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MEASURING THERMAL PERFORMANCE OF GRAVITATIONAL HEAT PIPES DEPENDING ON THE AMOUNT OF WORKING FLUID

Abstract

This paper deals with an impact of working medium on the performance parameters of the heat pipe. The aim was to find the ideal amount of working fluid used in gravitational heat pipes. For the working medium 96% alcohol was selected.

Keywords: gravity heat pipe, working substance ethanol, performance parameters

1. Introduction

In the area of research and development in the energy sector people now focus not only on the development of alternative fuels, reducing emissions and attracting new sources of energy, but also on efficient heat transfer, whether for cooling different components in electrical engineering, computer science, engineering or recovery of waste heat transport and heat in heating systems [1].

Heat pipes are precisely such devices to transfer heat while maintaining a small temperature difference. Therefore, the development and optimization are key to greater efficiency and application of heat pipes. Preferably, the heat pipe is that the small size can transfer large heat output while its construction is simple with long life, reliability and durability [2].

2. Theoretical analysis of gravitational heat pipe

Construction of gravity heat pipe is the easiest and also the principle is the basis for other types. The heat pipe consists of a closed outer shell and a working substance which is inside the tube. The tube operates in a vertical or slightly inclined position wherein the condensing section is always located above the evaporation part [3], [4]. In the evaporation part working fluid evaporates and condenses in condensation part. The condensate then returns to the evaporation part under gravity for smooth inner wall. The transferred heat flow depends on the thermal resistance of the liquid film on the wall of the condensation part. Proper operation of the heat pipe is dependent on a quantity of working fluid to cause a sufficient wetting of the surface of the evaporation part and, thus, there is no performance degradation. Conversely too much liquid in the evaporation part with boiling leads to the release of large steam bubbles, then the shock phenomena are formed. Heat transfer between the vapour phase of working fluid and the inner wall of the tube is mainly influenced by the character of flow in the falling film of liquid [5], [6], [7].

2.1 Design and method of filling gravitational heat pipes

Gravitational heat pipes were made of copper pipes (Fig. 1) with an external diameter of 15 mm, an internal diameter of 13 mm and the length of 500 mm. For the working substance 96% ethanol was selected. Outturn of heat pipes was done by vacuum pump (Fig. 2) through which we reached pressure of 80 Pa inside the tube.

Fig. 1. Closed heat pipes

Fig. 2. Vacuum pump

Through the filling system we never meet evacuating the heat pipe to desired amount of filling. Heat pipes are met at the level of 10, 20, 30, 40 and 50 % of their volume (Tab.1). To calculate the correct amount of working fluid, we used equation (1). After filling the heat pipe through a capillary, the capillary pressure and tin were closed.

Tab. 1 Capacities for individual gravitational heat pipes

Type of heat pipe	GHP 1	GHP 2	GHP 3	GHP 4	GHP 5
amount of working medium	10 %	20 %	30 %	40 %	50 %
	6.64 ml	13.27 ml	19.91 ml	26.55 ml	33.18 ml

$$V_{ethanol} = \frac{\pi d^2}{4} l \frac{x}{100} \quad (m^3) \qquad (1)$$

3. Measurement and recording of measured values

Measurement was carried out in the experimental device (Fig. 3), in which the gravitational heat pipe was placed. The evaporation section of the heat pipe was heated with water at 80 °C and the condensing section cooled with water at 15°C.

For a correct analysis of the performance parameters of the heat pipe it is necessary to specify default values:

- water temperature at the inlet and outlet of cooling (°C)
- water flow in the cooling circuit (l/min).

These values were measured at 10 second intervals for 20 minutes by means of sensors. Data from the sensors was transmitted through the measuring panel to the notebook in which software AMR WinControl from AHLBORN was installed and by which these values were recorded. Overall, the measurement and comparison of eight kinds of heat pipes in which medium 96% alcohol with different priming was operating. Readings were taken from AMR WinControl program from AHLBORN and exported to Microsoft Excel, where these values were then processed and analyzed. The parameters that were measured every ten seconds were used to produce the arithmetic means and the identified data necessary for analyzing the performance of individual heat pipes. For calculating performance of heat pipes it was necessary to determine the other parameters such as:

- specific heat capacity of water (J/kg . K),
- density of water (kg/m3).

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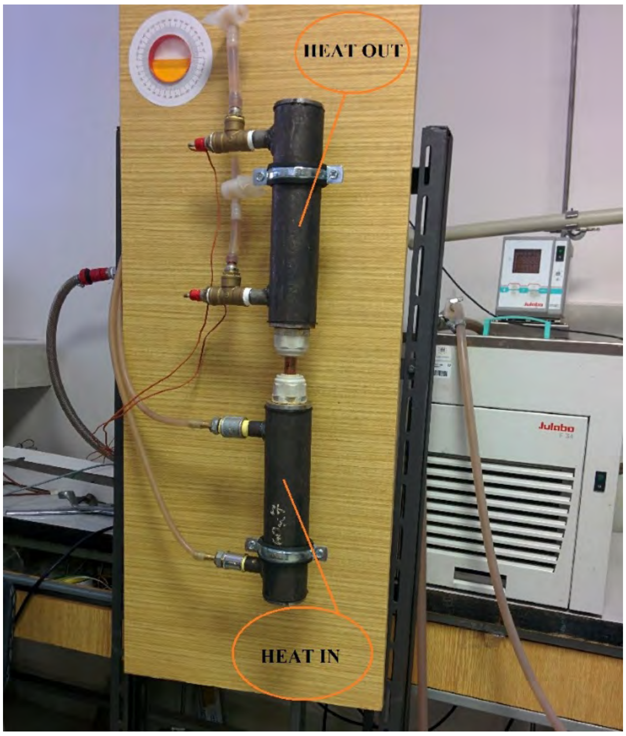

Fig. 3. Involvement of the gravitational heat pipe

4. Evaluation of performance parameters of gravitational heat pipes considering the amount of working fluid

Power of gravitational heat pipes was determined by calculating (2) crustaceans has been made on the basis of measured data.

$$Q = mc\Delta T \quad (W) \qquad (2)$$

Mass flow was recorded in l/min and it was to be recalculated according to equation (3) in units of kg/s taking into account the density of the fluid.

$$m = \rho V \quad \text{(kg/s)} \qquad (3)$$

From the measured and calculated data, we found that when the alcohol is used as the working medium the maximum power of the heat pipe 206,7 W reaches.

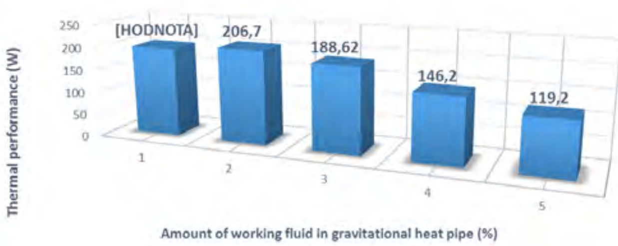

Fig. 4. Dependence of thermal performance of the GHP from the amount of the load

5. Conclusions

Quantity of working fluid in the GHP and its working position had a major impact on the performance and operation of the GHP. We verified that the ideal amount of working medium in the GHP is about 20% in vertical position. For larger quantity of working fluid occurs to reduce power.

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