Heat transfer
Convection

I. Forced convection-continued

1. Correlations for flows around a cylinder

We choose the simplest correlation: $2\ 10^4 < Re < 4\ 10^5$ et $Pr > 0.2$:

$$Nu_D = 0{,}3 + \frac{0{,}62 Re_D^{0{,}5}\ Pr^{0{,}33}}{\left[1+\left(\frac{0{,}4}{Pr}\right)^{0{,}67}\right]^{0{,}25}} \left[1 + \left(\frac{Re_D}{282000}\right)^{0{,}5}\right] \qquad (1)$$

- **Case of liquid metals**

$$Nu_D = \left[0{,}8237 - ln\left(Pe_D^{0{,}5}\right)\right]^{-1} \qquad (2)$$

2. Correlations for flows around a sphere

$0.71 < Pr < 380$ and $3.5 < Re < 7.6\ 10^4$, The following correlation is applicable:

$$Nu_D = 2 + (0{,}4 Re^{0{,}5} + 0{,}06 Re^{0{,}67}) Pr^{0{,}4} \left(\frac{\mu}{\mu_\infty}\right)^{0{,}25} \qquad (3)$$

3. Correlations for internal flows in tubes

a) Laminar regime

The laminar regime in the tubes is determined by $Re < 2300$.

In the case of circular tubes with uniform surface in laminar regime at constant flow, the Nusselt number is constant:

$Nu_D = 4.36$.

In the case of circular tubes with constant surface temperature, the Nusselt number is also constant:

$Nu_D = 3.66$.

b) Turbulent regime

The most used correlation for smooth tubes is the following:

$Nu = 0.023Re0.8Pr^n$ (4)

With: n = 0.3 for cooling and n = 0.4 for heating.

II.Correlations for natural convection

In natural convection, we use the numbers of Pr and Gr therefore (Ra = Pr x Gr) .

All correlations have the following form:

$$Nu = C\ (Gr\ x Pr)^n = Cx\ Ra^n \qquad (5)$$

C and n depend on the geometry of the surfaces.

1.Vertical plates

$$\overline{Nu_L} = 0,59 \times Ra_L^{0,25} \qquad 10^4 \leq Ra_L \leq 10^9 \qquad (6)$$

$$\overline{Nu_L} = 0,10 \times Ra_L^{0,33} \qquad 10^9 \leq Ra_L \leq 10^{13} \qquad (7)$$

A more general correlation can also be applied in all these cases regardless of the Raleigh number:

$$\overline{Nu}_L = \left\{ 0,825 + \frac{0,387\, Ra_L^{0,16}}{\left[1 + (0,492/\mathrm{Pr})^{0,56}\right]^{0,3}} \right\}^2 \qquad (8)$$