Experimental Investigation on Heat Transfer Enhancement of Jet Impingement Cooling Using Porous Material

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ABSTRACT

Transient liquid crystal technique was employed in this study to investigate the thermal performance of a single air jet impinging on a flat plate attached with porous material. From different combination of parameters, the effect of each parameter on convective heat transfer was investigated. The results could provide as a reference for related applications and the design of heat transfer enhancement techniques. In this study, results of single jet impingement on a flat plate were compared with akin data in the literature to assess the feasibility of the test rig, before extending to the heat transfer study of jet impingement onto a flat plate with attached porous material. The varying parameters for the heat transfer experiments of a flat plate with attached porous material include porosity (ε =0.94~0.76 five values), Reynolds number (Re=12400, 17900, 23750), nozzle-to-plate distance (H/dj=6, 8, 10), height of the porous material (Hp = 30, 40, 50 mm), and the center hole depth (Hh = 0, 30, 40, 50 mm). A baseline case for comparison in the parametric study was arbitrarily chosen to be ε = 0.79, Re = 17900, H/dj = 8, Hp = 50 mm, Hh = 50 mm. The porous material was mainly made from piling up the stainless-steel mesh of different mesh sizes. Some heat transfer results from using aluminum foam material were also compared. Experimental results show that heat transfer is enhanced with a drilled-through center hole since the jet fluid can easily reach the plate surface; that higher porosity can improve the heat exchange in the porous material; and that reducing the nozzle-to-plate distance can increase Nusselt number. In most cases, increasing Reynolds number increases Nusselt number. However, it happens that the Nusselt number for Re = 23750 is less than that for Re = 17900, possibly because the fluid is expelled out of the porous material before it has sufficient heat exchange. Therefore, higher Reynolds number does not guarantee higher Nusselt number for the situation in this study.

Keywords : jet impinging, porous material, porosity, Reynolds number, Nusselt number

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