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研　究　主　論　文　抄　録

論文題目

HEAT TRANSFER CHARACTERISTICS OF SELF-OSCILLATING MULTI-HEAT PIPE WITH THE USE OF PURE WATER AND NANOFLUID

(純水及びナノ流体を用いた自励振動多管ヒートパイプの熱伝達特性)

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主論文要旨

This experimental study was performed to investigate heat transfer performance of a self-oscillating multi-heat pipe in the condition of different fill charge ratios and different constant heat fluxes. In this experiment, pure water and nanofluid were employed as the working fluid, respectively. The heat pipe was composed of an evaporator section, a condenser section and an adiabatic section. The evaporator and condenser sections had the same size and were connected by four circular parallel tubes. The corresponding external dimensions were 45mm in length, 45mm in width and 8mm in thickness, and the internal dimensions were 42mm, 42mm and 5mm, respectively. The adiabatic section was consisted of four parallel circular tubes whose dimension was ϕ6 (external diameter) x ϕ5 (internal diameter) x 45 (length) mm. Nanofluid employed in this experiment was alumina (Al_2O_3) nanofluid, that is the mixing between alumina particles with the size around 30nm and pure water. In this experiment, the effect of inclinations of the heat pipe to its heat transfer

performance was also investigated. The fill charge ratio f_{cr}, which is volume ratio between fill charge volume of working fluid and internal evaporator section volume, was varied from 30% and 100% at 10% intervals. The corresponding constant heat fluxes applied to the evaporator session for each case of fill charge ratio were 5W/cm^2 (50kW/m^2), 10W/cm^2 (100kW/m^2), 15W/cm^2 (150kW/m^2), 20W/cm^2 (200kW/m^2) 25W/cm^2 (250kW/m^2) and 30W/cm^2 (300kW/m^2), respectively. When the experiment was performed to investigate the effect of inclination of the heat pipe to heat transfer performance, the angle between the axis of the heat pipe and vertical direction were 0^o; 45^o; 60^o; 75^o.

The measurement of temperature of the heat pipe as follow: for the evaporator section – 5 points H_1, H_2, H_3, H_4 and H_5 at four corners and center of the evaporator section. For the condenser section - points C_1, C_2 and C_3 at along the centerline of the condenser section. The temperature of the inlet cooling water (to cool the condenser section) was set at 15^{o}C using the controllable thermostatic bath and the cooling water were supplied to the water tank at rate of 3.5 l/min. After filling a calculated amount of working fluid in the heat pipe, the vacuum pressure would be generated by a vacuum pump and its value was maintained at 7400Pa in all cases. In order to get the accurate vacuum pressure value, the vacuum pressure value was read on the power indicator transducer after 20 minutes and when changing from one fill charge ratio to another, the working fluid was filled in when the evaporator section of the heat pipe was 25^{o}C. Temperature was measured until the experiment reached a steady state and the steady state time was at least 30 minutes.

Effective thermal conductivity was calculated as follows:

$$Q = \mathrm{NA}q' = \mathrm{NA}k_{eff}\frac{T_H - T_C}{\mathrm{L}} \quad \Rightarrow \quad k_{eff} = \frac{Q\mathrm{L}}{\mathrm{NA}(T_H - T_C)}$$

Where, Q is total heat load, q' is the heat flux from the evaporator section to the condenser section, L is the length from the center of the evaporator section to the center of the condenser section, that is, the approximate distance between T_H measured point and T_C measured point. N is the number of tubes of the adiabatic section (N = 4). A is the flux area of the inner part of a tube in the adiabatic section. To get mean temperature T_H of the evaporator section and T_C of the condenser section, temperatures were measured and averaged.

After doing cases of the experiment, the optimal fill charge ratio corresponding to the heat flux was determined (here the optimal fill charge ratio was the value which would bring the highest heat transfer performance to the heat pipe), and the optimal heat transfer performance of the heat pipe between the use of pure water and nanofluid was also determined.

The dissertation consists of six following chapters:

Chapter 1 – Introduction: Literature review on studies on heat pipe, advantages of using nanofluid on enhancement of heat transfer performance and objective of the experiment.

Chapter 2 - Description of the experimental apparatus, structure of the self-oscillating multi-heat pipe, making of nanofluid and experimental parameters.

Chapter 3 – Effect of inclination to heat transfer performance of the self-oscillating multi-heat pipe.

Chapter 4 – Effect of fill charge ratio and heat flux to heat transfer performance of the self-oscillating multi-heat pipe.

Chapter 5 – Effect of the use of working fluids to heat transfer performance of the self-oscillating multi-heat pipe.

Chapter 6 - Conclusion remarks and recommendations for future works.

Key words: Heat transfer performance; Self-oscillating multi-heat pipe; Working fluid; alumina nanofluid; fill charge ratio; Effective thermal conductivity