Study notes and solutions

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1 Dimensionless numbers

Knudsen : Particles mean free path over system characteristic dimension. Division between rarified gas (Boltzmann) and continuum mechanics (Navier-Stokes).

Prandtl : Ratio of momentum diffusivity to thermal diffusivity $\mathrm{Pr} = \nu/\alpha$. High Pr indicates that momentum transfer is more effective than heat transfer (oils), while low values (liquid metals) indicate thermal boundary layer is more important than viscous one.

Nusselt : Ratio of convective to conductive heat transfer at a boundary in a fluid, defined as $\mathrm{Nu} = hL/k$. Often in buoyancy-driven flow analysis it is correlated as $\mathrm{Nu} = a\mathrm{Ra}^b$. A Nusselt number of value one represents heat transfer by pure conduction. Increasing this number implies a laminar conductive-dominant flow and then a convective dominant turbulent flow.

Grashof : Ratio of buoyancy to viscous forces defined as $\mathrm{Gr} = g\beta(T_s - T_\infty)L^3/\nu^2$ and is analogous to Reynolds number in natural convection. Increasing the value of this number above a given threshold promotes buoyancy driven flow.

Rayleigh : Product of Grashof Gr and Prandtl Pr numbers. Related to the transition from laminar to turbulent in buoyancy-driven flows. Laminar to turbulent is assumed to take place at 10^9 (**?**).

References

C. Balaji. *Essentials of radiation heat transfer*. Wiley, Chichester, 2014. ISBN 978-1-118-90831-0.