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Research Article

Experimental study on thermal performance of ethanol loop heat pipe with flat evaporator under gravity – assisted condition

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ABSTRACT

Nowadays, extreme growing of telecommunication and information technology causes the significant changes in the electronics belonging to the high-performance computer, data centers that are miniaturizing in their size and increasing the heat power dissipation. As a result, it is important to study on new cooling methods rather than conventional air cooling to warrant electronic device operate durably and stably. Besides, saving electricity power consumed by cooling systems is another considerable concern. Loop heat pipe, a passive heat transfer device which functions based on phase change processes and natural forces like gravity or capillary force, has been being one of potential solutions for the above challenges. In this paper, a loop heat pipe with flat evaporator was fabricated to investigate its cooling characteristics during start-up, stable operating period at different heat loads under gravity–assisted condition. This loop heat pipe was charged with ethanol whereas sintered stainless steel wick was the capillary structure. Time for successful start-up shortened from 13 minutes to 4 minutes as heat load increased from 30 W to 225 W. When heating power supplied to loop heat pipe's evaporator was adjusted from 30 W to 400 W (14.8 W/cm^2), the heating block surface's temperature increased from 33^{o}C to 133^{o}C. This temperature could be maintained below 85^{o}C, electronics limitation temperature in industry, if heat power released from the heating block is smaller than 220 W (8.14 W/cm^2). Besides, the change of different types of thermal resistance such as total thermal resistance, evaporator and condenser thermal resistances with heating power is discussed detail in this paper.

Key words: Loop Heat Pipe, Electronics Cooling, Passive Cooling, Phase Changing Heat Transfer, Flat evaporator

INTRODUCTION

In recent decades, human have witnessed the explosion of telecommunication and information technology, artificial intelligence. It leads to not only the major advance but also noticeable challenges to electronics industry, and one of them relates to thermal management system. The heat generated by the electronics is greater while the number of components installed on one unit of area increases date after date. In 2006, a chip with 100 million transistors/cm^2 was fabricated while this number was only 1000 in 1960s[1]. Environmental issue is being recognized as another concern. Energy statistics show that from 2000 to 2005, the electric energy consumed by DCs increased twice and continued growing up 10% each year later. Concurrently, data center carbon emission has become a global concern. In 2002, the global data centers (DCs) footprints was 76 $MtCO_2$ and it is expected to grow up at the rate of 7%/years[2]. A remarkable point is that 40% of DCs electric consumption is spent for the mechanical devices in traditional cooling systems such as chiller, blower, pump and cooling tower[2,3]. Thus, it is necessary to find out the modern cooling method that not only has great capacity, operate stably and reliably but also be friendly with environment, and loop heat pipe, a passive phase changing heat transport device, has been considered as one of the potential candidates for the above issues.

Figure 1 explains LHP's working principle. LHP transfers heat from the source to cooling medium by the evaporation and condensation happening continuously in the evaporator and condenser. Capillary force or gravity force circulates the working fluid, thus there is no mechanical component and free of power consumption. Compared with conventional heat pipe (HP), LHP can avoid entrainment limitation because vapor and liquid flow in separate pipes. To create the capillary force, the fine pore wick is only installed in evaporator, instead of connection lines, thus it can enhance the boiling heat transfer and reduce the pressure loss because of the flowing of fluid. In the evaporator, there is the compensation chamber (CC) that tolerates and guarantees the sufficient liquid for evaporation when LHP operating at differ-

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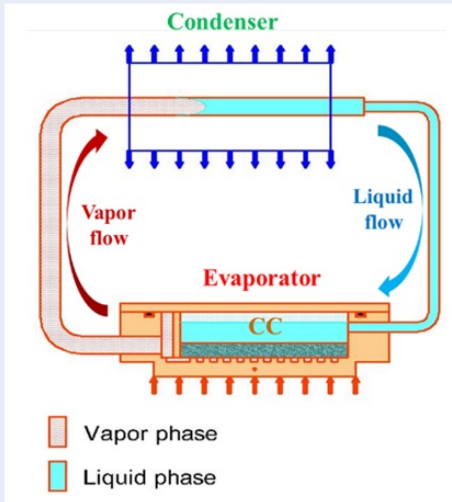

Figure 1: Loop heat pipe principal

ent heat loads. When applying LHP to cool electronics in DCs, it is possible to take advantage of gravity to increase cooling capacity. For these reasons, studying on LHP for electronics cooling is an attractive researching topic. Li *et al.*[4] carried out the experimental study on start-up and stable operation of LHP with flat square evaporator. This loop heat pipe worked with copper sintered wick structure and water as working fluid. He also proposed this LHP model works with parallel condensers to cool high-power integrated LED chips[5]. In the study[6], Xu *et al.* fabricated the round flat evaporator LHP to investigate the effect of working fluid inventory on fluid circulation and heat transfer happening inside LHP. Besides, effects of some factors like heat sinks temperature, slope angle and heat transfer with ambient were experimentally investigated by Chernysheva *et al.*[7]. In the studies[8,9] Huynh and HToo *et al.* conducted the investigation thermal performance of a water LHP with flat-rectangular evaporator. This loop heat pipe can maintain the electronics temperature is not higher then 124^{o}C at the heat load of 244 W when functioning horizontally. With the favor of gravity force, the heat load increased to 520 W and electronics temperature was not higher than 105^{o}C.

In this study, an experiment on ethanol LHP was conducted detailly. LHP's evaporator has flat – rectangular active surface to minimize the thermal contact resistance, uniform the heat flux and temperature distribution. As described in Figure 2, the evaporator combines from copper base (4), SS wick (3), SS body (5) and lid (7). The SS wick takes a role as a hydraulic barrier that assures the working fluid circulate correctly, especially under low heat load conditions. The space above the wick is the compensation chamber (7). A crossing groove system was fabricated on the inner surface of evaporator to supply heat transfer area for boiling and adequate paths for vapor flow out evaporator easily. This design avoids machining the vapor grooves on wick body that causes to complicate the manufacturing process and high in fabrication cost. LHP was charged with ethanol (99.5%) supplied by Kishida Chemical Co. From the experimental results, it is concluded that the LHP can start-up and operate stably with heat load from 30 W to 400 W. LHP total thermal resistance change a little between 0.218 K/W and 0.289 K/W and is almost dominated by the thermal resistance existing at LHP condenser.

METHODOLOGY

Experimental setup

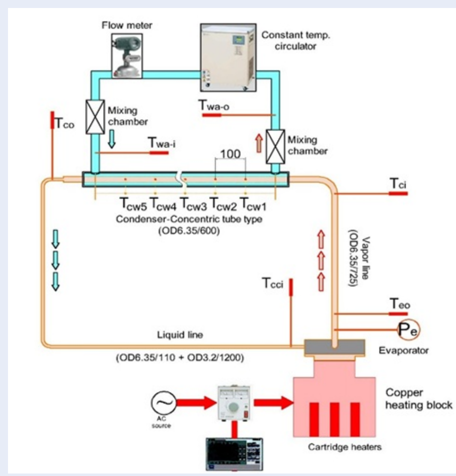

Figure 3: Schematic diagram of experimental setup[10]

Figure 3 and Table 1 show the schematic diagram, main parameters of the experimental setup. Heat generated from electronics was simulated by four 150 W cartridge heaters installed in the copper heating block. Heat load was adjusted by the Yamabishi MVS-520 volt-slider and displayed on the Yokogawa WT230 digital power meter. However, the accurate value of heat load supplied to LHP evaporator was determined by temperature gradient measured by three K-type thermocouples fixed to the copper heating block at three positions as described in Figure 4. Besides, a K-type thermocouple T_4 was inserted to the

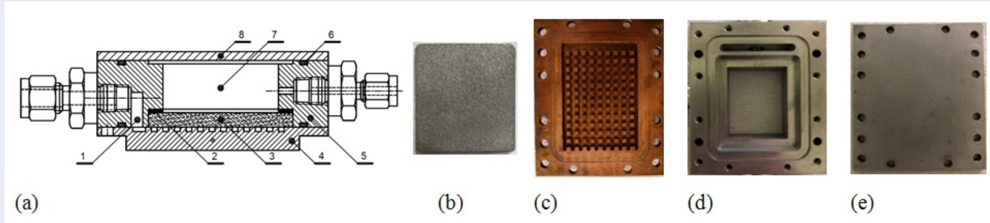

Figure 2: (a) Evaporator structure: vapor collector (1), silicone gasket (2), Stainless steel (SS) wick (3), copper base (4), SS body (5), O-ring (6), compensation chamber (7), SS lid (8); (b) SS sintered wick; (c) copper base of evaporator; (d) SS body; (e) SS lid

base of evaporator to estimate temperature at the bottom surface of the evaporator and the thermal contact resistance values. Water was the cooling medium for LHP condenser. The Advantec LV-400 circulator device kept cooling water temperature and mass flow rate at condenser inlet stable at around 25^{o}C and 35 kg/h. A flow meter and two thermocouples measured mass flow rate and temperatures of cooling water flowing in and out condenser T_{wa-I} T_{wa-o}. To exam the fluid circulation and phase distribution in the LHP, four K-type thermocouples, including T_{eo}, T_{ci}, T_{co}, T_{cci}, were inserted directly to LHP to measure temperatures at evaporator outlet, condenser inlet, condenser outlet and compensation chamber inlet. Data of each measurement devices was collected and transferred to PC by Keithley 2701 data acquisition automatedly.

Table 2 displays the uncertainties of thermocouples used in the experiment. The thermocouple's uncertainties were estimated from the calibration process where Pt100 thermometer (Chino Co. Model – R900-F25A) was used as the standard device.

Data reduction

Heat flux q and heat load Q flowing from heating block to LHP's evaporator

$$q = \frac{1}{3}\left[k\left(\frac{T_1-T_2}{\delta_1}\right)+k\left(\frac{T_2-T_3}{\delta_1}\right)+k\left(\frac{T_1-T_3}{2\delta_1}\right)\right] \tag{1}$$

$$Q = q \cdot A \tag{2}$$

Temperature at the top surface of the heating block T_{s1}

$$T_{s1} = \frac{1}{3}\left[\left(T_1 - 3\frac{q\delta_1}{k}\right)+\left(T_2-2\frac{q\delta_1}{k}\right)+\left(T_3-\frac{q\delta_1}{k}\right)\right] \tag{3}$$

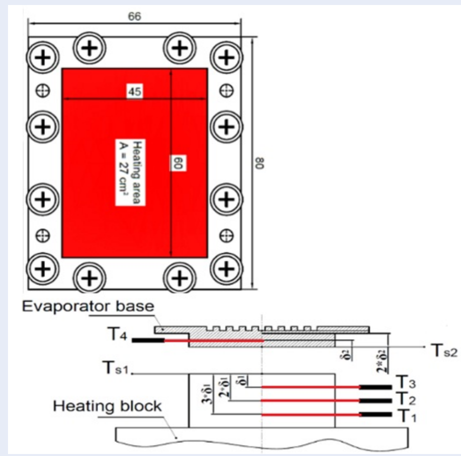

Figure 4: Evaporator active surface and temperature gradient measurement

With the measured value from thermocouple T_4, it is possible to estimate the temperature T_{s2} at the evaporator bottom surface

$$T_{s2} = T_4 + \frac{q\delta_2}{k} \tag{4}$$

Where:

δ_1 = 5 mm, distance between the thermocouples T_1, T_2, T_3.

δ_2 = 2.5 mm, distance between the thermocouples T_4 and active surface of evaporator

A = 27 cm^2, area of top surface of the heating block (Figure 3)

Hence, the total thermal resistance R_t, evaporator thermal resistance R_e, condenser thermal resistance R_c and contact thermal resistance can be determined as following equations

$$R_t = \frac{T_{s1} - T_{wa-i}}{qA} \tag{5}$$

$$R_e = \frac{T_{s2} - T_{eo}}{qA} \tag{6}$$

Table 1: The main parameters of experimental setup

Heating block	Copper
Mass, kg	4.36
Evaporator base	Copper
Length x Width x Height, mm	80 x 66 x 8
Active area, mm^2	60 x 45
Evaporator body	Stainless steel
Length x Width x Height, mm	80 x 66 x 23
Fin geometry	
Cross area, mm^2	2 x 2
Height, mm	1.5
Fin pitch, mm	4
Wick structure [10]	Stainless steel
Opening, μm	16.4
Void ratio, %	31.5
Bulk volume, mm^3	50 x 41 x 5
Compensation chamber	
Length x Width x Height, mm	40 x 31 x 18
Vapor pipe	Copper
OD/ID x Length, mm	6.35/4.35 x 725
Condenser	Copper
OD/ID x Length, mm	6.35/4.35 x 600
Liquid pipe	Copper
OD/ID x Length, mm	6.35/4.35 x 110
OD/ID x Length, mm	3.2/1.7 x 1200
Working fluid amount (ml)	
Ethanol	36

Table 2: Thermocouples' properties

	Type	Diameter, mm	Uncertainty
T_1, T_2, T_3	K type	0.5	$\pm 0.06^oC$
T_{eo}, T_{ci}, T_{wa-o}	K type	1	$\pm 0.06^oC$
T_4	K type	1	$\pm 0.07^oC$
T_{co}, T_{cci}, T_{wa-i}, T_{cw}	K type	1	$\pm 0.1^oC$

$$R_c = \frac{T_{ci} - T_{wa-i}}{Q} \quad (7)$$

$$R_{ct} = \frac{T_{s1} - T_{s2}}{Q} \quad (8)$$

EXPERIMETAL RESULTS & DISCUSSIONS

Loop heat pipe start-up characteristics

Start-up characteristics of present LHP are interpreted by Figure 5a, 5b, 5c and 5d. These figures display the change in temperatures measured at the evaporator base T_4 and at four LHP's positions such as evaporator outlet T_{eo}, condenser inlet T_{ci}, condenser outlet T_{co} and compensation chamber inlet T_{cci} after heating the LHP evaporator. The signs that LHP starts up successfully is the sequence increase of temperatures T_{eo} and T_{ci} to near the temperature T_4 while temperatures T_{co} and T_{cci} are close to cooling water temperature at condenser inlet. It indicates that the working fluid has circulated correctly, vapor generated in the evaporator can enter the condenser, condense into liquid and return compensation chamber through the liquid line smoothly.

Experimental results show that it is difficult for LHP to start at low heat load. Time for start-up at 225 W was 4 minutes while it prolonged to 13 minutes with 30 W of heat load. Focusing on the temperature change at 30 W and 90 W, before start-up, T_{cci} rose significantly higher than T_{eo}, and T_{ci} which was almost stable around its initial value, especially at 30 W, T_{eo} changed little. Meanwhile, at heat load of 150 W and 225 W, LHP started easily with no noticeable rise of T_{cci}. T_{eo} and T_{ci} reached to near T_4 quickly whereas T_{cci} and T_{co} were close to cooling water temperature T_{wa-i}.

When starting, evaporator and a part of vapor pipe are flooded with liquid at ambient temperature. This situation combining with small applied heat load prevent the boiling happen in the evaporator grooves, instead, the evaporation happens at the liquid – vapor interface in the compensation chamber. As a result, vapor infiltrates in the liquid pipe and no vapor can reach condenser. It leads to temperature measured at T_{cci} is higher than T_{eo} no increase in T_{ci}. When temperature at evaporator base is high enough, the boiling in the vapor grooves creates vapor bubbles at higher pressure that can escape evaporator and flow to condenser for condensation. At this moment, there is the sequence increase of T_{eo} and T_{ci} as well as the sudden drop of T_{cci} to T_{co}, or circulation of fluid happens correctly. With the start-up at high heat load, evaporator base is warmed up quickly and the rate of boiling happens faster. It helps vapor escape the evaporator easily to form the circulation; therefore at 150 W and 225 W of heat load, there is no tends of increase of T_{cci}.

Loop heat pipe thermal performance

Loop heat pipe cooling capacity

Figure 6 plots the variation temperature at the top surface of copper heating block T_{s1} as a function of heat load. This temperature is assumed as working temperature of electronics. With the electronics device like CPU or GPU, their temperature threshold value is normally suggested at 85^{o}C to ensure they work safely[11]. When LHP's condenser is cooled by water whose mass flow rate and temperature is controlled at 35 kg/h and 25^{o}C, temperature T_{s1} rises almost linearly from 33^{o}C to 133^{o}C in the range of heat load between 30 W and 400 W. The vertical and horizontal bars appended to the symbols of T_{s1} display the maximum and minimum deviation from mean values of temperature T_{s1} and heat load Q. It is sure that the heat load magnitude was controlled very stable during experiment and LHP kept electronics functioning at very steady temperature corresponding to every heat load. The LHP maintains T_{s1} below the safety limitation when heat dissipated from electronics did not exceed 220 W (8.1 W/cm^2).

Variation of LHP's working fluid temperatures with heat load

Figures 7 shows temperatures taken at evaporator outlet T_{eo}, condenser inlet T_{ci}, condenser outlet T_{co} and inlet of compensation chamber T_{cci} with against heat load. These temperatures are the basis for evaluating the stability and reliability of LHP performing under different applied heat load. On the whole range of heat load, values of temperature T_{ci} are close to T_{eo} and both of these temperatures increase linearly with increasing heat load as the way that T_{s1} varies in Figure 6. In contrast, temperatures T_{co} and T_{cci} are little affected by heat load variation, their values rose only from 26^{o}C to 30^{o}C that is slightly higher than temperature of cooling water at inlet of condenser. This temperature distribution proves that the phase changing and circulation of fluid in LHP happen smoothly and stably or LHP functions well in the whole range of heat load. All vapor flows easily to condenser and becomes liquid that returns evaporator again for continuous circle. There is absolutely no liquid in the vapor line and vice versa. When heat load was controlled more than 300 W, there are the noticeable difference

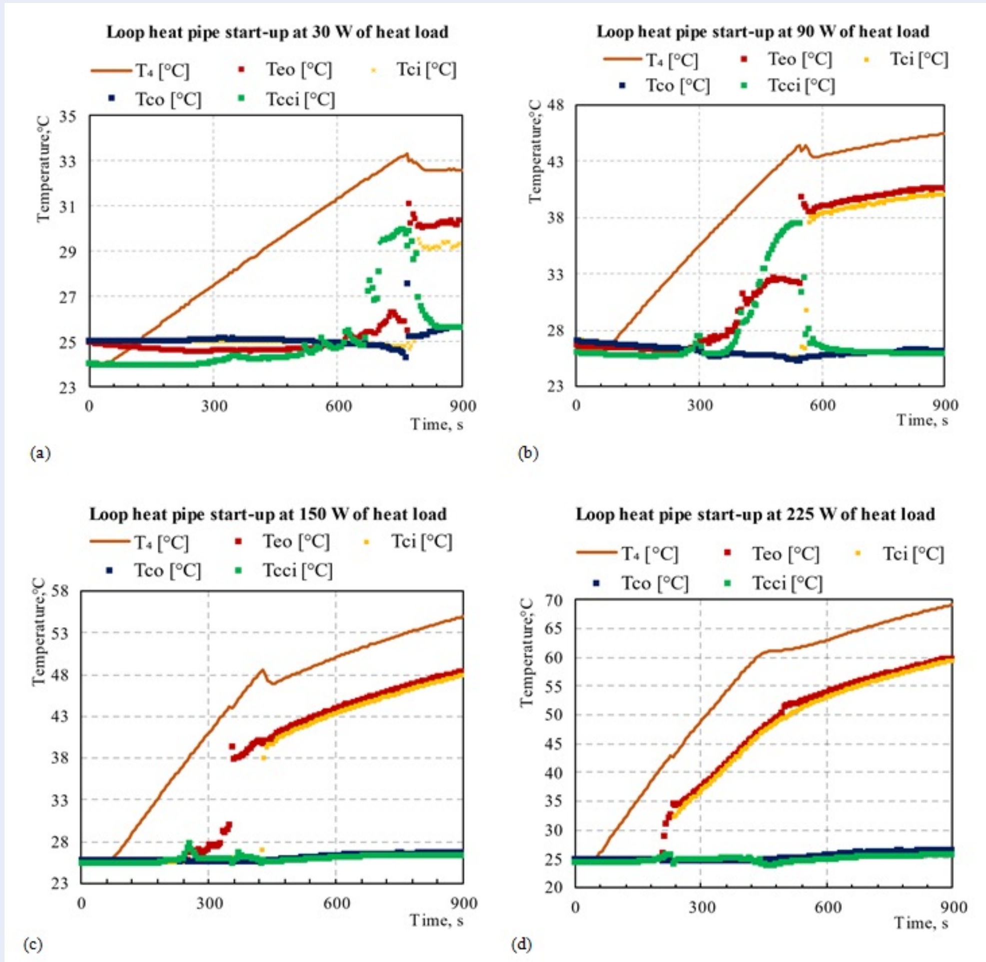

Figure 5: LHP start-up at (a) 30 W, (b) 90 W, (c) 150 W, (d) 225 W

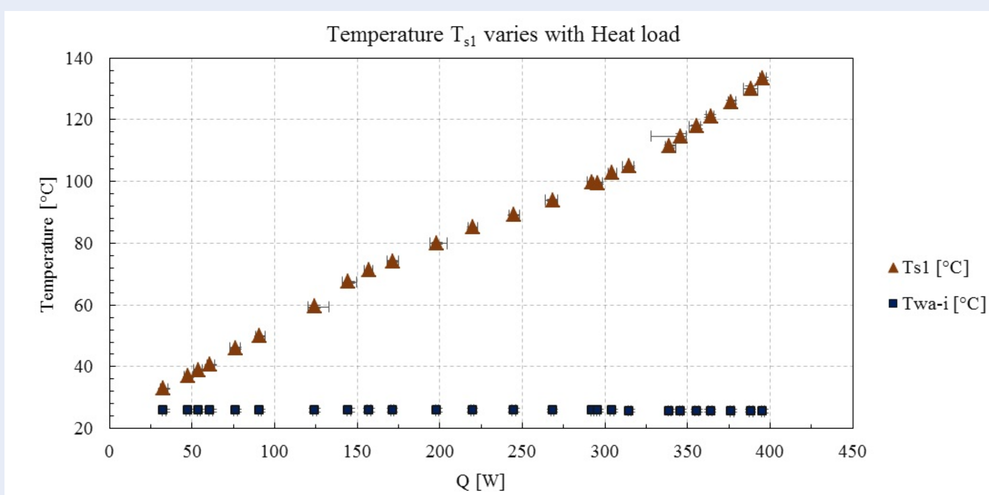

Figure 6: Temperature on the top surface of heating block Ts1 varies with heat load Q

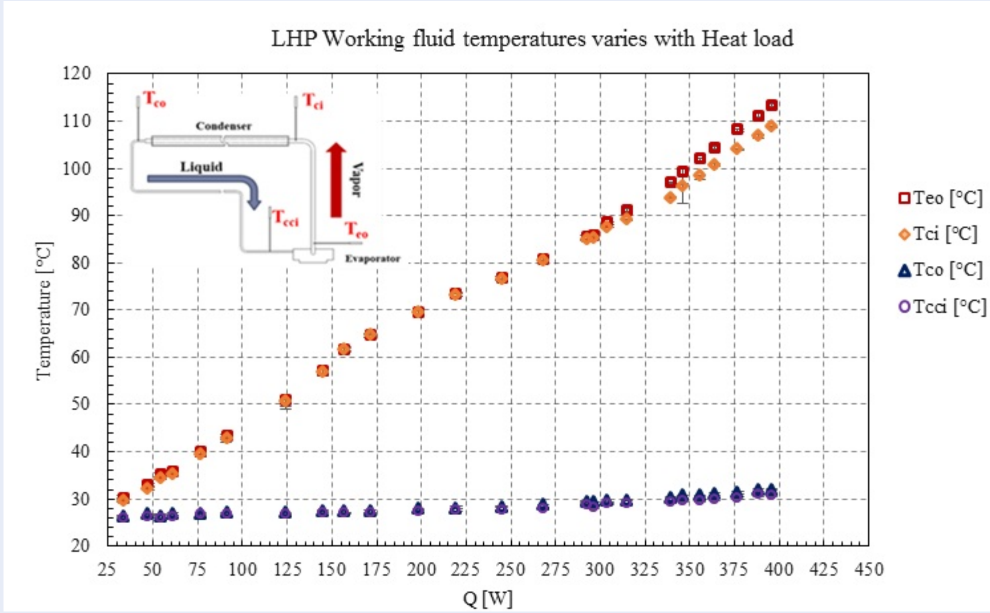

Figure 7: LHP working fluid temperature varies with Heat load

between T_{eo} and T_{ci}. It can be explained by the gaining in vapor pressure drop in the vapor pipe when vapor mass flow rate increases due to high heat load

Variation of loop heat pipe thermal resistance with heat load

Figure 8 plots four types of thermal resistances evaluated in experiment including total thermal resistance R_t, evaporator thermal resistance R_e, condenser thermal resistance R_c and contact thermal resistance R_{ct}. On the whole range of heat load, LHP total thermal resistance R_t changes narrowly between 0.218 K/W and 0.289 K/W and is dominated by the condenser thermal resistance R_c whose magnitude increases sharply within the range from 30 W to 150 W and then become more stably with heat load increasing. More heat load applied to LHP also causes more condensed liquid in condenser that acts as the resistance of heat transfer between vapor and cooling water; however, the high supplied heat load also makes the vapor flow faster, thus enhance the turbulent of condensation process. Therefore, condenser thermal resistance R_c varies with heat load as the tendency shown in Figure 8. On the other hand, evaporator thermal resistance R_e almost reduces with heat load increasing. R_e magnitude being higher under low heat load can be explained by the flooded of liquid accumulated in the vapor grooves and a part of vapor pipe that creates a little resist to vapor flowing to condenser. In this experiment, the thermal contact resistance R_{ct} was also evaluated. Although evaporator and copper heating block were fastened by the screws and a thin flayer of thermal conductivity grease was used to improve the contact quality, it is still a resistance contribute to the LHP total thermal resistance. This resistance's value changes little from 0.006 K/W to 0.008 K/W in the range of heat load and takes around 3% LHP total thermal resistance.

CONCLUSIONS

In this study, the experiment was setup and conducted to investigate thermal performance of the ethanol LHP with flat evaporator in detail. The results show that heat load at each experimental condition was controlled stable and LHP could kept electronics working at very steady temperature corresponding to every supplied heat load value in the range from 30 W to 400 W. Temperature of the top surface of the heating block T_{s1}, which is assumed as electronics temperatures, increases almost linearly with heat load from 33^{o}C to 133^{o}C and does not beyond 85^{o}C when heat load supplied to LHP is not higher than 220 W. This LHP can start up successful at various applied heat load. At 30 W of heat load, it takes thirteen minutes to establish the working fluid circulation whereas staring at 225 W, this duration can be shortened to four minutes. On the term of thermal resistances, LHP total thermal resistance changes in narrow range from 0.218 K/W and 0.289 K/W with the whole range

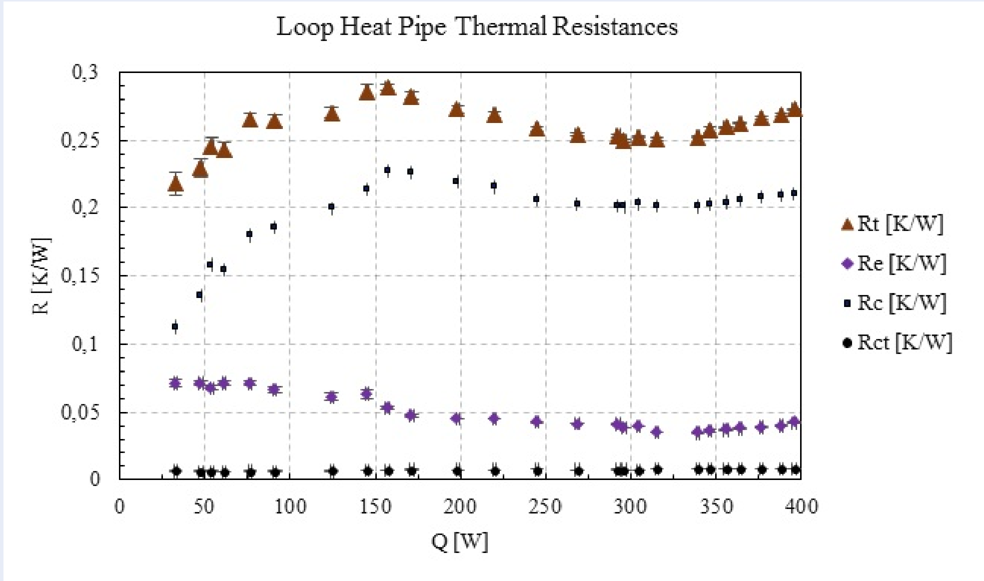

Figure 8: LHP thermal resistances vary with Heat load Q

of supplied heat load and is dominated mostly by thermal resistance existing at LHP condenser.

APPENDIX

DC/DCs: data center/data centers
HP/LHP: heat pipe/loop heat pipe
A: area of the top surafce of the heating block, m^2
ID/OD: pipe inner, outer diameter, mm
k: copper thermal conductivity, W/(m·K)
q: heat flux, kW/m^2
Q: heat load, W
$R_{t,}$: total thermal resistance, K/W
$R_{e,}$: evaporator thermal resistance, K/W
$R_{c,}$: condenser thermal resistance, K/W
R_{ct}: thermal contact resistance, K/W
T_1, T_2, T_3: heater temperatures, ^oC
T_4: evaporator base temperature, ^oC
T_{ci}: temperature at condenser inlet, ^oC
T_{co}: temperature at condenser outlet, ^oC
T_{cci}: temperature at compensation chamber inlet, ^oC
T_{eo}: temperature at evaporator outlet, ^oC
T_{s1}: temperature at heater surface, ^oC
T_{s2}: temperature at evaporator bottom surface, ^oC
T_{wa-i}: temperature of cooling water at inlet position, ^oC
T_{wa-o}: temperature of cooling water at outlet position, ^oC

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CONFLICT OF INTEREST

The authors declare no conflict of interest

AUTHORS' CONTRIBUTIONS

Akio Miyara, Keishi Kariya and Phuoc Hien Huynh contributed in conceptualization and methodology. Akio Miyara, Keishi Kariya supported the experimental apparatus. Phuoc Hien Huynh and Kyaw Zin Htoo contributed in conducting experiment and data collection. Phuoc Hien Huynh, Kyaw Zin Htoo and Kien Quoc Vo interpreted the experiment data. Phuoc Hien Huynh, Thanh Nhan Phan did the bibliography and wrote the manuscript. Phuoc Hien Huynh gave the final correction to the manuscript.

REFERENCES

1. Murshed SMS, de Castro CAN. A critical review of traditional and emerging techniques and fluids for electronics cooling. Renew. Sustain. Energy Rev. 2017;78(2016):821–833. Available from: https://doi.org/10.1016/j.rser.2017.04.112.
2. Nadjahia SLC, Louahliaa H. A review of thermal management and innovative cooling strategies for data center. Sustain. Comput. Informatics Syst. 2018;19:14–28. Available from: https://doi.org/10.1016/j.suscom.2018.05.002.
3. Zhang H, et al. Free cooling of data centers : A review. 2014;35:171–182. Available from: https://doi.org/10.1016/j.rser.2014.04.017.

4. Li J, et al. Experimental studies on a high performance compact loop heat pipe with a square flat evaporator. Appl. Therm. Eng. 2010;30(6-7):741–752. Available from: https://doi.org/10.1016/j.applthermaleng.2009.12.004.
5. Li J, et al. A loop-heat-pipe heat sink with parallel condensers for high-power integrated LED chips. Appl. Therm. Eng. 2013;56(1-2):18–26. Available from: https://doi.org/10.1016/j.applthermaleng.2013.03.016.
6. Xu J, et al. Experimental research on the heat performance of a flat copper-water loop heat pipe with different inventories. Exp. Therm. Fluid Sci. 2017;84:110–119. Available from: https://doi.org/10.1016/j.expthermflusci.2017.02.003.
7. Chernysheva MA, et al. International Journal of Heat and Mass Transfer Effect of external factors on the operating characteristics of a copper - water loop heat pipe," Int. J. Heat Mass Transf. 2015;81:297–304. Available from: https://doi.org/10.1016/j.ijheatmasstransfer.2014.10.037.
8. Huynh HP, et al. Experimental Study on Thermal Performance of Loop Heat Pipe with Flat-Rectangular Evaporator Under Gravity Assisted Condition. EPI Int J Eng. 2018;1(2):40–46. Available from: https://doi.org/10.25042/epi-ije.082018.06.
9. Htoo KZ, et al. Experimental study on loop heat pipe under horizontal condition with different working fluids. J. Mech. Eng. Res. Dev. 2020;43(1):235–245.
10. Htoo KZ, et al. Experimental study on thermal performance of a loop heat pipe with different working wick materials. Energies. 2021;14(9). Available from: https://doi.org/10.3390/en14092453.
11. Ebrahimi K, et al. A review of data center cooling technology, operating conditions and the corresponding low-grade waste heat recovery opportunities. Renew. Sustain. Energy Rev. 2014;31:622–638. Available from: 10.1016/j.rser.2013.12.007.

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Bài nghiên cứu

Nghiên cứu thực nghiệm đặc tính nhiệt của ống nhiệt vòng làm việc với môi chất ethanol và thiết bị bay hơi dạng phẳng trong điều kiện có hỗ trợ trọng trường

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TÓM TẮT

Ngày nay, sự phát triển vượt bậc của công nghệ viễn thông và công nghệ thông tin đã kéo theo những thay đổi đáng kể trong việc làm mát các thiết bị điện tử và một trong những thay đổi cơ bản đó là yêu cầu về năng suất làm mát lớn với kích thước nhỏ gọn. Vì vậy, việc nghiên cứu phương pháp làm mát mới thay cho phương thức sử dụng không khí thông thường để đảm bảo linh kiện hoạt động bền bỉ và ổn định là hết sức cần thiết. Bên cạnh đó, tiết kiệm điện năng tiêu thụ bởi hệ thống cũng là một vấn đề đáng để quan tâm. Ống nhiệt vòng (loop heat pipe), là một thiết bị truyền nhiệt thụ động, hoạt động dựa trên quá trình thay đổi pha và các lực tự nhiên như trọng lực hoặc lực mao dẫn, đã và đang là một trong những giải pháp tiềm năng cho các vấn đề trên. Trong bài báo này, một ống dẫn nhiệt vòng với phần bay hơi phẳng đã được chế tạo để khảo sát các đặc tính làm việc của nó trong quá trình khởi động, giai đoạn hoạt động ổn định trong điều kiện có trọng lực hỗ trợ ở các tải nhiệt khác nhau. Ống nhiệt vòng này được nạp môi chất ethanol và có sử dụng cấu trúc bấc mao dẫn được thiêu kết từ thép không gỉ. Thời gian để khởi động thành công rút ngắn từ 13 phút xuống còn 4 phút khi tải nhiệt tăng từ 30 W lên 225 W. Khi công suất cấp nhiệt cho thiết bị bay hơi được điều chỉnh từ 30 W đến 400 W (14.8 W/cm^2), nhiệt độ bề mặt khối gia nhiệt tăng từ 33^{o}C lên 133^{o}C. Nhiệt độ này có thể được duy trì dưới 85^{o}C, nhiệt độ giới hạn của thiết bị điện tử trong công nghiệp, nếu nhiệt lượng cấp cho ống nhiệt nhỏ hơn 220 W (8.14 W/cm^2). Bên cạnh đó, sự thay đổi của các loại nhiệt trở như nhiệt trở tổng, nhiệt trở tại phần bay hơi và phần ngưng theo công suất cấp nhiệt cũng được thảo luận chi tiết trong bài báo này.

Từ khoá: Ống nhiệt vòng, Giải nhiệt thiết bị điện tử, Làm mát thụ động, Truyền nhiệt có thay đổi pha, Thiết bị bay hơi dạng phẳng

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