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Entitled

A NUMERICAL INVESTIGATION REALIZING THE FLOW STRUCTURE AND HEAT TRANSFER PERFORMANCE OF THE POTENTIAL IMPINGING JETS

by

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Abstract:

The demand for improvement in the performance of gas turbines has led to the consideration of flows at increasingly high temperatures, but this introduces challenges in terms of maintaining their structural integrity and preventing overheating. To respond to these challenges, gas turbine manufacturers have turned to internal cooling, and jet impingement provides an effective solution for cooling the leading edge of the blades of gas turbines. In this study, the author numerically simulated the cooling performance of the leading edge of the blades of a gas turbine under constant heat flux by using five configurations of jet impingement: a steady jet, a sweeping jet, a swirling jet, a chevroned steady jet, and a chevroned sweeping jet. Fluidic oscillators are known for their sweeping behavior and expansive coverage of the cooling surface while swirling jet owing to spiral geometry add tangential velocity component to the fluid which combines with the axial velocity component that generates enhanced momentum transfer area. On other hand by chevron attachment at exit of the nozzle are known to excite the jet downstream by forming coherent vortical structures that increase turbulence and, thus, promote the rates of mixing and heat transfer. These potential jets are compared at stationary and rotatory conditions (3000, 10000, 15000 rpm's) and results showed that at the stationary condition chevroned sweeping jet outperformed the steady jet configurations owing to oscillating jet impingement and a higher intensity of turbulence that increased the entrainment of jet flow. Under the configuration involving a chevroned sweeping jet, the target surface recorded an average Nusselt number that was 19.23% higher than that with a steady jet without chevrons, along with more uniform distributions of the temperature and the Nusselt number due to oscillations of the sweeping jet and higher turbulence at the exit of the nozzle with chevrons. While for rotation case sweeping jet performed the best as chevroned nozzles due to higher disturbance generated high recirculation regions leading to hotspots formation while swirling jet performed worse of all as swirling strength was negatively impacted due to rotatory motion. It can be concluded that the addition of chevrons and swirling angle improved heat transfer rate for sweeping and steady jet. However, upon rotation sweeping jet predominantly captures the best performance amongst all the jets.

Keywords: Gas turbine blade, Impingement cooling, SST k-ω model, Sweeping jet, Fluidic oscillator