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Experimental study on heat transfer performance of curved heat pipe

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Extended Abstract

Heat dissipation has always been a major issue in the thermal management field. In recent years, some emerging advanced microelectronic heat dissipation technologies have been developed, including direct immersion cooling, thermoelectric cooling, jet cooling, and heat pipe. Wherein, heat pipe is widely used in aerospace thermal control for high heat flux conditions because of its excellent performance of heat dissipation. Therefore, heat pipes have become a research focus in the field of heat and mass transfer. However, most of the existing researches focus on flat heat pipes, it is relatively rare on curved heat pipes. Herein, a thermal performance test of curved heat pipes is assembled. The operating performance, including heat transfer capability and unsteady temperature responses, is measured for both the metal sintered power heat pipe and screen mesh heat pipes, which provides a reliable basis for the design and research of curved heat pipes. The metal sintered power heat pipe is made of copper and water is used as a working fluid. For screen mesh heat pipes, there are four types, namely copper-water heat pipe, aluminum-alcohol heat pipe, aluminum-acetone heat pipe, and copper-acetone heat pipe.

In this paper, the effects of working fluid and solid material on the maximum heat transfer capability, equivalent thermal conductivity, and unsteady heat transfer characteristics of curved heat pipes are analyzed and discussed. The results indicated that (1) the lengths of evaporator and condenser section for curved heat pipe have a great influence on the heat transfer performance. The heat transfer performance of the curved heat pipe will be improved by enlarging the evaporation section or the condensation section of curved heat pipes. As the temperature of the cold source increases, the operating temperature of the curved heat pipe also rises, and the difference between the operating temperature of the curved heat pipe and the temperature of the cold source is small, which indicates that the heat pipe has superior isothermal characteristics. (2) The maximum heat transfer capability of metal sintered power copper-water heat pipe is greatly affected by the temperature of the cold source. In other words, excellent heat transfer capability of curved heat pipes can be maintained when the working temperature is high, however, under low temperature conditions, the heat transfer capability is weakened to some extent. (3) The equivalent thermal conductivity of the metal sintered power copper-water heat pipe and screen mesh heat pipes is higher than that of pure copper heat pipe, which is about several times of that of pure copper. The curved heat pipe has excellent heat transfer performance and incredible temperature uniformity, so the near isothermal and long distance heat transfer is realized. (4) The thermal response of curved heat pipe is faster for a larger heat load during the heating period. After the heat source is turned off, the temperature drop of the evaporator section, adiabatic section, and condenser section of the curved heat pipe is smaller than the temperature rise of the curved heat pipe during the heating process. (5) Working fluids of heat pipe have a great influence on heat transfer performance, for the screen mesh heat pipes, the copper-water heat pipe has the optimal heat transfer capability, followed by the aluminum-ethanol heat pipe, and the performances of the aluminum-acetone heat pipe and copper-acetone heat pipe are inferior to the former two. Through the further research on heat transfer characteristics of the curved heat pipe of different materials, it is proved that the metal sintered power copper-water heat pipe has excellent heat transfer performance and is more stable than the wire mesh copper water heat pipe.