DIRECT NUMERICAL SIMULATIONS OF HEAT TRANSFER FROM A CYLINDER IMMERSED IN THE PRODUCTION AND DECAY REGIONS OF GRID TURBULENCE

George Papadakis
Dept. of Aeronautics, Imperial College London, England

ABSTRACT We consider a cylinder immersed in the turbulent wake of a grid-element and explore the effect of cylinder location on heat transfer using direct numerical simulations (DNS). Three locations downstream of the grid-element, inside the production, peak and decay regions, are investigated. The turbulence intensities at the location of the cylinder in the production and decay regions are almost equal at 11%, while in the peak location the turbulence intensity is 15%. Although the oncoming turbulent intensities are similar in the two regions, we notice a peculiar behaviour: in the production region the stagnation point heat transfer is increased by 63%, while in the decay region it is enhanced by only 28% (compared to the baseline case of approaching flow without turbulent fluctuations). Also, existing correlations for the stagnation point heat transfer coefficient are found to be invalid in the production and peak locations, while they are satisfied in the decay region.

In order to explain these findings, we study the flow structures and find that in the production and peak regions the flow is dominated by shedding events, in which the predominant vorticity component is in the azimuthal direction. This leads to increased heat transfer from the cylinder, even before vorticity is stretched by the accelerating boundary layer. Also, the frequency of oncoming turbulence in the production and peak locations lies close to the range of frequencies that can penetrate inside the boundary layer developing on the cylinder, and therefore the latter is very responsive to the impinging disturbances. The highest Nusselt number along the circumference of the cylinder is shifted 45 degrees from the front stagnation point. This shift is due to the turbulence-generating grid-element bars that result in the prevalence of intense events at the point of maximum Nusselt number compared to the stagnation point.