POLITECNICO
MILANO 1863

DIPARTIMENTO DI
ENERGIA

TRACCIA 1

1) Descrivere anche per punti le operazioni di taratura di una catena termometrica, indicando quali sono le principali fonti d'incertezza.

2) Scrivere il bilancio energetico per unità di tempo ed in condizioni stazionarie per un radiatore alimentato ad acqua calda.

POLITECNICO
MILANO 1863

DIPARTIMENTO DI
ENERGIA

TRACCIA 2

1) Descrivere anche per punti le operazioni di taratura di una termoresistenza, indicando quali sono le principali fonti d'incertezza.

2) Scrivere il bilancio di potenze ed in condizioni stazionarie per un radiatore alimentato ad acqua calda.

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DIPARTIMENTO DI
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TRACCIA 3

1)Descrivere anche per punti le operazioni di taratura di una termocoppia a metallo nobile, indicando quali sono le principali fonti d'incertezza.

2)Scrivere il bilancio energetico in condizioni stazionarie per un radiatore alimentato ad acqua calda.

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DIPARTIMENTO DI
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TRACCIA 1

1) Leggere e tradurre il seguente testo:

Gas temperature measurement in WTE boilers

Temperature measurement of combustion gas at different locations within the boiler is important to both the boiler design and the operating plant engineers. Accurate gas temperature measurements can confirm design predictions and operating performance, allows working order in ideal temperature ranges, maximum plant energy efficiency, and increases the lifespan of both the materials and the components.

Bare thermocouples and radiation pyrometers are generally used in nearly all WTE plants. It is however the commonplace experience of plant operating engineers that temperature measurements given by these instruments differ from the real gas temperature, even by a number of degrees.

Whatever instrument is used for temperature readings, the temperature sensitive element of an industrial thermometer will stabilize at a level which balances the heat flow by convection between the element and the gas, against the heat flow by radiation and conduction. The element temperature can be determined by the simultaneous solution of three heat flow rates; the energetic balance per unit of time t of the thermal element is therefore:

$$\frac{\partial U}{\partial t} = M \cdot c_v \frac{\partial T}{\partial t} = \rho \cdot V \cdot c_v \frac{\partial T}{\partial t} = \dot{Q}_{cv} - \dot{Q}_{rad} - \dot{Q}_{cd} \qquad (1)$$

Where U, c_v, ρ and V are respectively the internal energy, the specific heat, the density and the volume of the thermal element.

During transients, the element will lag behind any change in gas temperature, due to its thermal capacity, resulting in a response-rate error.

2) A cosa serve la libreria di *"Python"* denominata *"Numpy"*?

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TRACCIA 2

1) Leggere e tradurre il seguente testo:

Errors using a bare thermocouple

For the hot junction of a thermocouple, the equations for radiant, conductive, convective heat transfer and for response rate are well known.

In WTE applications thermocouples are inserted inside a volume where the hot flue-gas is surrounded by cold membrane walls, this is particularly true in the radiant zone of the boiler where the heat flux exchanged by radiation is dominant.

Any difference between thermocouple junction temperature T_{tc} and gas stream total temperature T_g is considered to be an error E. The following errors are evaluated considering a steady state condition, so that equation (1) reduces to:

$$\dot{Q}_{cv} = \dot{Q}_{rad} - \dot{Q}_{cd} \tag{2}$$

Radiation-convection error

This error $E_{cv\text{-}rd}$ can be calculated neglecting the heat flux by conduction and considering both the convection and radiation equations (6) and (7):

$$\dot{Q}_{cv} = A_{cv} h_{cv} (T_g - T_{tc}) \tag{6}$$

$$\dot{Q}_{rd} = A_{rd} F_{tc-wall} \sigma \varepsilon (T_{tc}^4 - T_{wall}^4) \tag{7}$$

The radiation – convection error is therefore:

$$E_{cv-rd} = (T_g - T_{tc}) = \frac{A_{rd} F_{tc-wall} \sigma \varepsilon (T_{tc}^4 - T_{wall}^4)}{A_{cv} h_{cv}} \tag{8}$$

This error for a thermocouple inside an enclosure can be expressed as a simplified form of equation (8), if the enclosure is greater compared to the thermocouple diameter, as it is in the WTE applications. In our particular case the radiation view factor $F_{tc\text{-}wall}$ equals 1 and the area available for radiation A_{rd} can be considered equal to the area available for convection A_{cv}; the expression of $E_{cv\text{-}rd}$ can be therefore written as:

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$$E_{cv-rd} = (T_g - T_{tc}) = \frac{\sigma\varepsilon(T_{tc}^4 - T_{wall}^4)}{h_{cv}} \quad (9)$$

To reduce this error, thermocouple emissivity must be maintained as low as possible while h_{cv} must be as high as possible.

Polished metal surfaces have a low emissivity [19] ($\varepsilon \leq 0,2$) at temperatures below 250°C but emissivity increases rapidly with temperature as well as by oxidation or deposition on the surface. In some case emissivity of thermocouple can easily and quickly reach 0.8.

2) A quale categoria di linguaggio di programmazione appartiene "*Python*"?.