Effect of wall curvature on a round subsonic impinging jet: DNS study

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Abstract

We report on Direct Numerical Simulation (DNS) of a subsonic jet impinging on a curved surface. The configuration resembles a turbine leading edge cooling system. The bulk Reynolds number (based on bulk velocity U_b and jet diameter D) is 3300. The impinging wall was kept at a constant temperature, 80 K higher than the jet bulk temperature. Comparisons with the jet impinging on a flat plate are carried out. Our major findings are that turbulent flow field is influenced by the shape of the impinging wall, although the averaged heat transfer is not affected at all by the wall curvature. The frequencies which dominate heat transfer are found to be, through a Dynamic Mode Decomposition (DMD), the same that dominate primary vortices in the shear layer and secondary vortices produced by the interaction of primary vortices and the target plate. These frequencies are $30-40\%$ lower than the flat plate reference case. The same frequencies, used to excite a pulsating inlet condition, are responsible for heat transfer augmentation of 20% at maximum, and their precise prediction is of importance when design a turbine impingement cooling system.

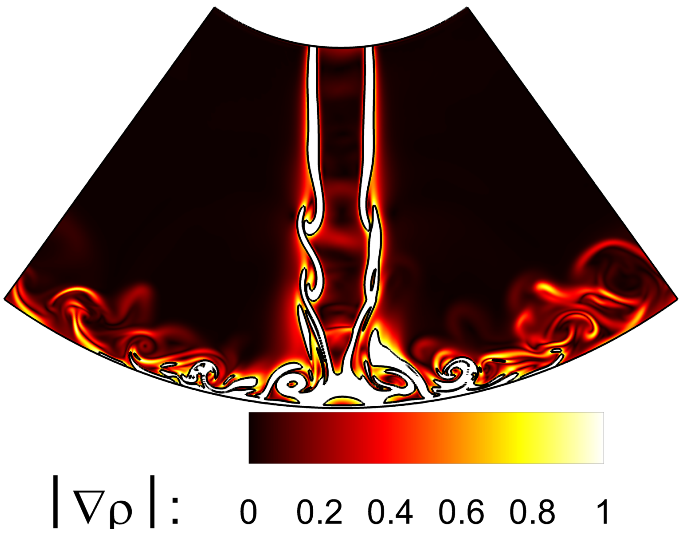

Figure 1: Absolute value of density gradient at a selected snapshot.