Nusselt number = Nu

@wikipedia

Dimensionless quantity characterising the ratio of thermal convection to thermal conduction in fluids across (normal to) the boundary with solids:

(1) $$\mathrm{Nu} = \frac{\text{Convective heat transfer}}{\text{Conductive heat transfer}} = \frac{U}{\lambda/L} = \frac{U \cdot L}{\lambda}$$

where U is the convective heat transfer coefficient of the flow, L is the characteristic length, λ is the thermal conductivity of the fluid.

Stagnant Fluid

For Stagnant Fluid the Nusselt number is a constant number (OEIS sequence A282581):

(2) $$\mathrm{Nu} = 3.6568$$

Natural Convection

In Natural Fluid Convection becomes dependant on Rayleigh number Ra and Prandtl number Pr: $\mathrm{Nu} = f(\mathrm{Ra}, \mathrm{Pr})$:

(3) $\mathrm{Nu}_D = \left[0.825 + \frac{0.387\,\mathrm{Ra}_D^{1/6}}{\left[1 + (0.492/\mathrm{Pr})^{9/16}\right]^{8/27}} \right]^2$	Churchill and Chu Unknown macro: 'single-cite'	All convection regimes in pipelines $\mathrm{Ra}_D \le 10^{12}$
(4) $\mathrm{Nu}_L = 0.68 + \frac{0.663\,\mathrm{Ra}^{1/4}}{\left[1 + (0.492/\mathrm{Pr})^{9/16}\right]^{4/9}}$	Churchill and Chu Unknown macro: 'single-cite'	Laminar convection $\mathrm{Ra} \le 10^9$

In case of natural convection in the annulus the Nusselt number becomes also dependant on the annulus geometry:

(5) $$\mathrm{Nu}_{ann} = \frac{2 \cdot \epsilon(\mathrm{Ra})}{\ln(r_{out}/r_{in})}$$

where

$\epsilon(\mathrm{Ra})$	Natural Convection Heat Transfer Multiplier
Ra	Rayleigh number
r_{out}	inner radius of outer pipe

r_{in}	outer radius of inner pipe

Forced Convection

In Forced Fluid Convection the Nusselt number becomes dependant on Reynolds number Re and Prandtl number Pr: $\mathrm{Nu} = f(\mathrm{Re}, \mathrm{Pr})$.

(6) $\mathrm{Nu} = 3.66 + \dfrac{0.065 \cdot \mathrm{Re} \cdot \mathrm{Pr} \cdot D/L}{1 + 0.04 \cdot (\mathrm{Re} \cdot \mathrm{Pr} \cdot D/L)^{2/3}}$	Mills Unknown macro: 'single-cite'	Laminar flow in pipeline with diameter D and length L.
(7) $\mathrm{Nu} = 0.023 \cdot \mathrm{Re}_D^{3/4} \cdot \mathrm{Pr}^{0.4}$	Dittus-Boelter Unknown macro: 'single-cite'	Turbulent flow in pipeline $\mathrm{Re} \geq 10,000$
(8) $\mathrm{Nu} = \dfrac{(f/8)\,(\mathrm{Re} - 1000)\mathrm{Pr}}{1 + 12.7\,(f/8)^{1/2}\,(\mathrm{Pr}^{2/3} - 1)}$	Gnielinski Unknown macro: 'single-cite'	Transitional flow and turbulent flow in rough pipeline $3000 \leq \mathrm{Re} \leq 5 \cdot 10^6$ $0.5 \leq \mathrm{Pr} \leq 2000$ f is Darcy friction factor
(9) $\mathrm{Nu} = 0.3 + \dfrac{0.62\,\mathrm{Re}^{1/2}\,\mathrm{Pr}^{1/3}}{\left[1 + (0.4/\mathrm{Pr})^{2/3}\right]^{1/4}} \left[1 + \left(\dfrac{\mathrm{Re}}{282000}\right)^{5/8}\right]^{4/5}$	Churchill–Bernstein Unknown macro: 'single-cite'	All flow regimes in pipelines $\mathrm{Re} \cdot \mathrm{Pr} \geq 0.2$ Accuracy $\sim 20\%$

Relation to Biot Number

Both numbers naturally arise in modelling the heat exchange between solid body and fluid.

Both numbers have similar definition except that Nusselt number is based on thermal conductivity of the fluid while Biot Number is based on thermal conductivity of the solid body.

Normally Nusselt number indicates whether conductive or convective heat transfer dominates across the interface between solid body and fluid.

While Biot Number indicates whether significant thermal gradient will develop inside a solid body based on the ratio of heat transfer away from the surface of a solid body to heat transfer within the solid body.

See also

Physics / Thermodynamics / Heat Transfer

[Heat Transfer Coefficient (HTC)] [Heat Transfer Coefficient @model]

[Dimensionless Heat Transfer Numbers]

[Prandtl number] [Rayleigh number] [Reynolds number] [Biot Number]

References

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