Fluctuating fluid flow and heat transfer measurements of an impinging air jet

Tadhg S. O'Donovan, Darina B. Murray

Mechanical & Manufacturing Engineering, Trinity College Dublin, Ireland, tadhg.odonovcan@tcd.ie

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Impinging air jets are known to yield relatively high local and area averaged convective heat transfer coefficients and can be used for the cooling of electronic components, gas turbine blades and manufacturing processes such as grinding. The current research is concerned with the measurement of fluid flow and heat transfer to an impinging air jet. This investigation was limited to a Reynolds Number, (Re) of 10000 and nozzle to impingement surface distance, (H/D) from 1.0 to 2.0.

Both mean and fluctuating heat transfer profiles are presented for the range of variables considered. Heat transfer distributions, an example of which is presented in figure 1, exhibit secondary peaks at a radial position which is dependent on H/D. The secondary peaks in the mean Nusselt number distribution are a result of an abrupt increase in turbulence in the wall jet boundary layer. The fluctuating Nusselt number distributions also reflect where fluctuations in the local fluid velocity increase.

Laser Doppler Anemometry has been used to acquire time resolved velocity measurements. Spectral and coherence information of the individual velocity and heat transfer signals is presented. It has been shown that fluctuations in the fluid velocity close to the impingement surface correlate well with the heat transfer from the surface. It has been shown also that vortices which are responsible for introducing regular velocity fluctuations in the transitional wall jet region can influence the magnitude of the heat transfer coefficient. The evolution of vortices in the impingement jet flow has been discussed.

The comparison of the velocity and heat transfer data has facilitated an understanding of the effect vortices have on the mean heat transfer coefficient. It has been shown that the magnitude of the heat transfer coefficient is highly dependent on the size and coherence of the vortices in the impinging jet flow. Small coherent vortices that pass at a relatively high frequency have been shown to enhance the heat transfer in the wall jet. Larger vortices passing at low frequencies do not enhance the heat transfer coefficient to the same degree.

It has been shown that the break-up of vortices in the wall jet increases the magnitude of the velocity fluctuations normal to the impingement surface. It has also been shown that vortices at an early stage of their development enhance the heat transfer in the wall jet contributing to the magnitude of the secondary peak in the heat transfer distribution.

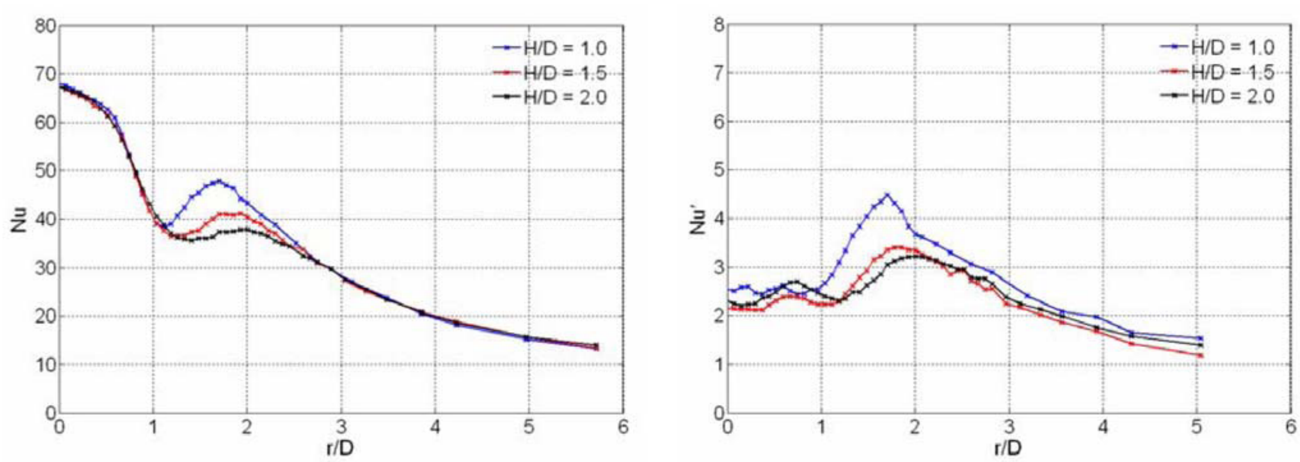

Fig. 1 Mean & Fluctuating Nusselt Number Distributions, Re = 10,000