Proceedings of the Canadian Society for Mechanical Engineering International Congress 2021
CSME Congress 2021
June 27-30, 2021, Charlottetown, PE, Canada

AN INVESTIGATION OF THE THERMAL PERFORMANCE OF HEAT PIPES UNDER DIFFERENT OPERATING CONDITIONS

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ABSTRACT

Heat pipes are enhanced heat transfer devices that can transfer large amounts of heat rapidly over large distances with minimal temperature difference. The high heat transfer rate is achieved through recirculation of the working fluid in its liquid and vapor phase. Heat pipes are used in a multitude of heating and cooling applications such as electronics cooling, heating ventilation and air-conditioning (HVAC) systems and cooling of mold castings.

The present work investigates the thermal performance of cylindrical heat pipes through a series of experimental tests under different operating conditions (heat flux, pipe length (L), diameter (D), working fluids (water and ethanol mixture), orientations, wick mesh density). Additional tests in a gravity opposed orientation are carried out to understand the influence of negative gravity on heat pipe performance. Currently, there are no predictive methodologies for estimating the overall effective thermal resistance (R_{eff}) of a heat pipe under different operational parameters. This can be a major challenge while designing heat pipes for different cooling applications. This work, therefore, aims to address this issue by formulating a predictive correlation for determining the thermal resistance of heat pipes under different working configurations. It is expected that the results from the current study may be used in the development and modification of existing designs of heat pipes.

The length and the diameter of the tested heat pipes range between 0.254m (gravity opposed)-0.572m (gravity assisted) and 0.015-0.019m, respectively. The pipes are made up of copper with distilled water and a mixture of water-methanol as the working fluids. The working fluid occupies 10-20% of the internal volume of the heat pipe. The evaporator section is heated using mica band heaters and the input heat flux is varied using a variac. A water jacket is employed at the condenser section to achieve the desirable cooling rate. The circulation of the cooling water through the circuit is maintained by a single-stage centrifugal pump. K-type thermocouples are used to monitor the temperatures along the axial length of the heat pipe. The heat pipes are insulated carefully to minimize the influence of the ambient thermal conditions. The results will be compared and presented in a thermal resistance network framework to understand the relationship between the individual operating operations and determine the optimum working configuration for each heat pipe.