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Heat Transfer Characteristics of A Porous Medium Subjected To Water Jet Impingement

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Extended Abstract

Impinging jets are a practical application in the engineering field as they offer high rates of heating, cooling and drying. Industrial applications include gas turbine cooling, metal annealing, and high-density electronic equipment cooling. Due to these wide range of applications, many studies on the heat transfer properties of impinging jets have been conducted in modern day thermal engineering [1-3]. Porous mediums are another application used in thermal engineering with industrial applications, including heat exchangers and heat pipes. Studies conducted for utilizing pool boiling have shown that employing a porous medium improves both critical heat flux and heat transfer coefficients [4,5].

The purpose of this experimental study is to determine the heat transfer effects on a porous medium subjected to an impinging jet. Boiling and non-boiling conditions were applied as the porous medium was exposed to a free surface jet and a submerged jet with water as the working fluid. The effects of the volumetric flow rate on the lateral temperature profile were considered. The volumetric flow rate had numerical values ranging from 0.3-0.6 L/min under a constant heat flux.

The test section apparatus consisted of six Tutco CH43810HW cartridge heaters which were powered by two Staco Energy 3PN1010B variable transformers. The cartridge heaters were inserted into a machined copper block which heated the 13 mm x 13 mm impinging surface. The copper test section was then encased in machined PTFE Teflon to provide an insulated boundary condition. The water source was provided through a commercial water line and the volume flow rate was controlled by a flow meter (Dwyer RMB-82D-SSV). The water then travelled through flexible tubing until it reached the nozzle. The nozzle was a stainless-steel nozzle provided by IDEX Health and Science and had an inner diameter of 2 mm and a length of 150 mm. To submerge the impinging surface, an acrylic tube four times the size in diameter and height of the impinging surface was used. Two copper plates were utilized for this experiment: A regular non-porous copper plate and the porous medium copper plate. The porous medium copper plate consisted of 200 μm copper sintered particles which were aligned in a columnar post structure. The two copper plates were cut to the size of the 13 mm x 13 mm impinging surface to ensure a constant heat flux boundary condition. The copper plates were fixed onto the copper test section using thermal glue to ensure no air gaps were present. Lastly, a total of three thermocouples were used. The thermocouples were K-type thermocouples with 24 AWG wire with PFA insulation. Two thermocouples were fixed along the center line of the copper test section spaced 20 mm vertically apart. The third thermocouple was used to measure the temperature of the water. All three thermocouples were plugged into an Omega-OM-CP-Quad Temp 2000 data acquisition system to record the temperature differences.

The nozzle was fixed in the center of the 13 mm x 13 mm impinging surface with an H/D ratio set to 7. The nozzle was then moved in 1 mm increments to a final position of 6 mm from the center. A temperature difference was recorded at each of the 1 mm increments. This procedure followed suite for both boiling and non-boiling conditions. Early results show an increasing temperature profile as the nozzle is moved in the lateral direction for the non-porous copper plate. The porous medium plate shows a constant temperature profile in the lateral direction due to the porous media columnar post even heat distribution.

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