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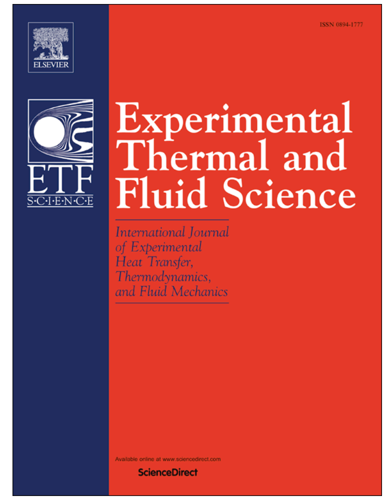

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Particle Image Velocimetry and Infrared Thermography of Turbulent Jet Impingement on an Oscillating Surface

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Abstract

Jet impingement is widely used for forced-convection heat transfer applications and knowledge about its flow structure and heat transfer rate on a static surface are well established. However, the characteristics of jet impingement on an oscillating surface are relatively unknown. This study experimentally investigates the effect of surface oscillation on the fluid dynamics and heat transfer of an unconfined turbulent impinging jet. The Reynolds numbers of the axisymmetric jet are 5000 and 10000, based on the jet-nozzle exit diameter, and the surface is placed at nominal standoff distances of 2 and 5 diameters from the jet-nozzle exit. The surface oscillates in a direction parallel to the jet axis at frequencies of 20 Hz and 50 Hz and at a peak-to-peak displacement amplitude of 0.2 times the jet-nozzle exit diameter. The phase-average and mean flow characteristics at six phases through the surface oscillation cycle, and the steady-state mean heat transfer rate at the oscillating surface, are determined using particle image velocimetry and infrared thermography respectively. These are analyzed and compared with the mean flow and heat transfer characteristics for jet impingement on a static surface. Surface oscillation directly affects the mean axial jet velocities and thence the mean radial velocities, and this effect is greater at locations in the flow-field closer to the surface. This gives rise to lower mean axial and radial strain rates in the impingement region and lower turbulence intensities in the wall-jet region when compared with those for a static surface. The frictional interaction between the impinging jet and oscillating surface induces higher surface temperatures than those on a static surface. These factors reduce the heat transfer rate for jet impingement on an oscillating surface when compared with that on a static surface. The reduction is greater in the impingement region than in the wall-jet region with the stagnation point Nusselt number for an oscillating surface being lower by a maximum value of 15%. Overall, for the range of parameters considered in this study, these findings suggest that surface oscillation in jet impingement weakens the transport phenomena capabilities from those present in the case of a static surface.

Keywords: impinging jet; oscillating surface; particle image velocimetry; infrared thermography

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