UNIVERSITI TEKNOLOGI MARA

AN EXPERIMENTAL INVESTIGATION ON THERMAL BEHAVIOR AND PERFORMANCE OF SINTERED-WICK CYLINDRICAL HEAT PIPE AT STEADY-STATE AND TRANSIENT RESPONSE

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PhD

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AUTHOR'S DECLARATION

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and is the results of my own work, unless otherwise indicated or acknowledged as referenced work. This thesis has not been submitted to any other academic institution or non-academic institution for any degree or qualification.

I, hereby, acknowledge that I have been supplied with the Academic Rules and Regulations for Post Graduate, Universiti Teknologi MARA, regulating the conduct of my study and research.

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ABSTRACT

The effects of heat load and operating time on thermal behavior and thermal performance of a sintered wick cylindrical heat pipe (CHP) was investigated in this experimental study. It was evaluated under various operating conditions; start-up, steady-state and transient response conditions. The transient response conditions comprise varying operating time, abrupt heat load and termination of operation. The heat pipe consists of a copper tube with 10 mm in diameter and 300 mm in length with copper sintered powder act as the wick. The heat pipe was platted with nickel-plating on the outer wall and was filled of water as its working fluid. For the experimental study, a complete heat pipe test rig was developed and set-up at the Thermodynamics Laboratory of Universiti Teknologi MARA (UiTM) Pulau Pinang. The steady-state results were validated with the analytical results of the thermal resistance network modeling and the lumped capacitance method (LCM) and also with the results from the numerical study by other researcher who employed the computational fluid dynamics (CFD). In this experiment, the start-up thermal behavior of the CHP was conducted at various combinations of heat input-operating time within the range of 10 W - 60 W and 600 s - 3000 s. The varying heat load was effective when the period was long enough to overcome the thermal inertia of the evaporator and that of the working fluid. With the increase in start-up heat load, the start-up time decreased and a successful start-up became easily achievable. For the start-up operating condition, the CHP had achieved its steady-state at the heat input of 40 W and operating time of 1800 s. As for the steady-state condition, the experiment was accomplished at varying heat load, commencing from 40 W – 100 W and constant operating period of 1800 s. The effect of power input to the temperature variations along the heat pipe wall could be observed where the steady-state temperature increases with increased heat load. The increase of heat input influences the temperature difference between the evaporator and condenser regions along the CHP axial position. The minimum temperature difference of 38.1°C was indicated at 40 W. Also, the overall thermal resistance decreases as the heat input increased. The lowest thermal resistance of 0.8180°C/W was recorded at 100 W. The rise in heat load significantly affects the increase of heat transport capacity. The maximum heat transfer rate of 36.35 W was also observed at 100 W. For the varying operating time condition, the increase of the operating period from 600 s – 3000 s leads to increase of wall temperatures along the CHP axial direction thus notify the effect of operating time in temperature variations. It was also revealed that the decrease of abrupt heat load from 70 W to a range of 20 W – 50 W had influenced the performance at the evaporator which could be notified by the temperature changes. For the sudden abrupt heat load increase from 70 W to 90 W - 100 W, higher evaporator temperature was indicated at the end of the operation thus eliminating the effect of sudden changed of heat input back to the initial supply at 70 W. The termination of operation influences the temperature deteriorations, the most at the evaporator compared to the adiabatic and condenser sections. This different trend of temperature variations of the evaporator was due to the proximity of the evaporator to the heater.

Key Words: Cylindrical Heat Pipe, Test Rig, Start-up, Steady-state, Transient Response, Thermal Behavior and Thermal Performance

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