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Experimental Investigation Of Copper Sintered Heat Pipe Flow For Power Electronic Coolingby Vortex

Indira A Mhaisne[1], P.B. Borade[2], S.V. Mohitwar[3],Dr.A.A. Pawar[4], Dr. R.N. Panchal[5]
[1]*M.E(Heat and Power) Student,JSPM RSSOER Narhe, Pune, India.*
[2,3]*Assistant Professor,JSPM RSSOER Narhe, Pune, India.*
[4]*Head Mech. Engg.JSPM RSCOE Tathwade, Pune, India.*
[5]*Assistant Professor,JSPM RSSOER Narhe, Pune, India.*

Abstract: *An issue of concern with the recent electrical components in integrated circuits is heat removal to avoid damage therefore, removal of this heat is prime concern. Among all the cooling methods, heat pipe is a better selection because of its high efficiency and reliability. In the present work, two heat pipes of the same dimensions of 200 mm length and 5mm outer diameter having two different working fluids were constructed with some modifications in the condenser section, in order to provide two different modes of cooling at condenser section viz. cooling with normal flow and cooling with vortex flow. For each working fluid, heat transfer characteristics are determined experimentally for fixed coolant flow rate at different heat input. A cylindrical shell was fabricated in which the coolant is forced tangential. A spiral is inserted in the cylindrical shell due to this vortex flow is generated. Vortex generators are used for heat transfer enhancement of the modern thermal systems. This mixes the warm and cold fluid and thus takes away the latent heat of condenser of vapor quickly and thus increases the heat transfer in heat exchanger. The readings are taken for both normal and vortex flow at steady state and a comparative study is made. The result shows that as compared to general flow there is an increase in heat dissipation using vortex flow and the overall heat transfer rate for different working fluid was calculated out of which ethanol has the higher heat transfer value as compared to purified water.*

Key Word**:** *Copper Sintered Heat Pipe, Vortex Flow, Miniature Heat Pipe*

I. Introduction

With the development of electronic industry and reduction in size heat dissipation is becoming crucial. The removal of the heat generated during the operation of the electronic equipment is very necessary for enhancing the life of the equipment. So thermal management is a great challenge. Considering the other cooling techniques heat pipe is the effective solution because of excellent heat transfer capability and structural simplicity.Heat pipe moves heat from one end to the other without the use of pump. It has high heat transfer capabilities and can transfer heat with very less temperature difference between the hot and cold end. The heat pipe is a hollow element partially filled with a working fluid consists of three sections; evaporator section, adiabatic section and condenser section. Evaporator absorbs heat and uses it to convert working fluid to vapor, which expands to fill the entire internal space of heat pipe. The condenser rejects heat leading to the vapor losing the heat and condensing back to liquid. The liquid returns to evaporator and the cycle repeats itself.

The wick structure is important parameter other than working fluid and envelope material. There are several types of wick structures: screen, grooves, felt, and sintered powder. Sintered powder wick structure has many advantages as compared to other because of the ability to handle high heat flux. Also sintered heat pipe is efficient for cooling of electronic equipment becauseof the ability to work in any orientation. Since groove and screen mesh wicks have very limited capillary force capability, they typically cannot overcome significant gravitational forces, and dry out generally occurs. Sintered powder wick is integral with the heat pipe envelope, so it can be bent or flattened in different shapes. The above features make the sintered powder wick an efficient choice for thermal management of electronic equipment.

Y.-M. Chen et. al.[1] investigates the thermal performance of miniature heat pipe with sintered copper wick. Heat pipe with different copper powder wicks were fabricated and tested by using theory of capillary limitation. He found that increase porosity leads to increase in heat transfer. Sukhvinder S. Kang et al.[2] paper discusses cooling technologies that have evolved. NattawutTharawadeeet. al. [3] investigated the thermal performance of a sintered-wick heat pipe with double heat sources by changing the distance between the two heat sources and its effect on thermal resistance. Balewgize A. Zeruet. al.[4] studied, a FPHP and water is used

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as a working fluid to carry out the performance test and to study the effect of operational parameters for optimum heat capacity. He concluded that high permeability value leads to low flow resistance in the wick and thus higher heat transfer rates. CK Lohet. al. [5] studied the effect of orientation angle on sintered heat pipe. He concluded that sintered heat pipe can operate at any angle compared with other wick structure. SlavkaTzanova [6] studied the geometry ofthe wick structure heat transport capability can be raised by increasing the wick thickness. SomasundaramDhanabal [7] carried out comparative study of heat pipe with water, methanol, ethanol and acetone as working fluids. At lower heat flux the fluids such as acetone, ethanol, and methanol are better than water. Ravibabu P Rajshekar [8] studied the use of sintered heat pipe for electronic cooling. He found that the sintered heat pipe can be bent in different shapes which makes it an optimum solution for thermal management of electronic cooling. Salah R. Agha [9] studied the Taguchi method to investigate the effects of wick structure, heat pipe diameter, and working fluid on the thermal conductivity of the heat pipe. Results show that wick structure type is the highest parameter affecting the thermal performance of the heat pipe, followed by the pipe diameter and finally the working fluid.

The aim of the present experimental study is to investigate the thermal performance of a copper sintered wick heat pipe with ethanol represents a working fluid, and compare this performance with the pure water as working fluid. A cylindrical shell was fabricated in which the coolant is forced tangential at high pressure; due to this vortex flow is generated. Vortex generators (Spiral) are used for heat transfer enhancement of the modern thermal systems. They mix the warm and cold fluid and increase the heat transfer in heat exchanger. The present study differs from most previous studies in that it uses a heat pipe with sintered powder metal wick and a special cylindrical shell with a spiral to generate the vortex.

II. Design Specification Of Heat Pipe

A circular heat pipe is used for this study. A copper tube of 5mm outer diameter and 3 mm inner diameter is used. Copper tube is selected because it is compatible with the working fluid. It thermal conductivity is higher as compared to other tube materials. Copper facilitates the ease of fabrication, including weld ability, machine ability and ductility and also there are some other important properties required for heat pipe container like porosity, wet ability.The heat pipe consists of three sections; evaporator section, adiabatic section and condenser section .The total length of the heat pipe selected is 200 mm. The detail dimension of heat pipe used in the experiment is summarized in Table 1.

Table 1 Dimensions of heat pipe

Parameter	Dimension (mm)
OD	5
ID	3
Length of heat pipe	200
Length of evaporator section	65
Length of adiabatic section	65
Length of condenser section	70

A cylindrical shell of 80 mm length and 25.4 mm diameter is fabricated around the condenser section to form a water jacket. In the cylindrical shell a spiral is inserted and water is forced tangentially over the spiral. Due to this vortex are generated in the condenser section as shown in fig 1. This mixes the warm and cold fluid and thus takes away the latent heat of condenser of vapor quickly and thus increases the heat transfer in heat exchanger.

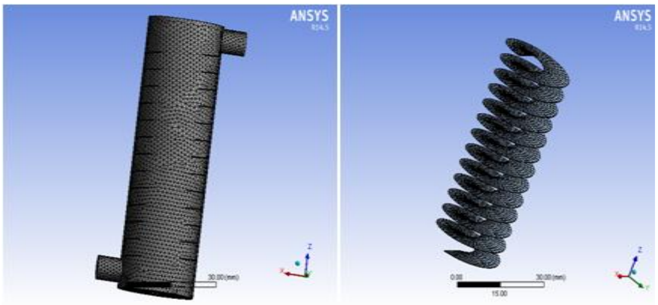

Fig1: Spiral

III. Experimental Procedure

In this study the heat pipe was fixed at the vertical position (θ=90°). The evaporator section is dipped in a tank. The tank contains water which is heated with the help of heater. The heater is connected to the dimmer for adjusting the heat input.The condenser section is cooled by a constant temperature water coolant, circulating in the cylindrical shell. The water coolant is taken from supply line through pipe and the flow is controlled by the flow meter. The inlet and outlet coolant temperatures are measured. Twelve calibrated *K* type (Φ 0.1 mm) thermocouples. Nine are attached at the wall to measure the wall temperature; three units at the evaporator section, two units at the adiabatic section and three units are at the condenser section. Remaining two is used to measure the inlet and outlet temperature of the condenser water and one is used to measure the lower tank water temperature. The thermocouples are attached at the wall surface-using adhesive.

At one heat input the heat pipe is allowed to reach steady state condition. After wards, the condenser water flow rate and the temperature of the various locations were all recorded. The same procedure was repeated at each power input. Two types of working fluid are used in this study, one of them is the pure water and the other is the ethanol. Also the cylindrical shell is changed at the condenser section. On set of reading are taken for normal flow and other for vortex flow. Comparative study is done for the heat pipe with this two flow for determination of heat transfer. Actual photo of the experimental setup is shown in fig.2.Vortices cause the flow towards the heat transfer surface. This causes fluid mixing and the thickness of the thermal boundary layer is reduced. This causes enhancement of heat transfer near the vortex. These vortexes have strong influence on velocity and temperature filed and disturbs the flow which causes enhancement in heat transfer.

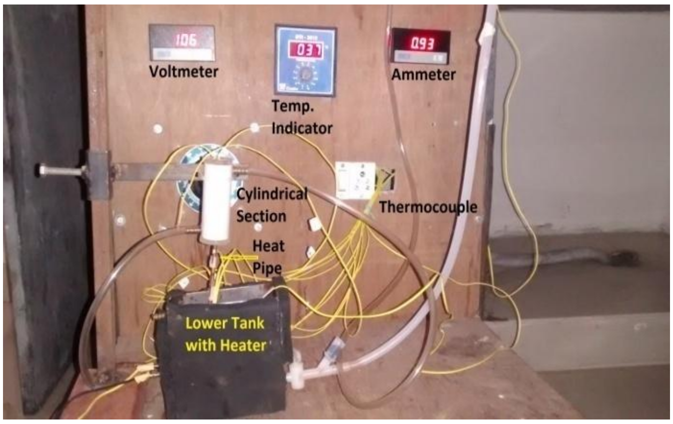

Fig 2: Experimental setup

IV. Result And Discussion

The fig 3 shows the comparison of effect of heat input and heat output for ethanol and water with normal and vortex flow. It is clear from the above graph that for the same heat input heat pipe with ethanol as working fluid has higher heat output as compared to water as working fluid. For heat pipe with ethanol as working fluid for vortex flow has highest heat output of 86.4 W. For ethanol with normal flow heat output is 73.3 W. For water the highest heat output for normal flow is 65.3 W and for vortex flow is 75.8 W.

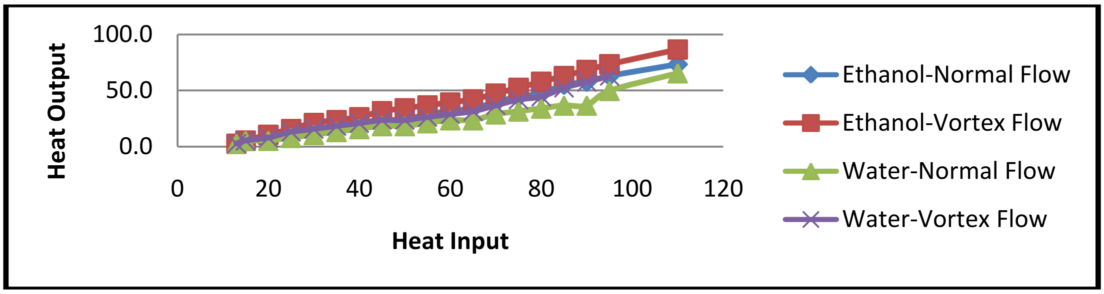

Fig 3: Comparison of effect of heat input and heat output for ethanol and water with normal and vortex flow

The fig 4 shows the comparison of effect of heat input on efficiency for ethanol and water with normal and vortex flow. The efficiency increases with increase in heat input. For ethanol with working fluid for vortex flow we are getting the highest efficiency. This is because of spiral; vortex flow is generated into the cylindrical shell which causes the mixing of hot and cold fluid thus increasing the heat transfer as compared to the normal flow. For ethanol with vortex flow the highest efficiency is of 78.51%. For ethanol with normal flow it is 66.61%. For water with normal and vortex flow the efficiency is 59.3% and 68.8% respectively.

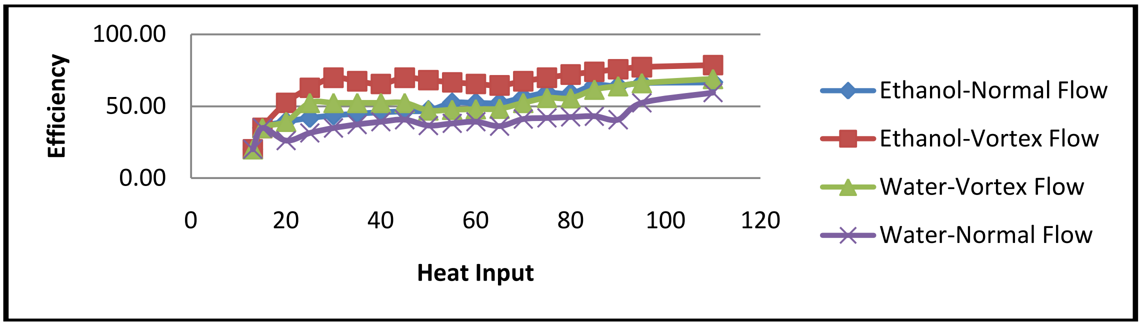

Fig 4: Comparison of effect of heat input on efficiency for ethanol and water with normal and vortex flow.

The fig 5 and 6 shows the comparison of effect of heat input on thermal resistance for ethanol and water with normal and vortex flow respectively. From the above graph it is clear that as the heat input increases the thermal resistance decreases and the fill ratio has a great impact on the thermal resistance. The thermal resistance is higher for lower fill ratio and starts decreasing for further fill ratios i.e. up to 75% and starts increasing again when the fill ratio is further increased.

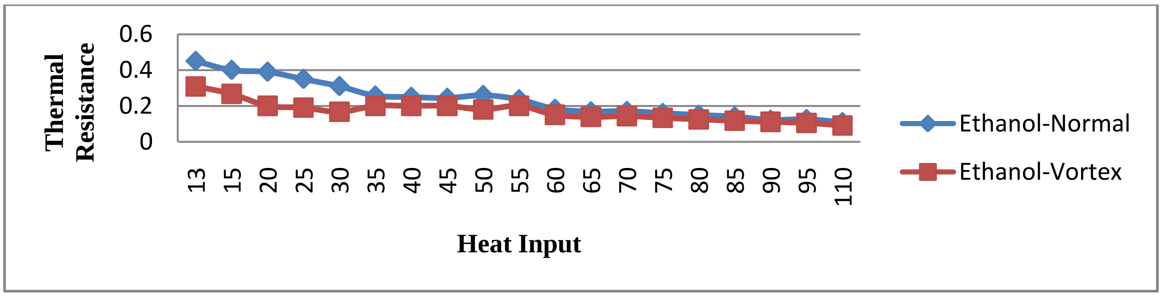

Fig 5: Comparison of effect of heat input on thermal resistance for ethanol with normal and vortex flow

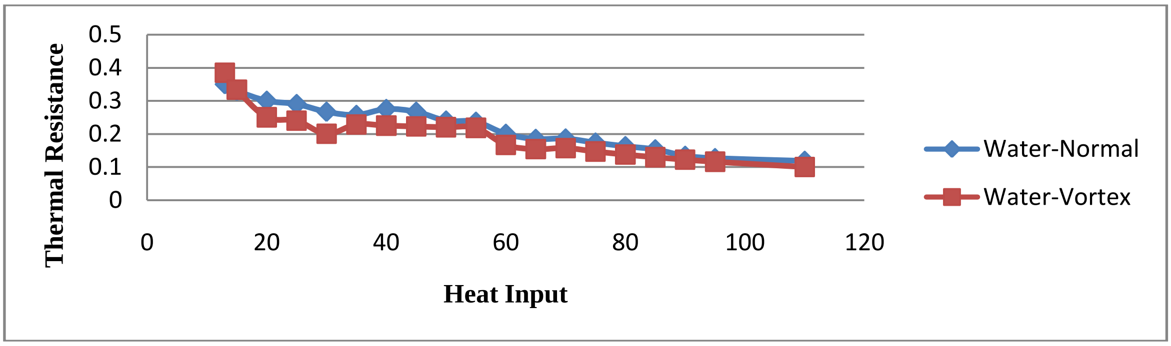

Fig 6: Comparison of effect of heat input on thermal resistance for water with normal and vortex flow

V. Conclusions

This paper presents experimental analysis of heat removal by using heat pipe. Current research on sintered wick heat pipe is mainly focused on its heat transfer mechanism and thermal performance. A cylindrical shell was fabricated in which vortex generators were used for heat transfer enhancement and a comparative study was made with normal flow for heat pipe with water and ethanol as working fluid. Following important conclusions are drawn from the work carried out on heat pipe for different heat input. As the heat input increases thermal resistance decreases.Efficiency increases with increase in heat input Vortex flow mix the warm and cold fluid and thus takes away the latent heat of condenser of vapor quickly and thus increases the heat transfer in heat exchanger as compared to normal flow. The result shows that as compared to general flow there is an increase in heat dissipation using vortex flow and the overall heat transfer rate for different working fluid was calculated out of which ethanol with vortex flow has the higher heat transfer value as compared to purified water.

References

[1]. Y.M. Chen, S.C. Wu, C.I. Chu, Thermal Performance of Sintered Miniature Heat Pipe, Heat and Mass Transfer37 (2001) Springer.
[2]. Sukhvinder S. Kang, Advanced Cooling for Power Electronics, CIPS 2012,Nuremberg, Germany.
[3]. NattawutTharawadee, PraditTerdtoon and NitiKammuanglue, An Investigation Of Thermal Characteristics Of A Sintered-Wick Heat Pipe With Double Heat Sources, American Journal of Applied Sciences 10 (9): 1077-1086, 2013
[4]. Balewgize A. Zeru and A. Mani, Experimental Studies on a Flat Plate Heat Pipe for Electronic Cooling, JimmaUniveristy Annual Research Conference Proceedings, 1st (2010) 145-157
[5]. CK Loh, Enisa Harris and DJ Chou, Comparative Study of Heat Pipes Performances in Different Orientations, 21st IEEE SEMI-THERM Symposium
[6]. SlavkarTzanova, Lora Kamenova, YvanAvenas, Christian Schaeffer, Evaluation of the Thermal and Hydraulic Performance of a very Thin Sintered Copper Flat Heat Pipe for 3D Microsystem Packages, DTIP 2007, Stersa, Italy, 25-27 April 2007.
[7]. Mani Annamalai, SomasundaramDhanabal, Experimental Studies On Porous Wick Flat Plate Heat Pipe, International Refrigeration and Air Conditioning Conference 2010.
[8]. Ravibabu P, Rajshekar.KRohit, Kumar Gupta.K, Heat Pipes –Integrated Circuit Coolers, Proceedings of the 7th IASME / WSEAS International Conference on Heat Transfer, Thermal Engineering And Environment (HTE '09)
[9]. Satish G. Kandlikar And Clifford N. Hayner, Liquid Cooled Cold Plates for Industrial High-Power Electronic Devices—Thermal Design and Manufacturing Considerations, Heat Transfer Engineering, 30(12):918–930, 2009 Taylor and Francis Group, LLC
[10]. Salah R. Agha, Heat Pipe Performance Optimization: A Taguchi Approach, IJRMET Vol. 1, Issue 1, Oct. 2011