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An Experimental Study on the Effect of Wick Structure With Different Working Fluid on Performance of L-Shaped Heat Pipe

Jaydeep H. Patel
Mechanical Engineering Department
C.G.Patel Institute Of Technology
Bardoli-India

Paresh C. Chhotani
Mechanical Engineering Department
C.G.Patel Institute Of Technology
Bardoli-India

Soyeb S. Multani
Mechanical Engineering Department
C.G.Patel Institute Of Technology
Bardoli-India

***Abstract*—Heat pipes are two phase heat transfer device which can transfer heat at high heat transfer rate. In these study experiment analysis a been performed with eight different heat pipe with Ethanol and Acetone as working fluid and Screen mesh and Sintered powder as wick structure. Experiment runs have been performed at different heat input. Result has been recorded in terms of temperature at different section of heat pipe at different length. Result shows that ethanol shows better result than Acetone as working Fluid.**

Keywords— Heat pipe,Workig Fluid, Screen Mesh and Sintered Powder.

I. INTRODUCTION

Heat pipes are two phase heat transfer device whose operate on evaporation/condensation of working fluid, and which use the capillary pumping force to ensure the fluid circulation in Heat pipe circuit. Heat pipes are mainly used in electronics device and space application for its light weight and compactness.

In Recent years, Heat removal is an important challenge in designing of electronic component. Now a day Heat pipe is used to remove instant heat. Heat pipes are most effective passive method for transferring heat in electronic device. Heat pipe can transmit heat at high rates and at a high thermal conductivity. It can transfer heat with low temperature drop and quick response time in a wide range of temperature.

II. CONSTRUCTION AND WORKING OF HEAT PIPES

A. Construction of Heat Pipe:

Figure 1 shows the schematic diagram of Heat Pipe. Heat pipe contain main three component: Container, Wick structure and Working Fluid.

Heat Pipes are hollow metal tube that can efficient transfer heat from Heat source to heat sink over relatively long distances (50-500 mm) via the latent heat of vaporization of a working fluid. The tube is provided with a wick structure, placed on the inner surface of the Heat pipe wall and partially filled with the liquid working fluid.

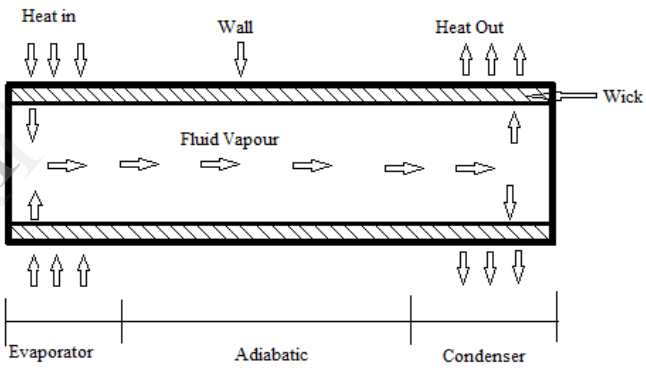

Figure 1. Heat pipe Components.

B. Working of Heat Pipe:

Thermodynamically Heat pipe consist of three main sections, which includes an evaporator section, an adiabatic section and a condenser section

- Heat added at the evaporator section vapories the working fluid, which is in equilibrium with its own vapour.
- Due to vapour Pressure difference vapour drives through evaporator section to condenser section.
- At the condenser section, heat is removed by condensation and is ultimately dissipated through fins.
- The capillary effect of the wick structure will force the flow of the liquid from condenser to evaporator section.

III. SPECIFICATION OF HEAT PIPE

The finned flat Heat pipe is shown in Figure 2. This finned Heat pipe used to cool the CPU of a modern notebook. In this system, the Heat pipe is used to transfer heat from CPU to the fins usually in the sides or corners of the PC. The finned flat Heat pipe consists of aluminium base block and condenser section of 72 mm long, with 35 numbers of copper rectangular fins of 20 mm × 10 mm size. The system is supported by fan. the specifications of the Heat pipe are shown in Figure 2.

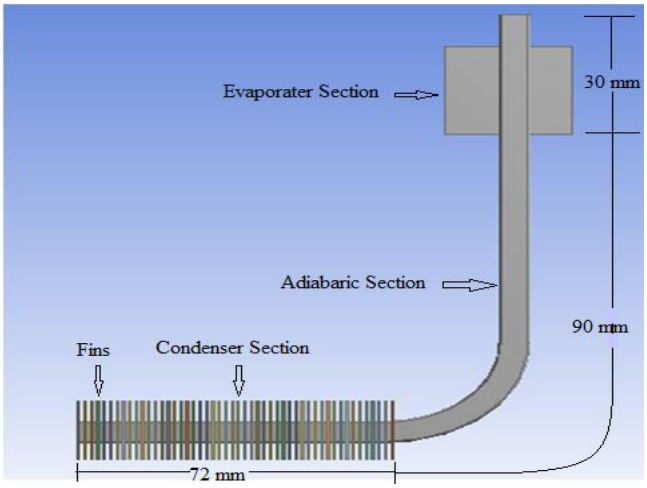

Figure 2. Finned Flat Heat Pipe

The general specifications of the Heat pipe have been shown in Fig.2 and summarized in Table I.

Table I. Specification of L shaped Heat pipe

Characteristics	***Dimensions/ Materials***
Evaporator length L_e	30 mm
Condenser Length L_c	72 mm
Adiabatic length L_{ad}	90 mm
Heat pipe Container thickness	0.5 mm
Wick thickness	0.5 mm, 0.75 mm
Working fluid	Ethanol, Acetone
Wick structure	Sintered Copper Powder, Screen Mesh
Material of pipe	Copper

IV. EXPERIMENT SETUP AND PROCEDURE

A. *Experiment Setup:*

Figure 3. Shows the Experimental Setup for the flat Heat pipe. The Heat pipe was fabricated with Copper tube of 190 mm long and 6 mm in diameter, than it was flatten. Copper Sintered Powder and Copper Screen Mesh were used in Heat pipe as Wick Structure. Heater of 230V, 100 W capacity was used to supply the heat to the evaporator section. Thermocouple wire was used to measure the wall temperature at varies length of Heat pipe. 35 numbers copper fins were mounted on the condenser section of Heat pipe. Fan with ac Supply was directed toward condenser section for forced cooling. Main Supply was attached with variac to control and measure the power supply input respectively.

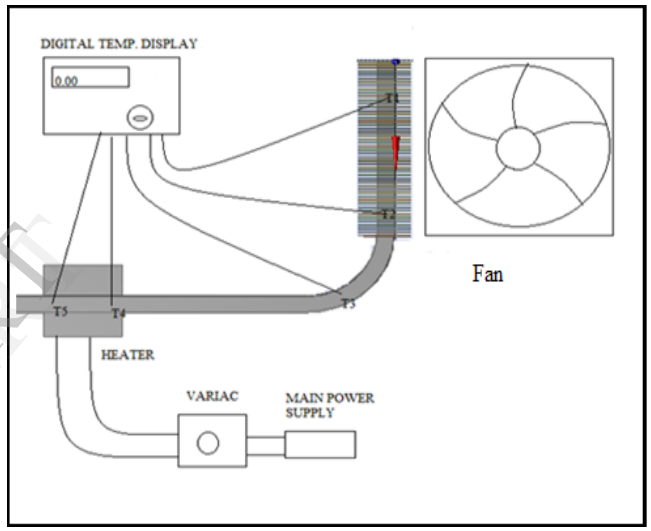

Figure 3. Schematic Diagram of Heat pipe Experiment Setup

B. *Experiment Procedure:*

The test section consists three parts, as mentioned earlier, evaporator, adiabatic and condenser section. In the experiment the heat transfer characteristics were measured for two different fluids as Acetone and Ethanol with different wick structure. Experiment runs were taken at Heat input of 15W for Heat pipe. As the Heat pipe was gained the heat, the Temperature rise was observed at regular interval of time till steady state was achieved. The temperature readings were noted at different length of Heat pipe for steady temperature. Experiment was repeated for different Heat pipe at different Heat input (20W to 35 W) and steady temperature were noted and various plots were drawn for investigate the effect of Fluid and wick structure on the performance of Heat pipe.

V. RESULT AND DISCUSSION

The Experiment has been conducted for different eight heat pipes for elaborate the effect of fluid as ethanol and acetone and wick structure and its thickness on heat pipe.

A. Effect of variation of wick structure on performance of heat pipe

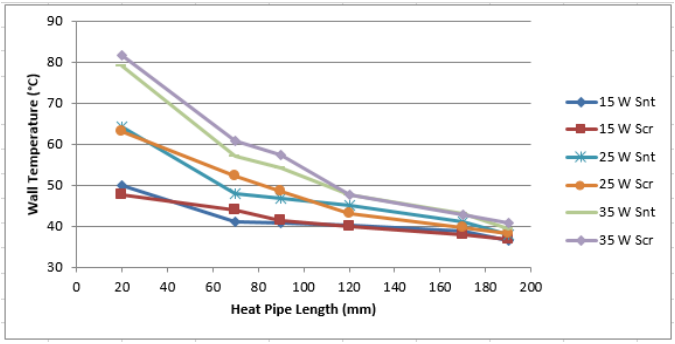

Figure 4. Effect of wick structure on heat pipe with ethanol as fluid and 0.5 mm wick thickness

The above figure shows the effect of wick structure screen mesh and sintered powder on the performance of Heat pipe at different heat input. The temperature result present that the temperature difference between evaporator section and condenser section for screen mesh wick has been recorded as 10.9 °C, 24.9 °C and 40.8 °C for 15 W to 35 W in the interval of 5W heat input. While for sintered powder temperature difference has been recorded as 13.6 °C, 26.3 °C and 39.8°C for the same variation of heat input. From these results it observed that Screen mesh gives better performance for heat pipe with Ethanol as fluid and 0.5 mm wick thickness.

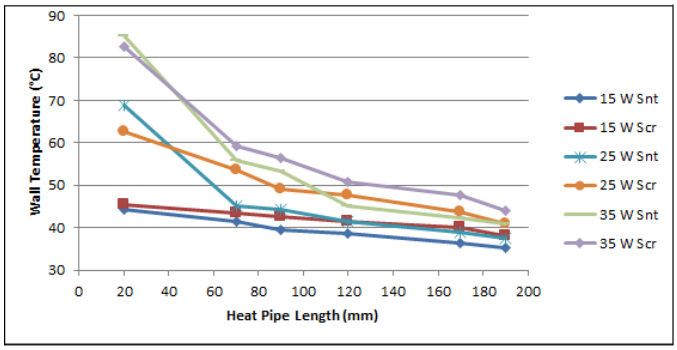

Figure 5. Effect of wick structure on heat pipe with ethanol as fluid and 0.75 mm wick thickness

Above figure represents the temperature difference of heat pipe with different wick structure with 0.75 mm thickness of wick and ethanol as working fluid. The figure shows that the temperature difference for 15 W has been recorded smallest temperature difference as 7.1°C. Whereas the highest temperature difference has been recorded for sintered powder as 44.4 °C. Overall for all heat input the screen mesh shows better result than sintered powder wick.

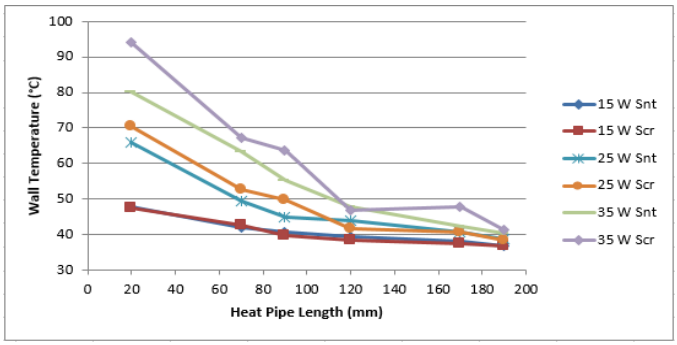

Figure 6. Effect of wick structure on heat pipe with acetone as fluid and 0.5 mm wick thickness

The above figure represents the variation of wick structure and effect of it on the temperature difference of evaporator and condenser section for heat pipes. Figure shows that for low heat input of 15 W the temperature difference has been small for screen mesh as 10.8 °C. For other heat input from 25 W and 35 W temperature differences as 27.3 °C and 39.8 °C has been recorded. Overall from the temperature difference sintered powder wick structure shows the better result in terms of small temperature difference than screen mesh wick structure.

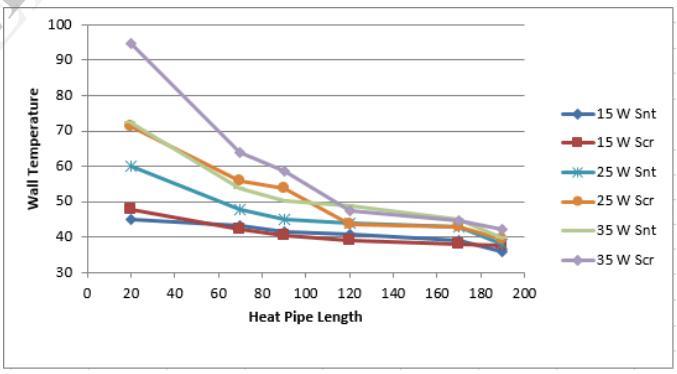

Figure 7. Effect of wick structure on heat pipe with acetone as fluid and 0.75 mm wick thickness

The figure shows the temperature difference of heat pipe at various heat input for acetone as working fluid and 0.75 wick thickness with two different wick structure. The temperature difference for screen mesh and sintered powder wick for 15 W has been observed 10.3 °C, 9.3 °C. For other heat input between 25 W and 35 W have been recorded as 22.1°C and 32.0 °C,32.5 °C and 52.5 °C for sintered and screen mesh wick structure for 0.75 mm wick thickness. From these data sintered powder shows better result for 0.75 mm thickness and acetone as fluid.

VI. CONCLUSION

The experiment analysis performed for enhance the effect of different fluid, different wick structure and variation in thickness of wick on the performance of flat heat pipe has been studied for various heat input. The main conclusions from this experiment investigation are as follow.

- The combination of ethanol as working fluid and screen mesh as wick structure performed good rather than acetone and screen mesh wick. While acetone and sintered powder wick shows better result in terms of small temperature difference.

- For low heat input with sintered powder and low thickness, acetone gives better result and for higher heat input ethanol performed well.

REFERENCES

[1] David Reay, Peter Kew, "Heat pipe Theory, Design, Applications" Fifth Edition. Elsevier Publications.
[2] Mahjoub, S., and Mahtabroshan, A., 2008, "Numerical Simulation of a Conventional Heat pipe," *Proceedings of World Academy of Science, Engineering and Technology*, 29, 117-122. http://www.waset.org/journals/waset/v15/v15-22.pdf
[3] Nouri-Borujerdi, A., and Layeghi, M., 2004, "A Numerical Analysis of Vapour Flow in Concentric Annular Heat pipes," *Journal of Fluids Engineering*, 126(3), 442-448. http://dx.doi.org/10.1115/1.1760549
[4] Mohamed H. A. Elnaggar, Mohd. Zulkifly Abdullah, and Sri Raj Rajeswari Munusamy, 2013 "Experimental and Numerical Studies of Finned L-Shape Heat pipe for Notebook-PC Cooling" *IEEE Transactions on Components, Packaging And Manufacturing Technology, Vol. 3, No. 6,* DOI: 10.1109/TCPMT.2013.2245944
[5] T Yoisefi, S.A Mousavi, M.Z. Saghir, 2013 "Experimental Investigation on Performance of CPU Coolers: Effect of Heat pipe Inclination Angle and The Use of Nano Fluids" *Microelectronics Reliability.* http://dx.doi.org/10.1016/j.microel.2013.06.012
[6] R. Mohan, and P. Govindarajan, 2011 "Experimental and CFD analysis of heat sinks with base plate for CPU cooling" *Journal of Mechanical Science and Technology 25 (8) (2011) 2003~2012.* DOI 10.1007/s12206-011-0531-8
[7] Yu-Wei Chang, Chiao-Hung Cheng, Jung-Chang Wang, Sih-Li Chen. 2008 "Heat pipe for Cooling of Electronic Equipment" *Energy Conversion and Management, 49, 3398–3404.* DOI:10.1016/j.enconman.2008.05.002