K(T_1 - T_2) \qquad K = \frac{1}{R} = \frac{KA}{L}$$

K conduttanza

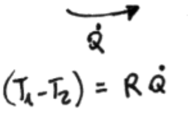
R resistenza

[Campo di tipo lineare]

Analogia OHM



$(V_1 - V_2) = R\,i$



$(T_1 - T_2) = R\,\dot{Q}$

Valgono tutte le regole x collegamenti in serie e parallelo

- Legge generalizzata

$$\dot{Q} = UA\,\Delta T$$

$\to UA =$ conduttanza globale $= \dfrac{1}{\sum_i R_i}$

$\to U =$ conduttanza unitaria $= \dfrac{1}{A \sum_i R_i}$

- Cilindro

$$\frac{dT}{dr} = -\frac{1}{r}\,\frac{T_1 - T_2}{\log(r_2/r_1)}$$

$$\dot{Q} = 2\pi k \ell \,\frac{T_1 - T_2}{\log(r_2/r_1)}$$

$$T(r) = T_1 - \frac{T_1 - T_2}{\log(r_2/r_1)} \log \frac{r}{r_1}$$

[Campo di tipo logaritmico]

$$\dot{Q} = K\,\Delta T \qquad K = \frac{2\pi k \ell}{\log(r_2/r_1)}$$

$$R = \frac{\log(r_2/r_1)}{2\pi k \ell}$$

- Problema transitorio

$$Bi = \frac{R_{int}}{R_{est}} = \frac{h_c L_c}{K}$$

$L_c =$ lunghezza caratt. — r cilindro — s lastra

$\to$ se $Bi \leq 0{,}1$

$$\frac{T - T_\infty}{T_i - T_\infty} = e^{-\frac{t}{\tau}} \qquad \tau = \frac{\rho c V}{h_c A}$$

Formule irraggiamento

$J = E + \rho G$

$G = \rho G + \alpha G + \tau G$ $\quad \alpha + \rho + \tau = 1$

- → Corpo nero $\alpha = 1$ $\rho = 0$ $\tau = 0$
- → corpo grigio $\tau = 0$ $\alpha + \rho = 1$
- → corpo trasparente $\tau = 1$ $\alpha = \rho = 0$

Corpo nero

1) $E_n = \sigma T^4$

2) $E_{n\lambda} = \dfrac{c_1}{\lambda^5 \left(e^{c_2/\lambda T} - 1\right)}$

3) $\lambda_{max}(T) \cdot T = 2898\ \mu m \cdot K$

$\varepsilon = \dfrac{E}{E_n} \rightarrow E = \varepsilon E_n$

$\alpha = \dfrac{G}{G_n} \rightarrow G = \alpha G_n$

$\alpha_\lambda = \varepsilon_\lambda$

$\sigma = 5{,}67 \cdot 10^{-8}\ \dfrac{W}{m^2 K^4}$

$c_1 =$

Def. corpo nero $\alpha = 1$

Def. corpo grigio $\dfrac{\partial \varepsilon_\lambda}{\partial \lambda} = 0$ $\quad \varepsilon_\lambda = \varepsilon$

Lo x corpo grigio $\alpha = \alpha_\lambda \rightarrow \alpha = \varepsilon$

Potenze termiche

	$A_1 = A_2$	$A_1 \neq A_2$
NERA / NERA	$A\sigma\left(T_1^4 - T_2^4\right)$	/
NERA / (2) GRIGIA	$A\sigma\varepsilon_2\left(T_1^4 - T_2^4\right)$	/
GRIGIA / GRIGIA	$\dfrac{\sigma_0 A\left(T_1^4 - T_2^4\right)}{\dfrac{1}{\varepsilon_1} + \dfrac{1}{\varepsilon_2} - 1}$	$\dfrac{\sigma\left(T_1^4 - T_2^4\right)}{\dfrac{1-\varepsilon_1}{\varepsilon_1 A_1} + \dfrac{1}{A_1 F_{12}} + \dfrac{1-\varepsilon_2}{A_2 \varepsilon_2}}$ $[F_{12} = 1]$

Sup. X (inclinate)

$A_1 \neq A_2$

$$\dot{Q} = \frac{\sigma\left(T_1^4 - T_2^4\right)}{\dfrac{1-\varepsilon_1}{\varepsilon_1 A_1} + \dfrac{1}{A_1 F_{12}} + \dfrac{1-\varepsilon_2}{\varepsilon_2 A_2}}$$

$$F_{ij} = \frac{\text{En. di } i \text{ che arriva a } j}{\text{En. tot. di } i}$$

- $A_i F_{ij} = A_j F_{ji}$
- $\sum_j F_{ij} = 1$
- $F_{ij} = F_{in} + F_{im}$