MEAN TEMPERATURE PROFILE PREDICTIONS AT LOW RE TURBULENT FLOWS

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Turbulent flow quantities, occurring at low and intermediate Reynolds numbers, have been conventionally scaled with viscous wall parameters. Results from direct numerical simulations have shown that scaling with wall parameters does not give a universal behavior for the fluctuating thermal field. Churchill and coworkers have recently suggested another theory for turbulent convection [1-4]. According to this theory, fully developed flow and convection can be expressed as local fractions of the shear stress and the heat flux density due to turbulent fluctuations; and the fully developed temperature can be predicted if the velocity field and the turbulent Prandtl number are known. However, comparisons of the model to either simulation results or experimental measurements for a truly extensive range of data have not been reported.

The present work explores the Churchill turbulent heat flux correlation for an extensive range of fluids, from *Pr* 0.1 to 50000, in Poiseuille channel flow (pressure driven flow) and in Couette flow (shear flow). Heat transfer in Poiseuille channel flow and in plane Couette flow has been studied using Direct Numerical Simulation (DNS) in conjunction with the Lagrangian Scalar Tracking (LST) method. Results by the DNS/LST method have previously shown very good agreement with experimental results. Mean temperature profiles, heat transfer coefficients and other turbulent quantities found by this method have been validated and reported [5, 6]. Application of the heat flux correlation for an extensive range of fluids and for different turbulence structures and comparison to the Lagrangian simulation results shows a deviation of less than 10% for most *Pr*, even though the model equations were developed for flows with higher Reynolds numbers than those employed by DNS. A correction factor can further be introduced for very high *Pr* fluids, which can provide model predictions that are within 1% of the simulation results.

References

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Keywords: Prandtl, turbulence, Lagrangian