Esercizi - Conduzione

Tuesday, 11 January 2022 11:25

ES 1

FORNO INDUSTRIALE $S = 15\,m^2$

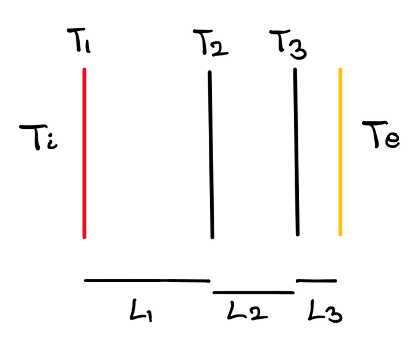
3 STRATI

$T_i = 900°C$ $T_e = 20°C$

$L_1 = 0,6\,m$ $K_1 = 3\,W/mK$ MATTONI

$L_2 = 0,3\,m$ $K_2 = 0.1\,W/mK$ ISOLANTE

$L_3 = 0.02\,m$ $K_3 = 20\,W/mK$ ACCIAIO



PARETE IN CONDIZIONE STAZIONARIA

SCAMBIO CONVETTIVO $h_1 = h_3 = 10\,W/m^2K$

$R_{TOT}, \dot{Q}, T(x), T_{MAX,2}$?

ANALOGIA ELETTRICA

$R_{COND\,i} = R_i = \frac{1}{h_i S} = 0.0067\,K/W$

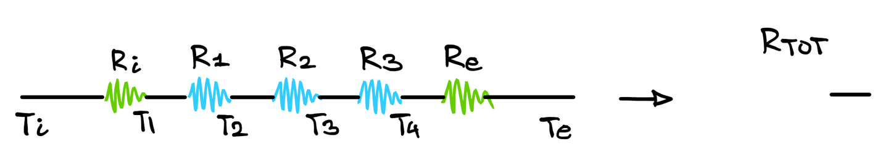
$R_{COND\,e} = R_e = \frac{1}{h_e S} = 0.0067\,K/W$

$R_{COND\,1} = R_1 = \frac{L_1}{K_1 S} = 0.0133\,K/W$

$R_{COND\,2} = R_2 = \frac{L_2}{K_2 S} = 0.2\,K/W$

$R_{COND\,3} = R_3 = \frac{L_3}{K_3 S} = 6.67 \cdot 10^{-7}\,K/W$

RESISTENZA TERMICA COMPLESSIVA



$R_{TOT} = \sum_K R_K = R_i + \dots + R_e = 0.\ \ 8\,K/W$

POTENZA TERMICA TRASMESSA

$$\dot{Q} = \frac{(T_i - T_1)}{R_i} = \frac{(T_1 - T_2)}{R_1} = \frac{(T_2 - T_3)}{R_2} = \frac{(T_3 - T_e)}{R_3}$$ LOCALMENTE

$$\dot{Q} = \frac{\Delta T_{TOT}}{R_{TOT}} = \frac{(T_i - T_e)}{\sum R_K} = 3880\,W$$

DISTRIBUZIONE DELLA TEMPERATURA

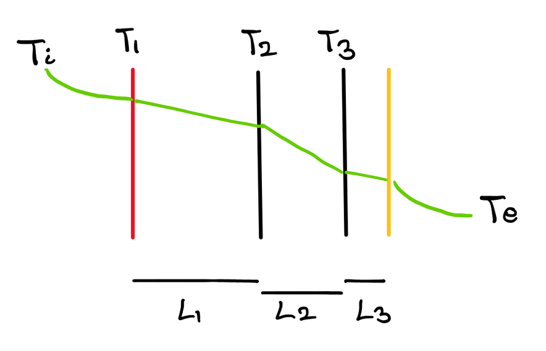
$$\frac{\partial}{\partial x}\left(K \frac{\partial T}{\partial x}\right) + \frac{\partial}{\partial y}\left(K \frac{\partial T}{\partial y}\right) + \frac{\partial}{\partial z}\left(K \frac{\partial T}{\partial z}\right) + \dot{Q}_{GEN} = \rho c \frac{\partial T}{\partial t}$$

IPOTESI

- MONODIMENSIONALITÀ $T(x,y,z,t) = T(x,t)$
- STAZIONARIETÀ $T(x,t) = T(x)$ $\rightarrow \frac{\partial T}{\partial t} = 0$
- NO GENERAZIONE $\dot{Q}_{GEN} = 0$

$\frac{\partial}{\partial x}\left(K \frac{dT}{dx}\right) = 0 \longrightarrow K \frac{dT}{dx} = C_1$

$dT = \frac{C_1}{K} dx$ $T(x) = \frac{C_1}{K} x + C_2$



CONDIZIONI AL CONTORNO

$T(x=0) = T_a$

$T(x=L) = T_b$ $\rightarrow$ $T(x) = \frac{T_b - T_a}{L} x + T_a$

TEMPERATURA DELLE PARETI

$T_1 = T_i - R_i \dot{Q}$

$T_2 = T_1 - R_1 \dot{Q} = T_i - (R_i + R_1)\dot{Q}$

$T_3 = T_2 - R_2 \dot{Q} = T_1 - (R_1 + R_2)\dot{Q} = T_i - (R_i + R_1 + R_2)\dot{Q}$

$T_4 = \dots = T_i - (R_i + R_1 + R_2 + R_3)\dot{Q}$

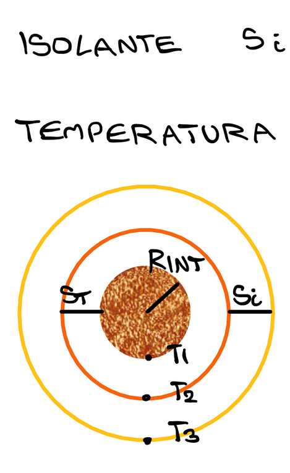
$T_e = T_i - R_{TOT}\dot{Q} \leftrightarrows T_i = T_E + R_{TOT}\dot{Q}$

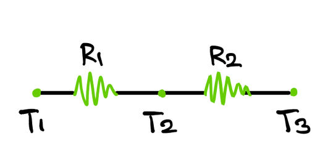
ES 2

TUBO $L = 1\,m$ $r_{INT} = 8\,mm$ $S_T = 2\,mm$ $K_T = 29\,W/mK$

ISOLANTE $S_i = 10\,mm$ $K_i = 0.116\,W/mK$

TEMPERATURA COSTANTE $T_1 = 80°C$ $T_2 = 10°C$





ANALOGIA ELETTRICA

$$R_{COND\ CILINDRICA} = \frac{\log(r_E/r_I)}{2\pi K L}$$

$$R_{COND,T} = \frac{\log\left(\frac{r_{INT} + S_T}{r_{INT}}\right)}{2\pi K_T L} = R_1$$

$$R_{COND,ISO} = \frac{\log\left(\frac{r_{INT} + S_T + S_i}{r_{INT} + S_T}\right)}{2\pi K_i L} = R_2$$

$R_{TOT} = \sum R_i = R_1 + R_2 = 0.9552\,\frac{K}{W}$

CALORE IN TRANSITO

$\dot{Q} = \frac{\Delta T}{R_{TOT}} = \frac{T_1 - T_3}{R_{TOT}} = 73.5\,W$

$T_2 = T_1 - R_t \dot{Q} = T_3 + R_{ISO}\dot{Q} = 79.9°C$

ES 3

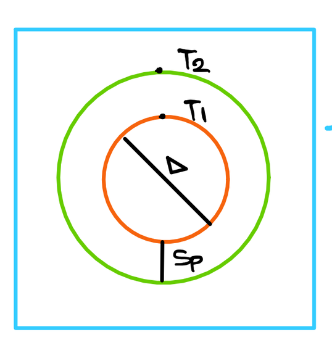
CONDUTTORE ELETTRICO $L = 5\,m$ $D = 3\,mm$ $K_c = 390\,W/mK$

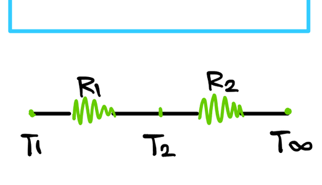
PLASTICA $S_P = 2\,mm$ $K_P = 0.15\,W/mK$

POTENZA DISSIPATA $Q = 400\,W/m^2$

ARIA $T_\infty = 30°C$ $h = 12\,W/m^2K$

T_1, T_2 IN CONDIZIONI STAZIONARIE





CALORE DISSIPATO

$\dot{Q} = Q_{DISS} \cdot 2\pi \frac{D}{2} L = 18.85\,W$

ANALOGIA ELETTRICA

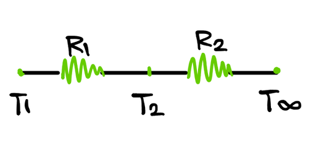
$$R_1 = R_{COND\ CILINDRICA} = \frac{\log\left(\frac{R + S_P}{R}\right)}{2\pi K_{ISO} L} = 0.1798\,K/W$$

$$R_2 = R_{CONVEZIONE} = \frac{1}{Sh} = \frac{1}{h\, 2\pi\, r_{EST}\, L} = 0.7578\,K/W$$

CON $r_{EST} = \frac{D}{2} + S_P$

$R_{TOT} = \sum R_i = R_1 + R_2 = 0.9377\,K$

TEMPERATURE SUPERFICIALI



$T_1 = T_\infty + R_{TOT}\dot{Q} = 47.67°C$

$T_2 = T_\infty + R_2 \dot{Q} = 44.28°C$

TEMPERATURA MAX ALL' INTERNO DEL CONDUTTORE

$$\frac{1}{R}\frac{\partial}{\partial R}\left(KR \frac{\partial T}{\partial x}\right) + \frac{1}{R^2}\frac{\partial}{\partial \varphi}\left(K \frac{\partial T}{\partial \varphi}\right) + \frac{\partial}{\partial z}\left(K \frac{\partial T}{\partial z}\right) + \dot{q} = \rho c \frac{\partial T}{\partial t}$$

MONODIMENSIONALE NO ACCUMULO REGIME STAZIONARIO

$\frac{1}{R}\frac{d}{dR}\left(KR \frac{dT}{dR}\right) = -\dot{q}$ GENERAZIONE INTERNA

DOVE $\dot{q} = \frac{\dot{Q}}{V} = \frac{\dot{Q}}{\pi r^2 L} = 533346\,W/m^3$

$\int \frac{d}{dR}\left(KR \frac{dT}{dR}\right) = \int -\dot{q}R$

$KR \frac{dT}{dR} = -\frac{\dot{Q}R^2}{2} + C_1$ $dT = \left(-\frac{\dot{Q}R}{2K} + \frac{C_1}{KR}\right) dR$

$$T(R) = -\frac{\dot{Q}R^2}{4K} + C_1' \ln R + C_2$$

CONDIZIONI AL CONTORNO

$r = 0 \rightarrow T(R) = +\infty$ IMPOSSIBILE QUINDI $C_1' = 0$

$T(r = r_c) = T_1 \rightarrow C_2 = T_1 + \frac{\dot{Q} r_c^2}{4K}$

$$T(R) = T_1 + \frac{Q r_c}{4K} - \frac{Q R^2}{4K}$$

TEMPERATURA MAX

PER SIMMETRIA E' IL CENTRO

$T(0) = T_1 + \frac{Q r_c}{4K} = 47.68°C \sim T_1$

ES 4

CORRENTE $H_2O_{(l)}$ $30°C$ $h = 1000\,W/m^2K$

SFERA BRONZO $D = 5\,mm$ $T = 200°C$

$\rho = 8800\,kg/m^3$ $K = 52\,W/mK$ $c = 420\,J/kgK$

TEMPERATURA DELLA SFERA DOPO $t = 15\,s$

APPROCCIO A PARAMETRI CONCENTRATI

$L_c = \frac{V}{A_{SCAMBIO}} = \frac{4}{3}\pi R^3 \frac{1}{4\pi R^2} = \frac{R}{3}$ LUNGHEZZA CARATTERISTICA

$Bi = \frac{hL_c}{K} = 0.016 < 0.1$ OK

IL NUMERO DI BIOT E' INFERIORE ALLA SOGLIA ACCETTATA
LA TEMPERATURA E' UNIFORME LUNGO IL CORPO $\forall$ ISTANTE t

$T(x,y,z,t) = T(r,t) = T(t)$

CONSERVAZIONE ENERGIA

$Q_{IN} + Q_{GEN} - Q_{OUT} = Q_{ACC}$

$-h A_{SCAMBIO}(T(t) - T_\infty) = \rho_B c_B \frac{dT}{dt}$

SOSTITUISCO $T(t) - T_\infty = \theta$

$t = -\frac{\rho c V}{hA} \ln\left(\frac{T(t) - T_\infty}{T_i - T_\infty}\right)$

$\frac{T(t) - T_\infty}{T_i - T_\infty} = e^{\left(-\frac{hA}{\rho c V} \cdot t\right)}$

$T(t) = T_\infty + (T_i - \infty)\, e^{(\dots)} = 31.3°C$ PER $t = 15\,s$

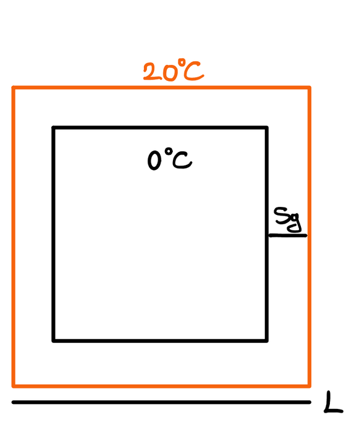
ES 5

GHIACCIO $T_{INT} = 0°C$ $T_{EST} = 20°C$

CAVITA' CUBICA $L = 0.2\,m$ $S_g = 1\,mm$ $K_g = 0.05\,W/mK$

$\rho_g = 920\,kg/m^3$ $\lambda_g = 334\,kJ/kg$

TEMPO SCIOGLIMENTO GHIACCIO



CALORE PER SCIOGLIERE IL GHIACCIO

$Q_g = m\lambda = \rho V \lambda = \rho(L - 2s)^3 \lambda = 2385\,J$

RESISTENZA TERMICA

$R_{TOT} = R_1 = \frac{s}{KA} = \frac{s}{K 6 L^2} = 0.083\,K/W$

POTENZA TERMICA SCAMBIATA

$\dot{Q} = \frac{\Delta T}{R_{TOT}} = \frac{T_{EST} - T_{INT}}{R_{TOT}} = 240\,W$

TEMPO NECESSARIO

$t = Q_g / \dot{Q} = 9937\,s$

ES 6

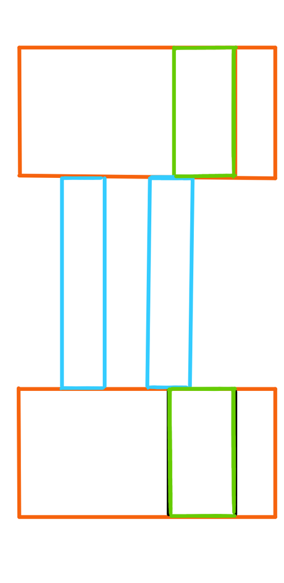
LOCALE QUADRATO $S_F = 1.6\,m^2$ (FINESTRA) $S_M = 39\,m^2$ (MURATURA)

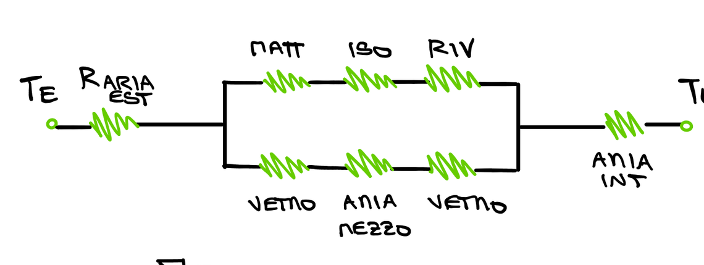
$T_{IN} = 20°C$ $T_E = -5°C$

MURATURA (3 STRATI)

CASO 1 - DOPPI VETRI SU UNICO TELAIO
$S_{VETRO} = 5\,mm$ $\Delta x = 1\,cm$ ARIA FERMA

CASO 2 - DOPPIA FINESTRA
$S_{VETRO} = 5\,mm$ $\Delta x = 20\,cm$ ARIA IN MOTO





$R_{SERIE} = \sum R_i$

$R_{PARALLELO} = \sum \frac{1}{R_i}$