ISSN: 0974-5823 Vol. 6 No. 3 December, 2021

International Journal of Mechanical Engineering

Analysis of Temperature Variation in Condenser and Evaporator Closed Loop Pulsating Heat Pipe: Part -2

Bukke Nagamuni Naik[1] Pramod R. Pachghare[2]

[1]*Research Scholar of Department of Mechanical Engineering, Government College of Engineering, Amravati, SGBAU*

[2]*Faculty of Mechanical Engineering, Government College of Engineering, Amravati, SGBAU*

Abstract: In the new era, heat removing is the major issue from the components likely electrical, chemical, aerospace. Pulsating Heat Pipe is the new era, where the heat is removed from electrical, chemical and aerospace. In this research PHP is taken as two turn with fifty percent of working fluid as water. Inner and Outer Diameter are 2 mm & 6mm respectively. Heat input is varied from 20W to 80W with increase of 10W each. The visualization part – 1 is shown clearly about the images of different flows at various input of heats. In this journal analysis the evaporator and condenser temperature analysis from 20W to 80W heat input varying 10W at step wise.

Index Terms –Pulsating heat pipe, heat input and thermal analysis.

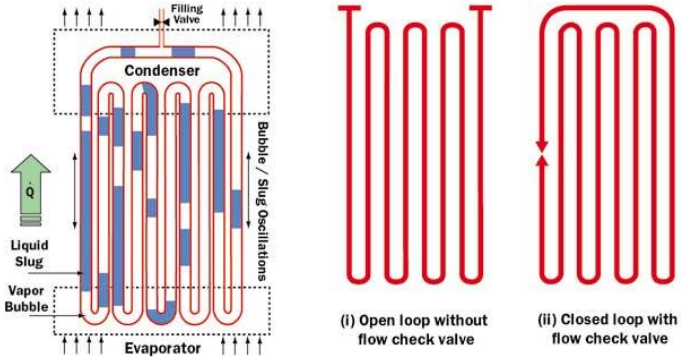

Figure1: Pulsating Heat Pipe: Open Loop and Closed Loop Pulsating Heat Pipe

INTRODUCTION:

Closed Loop Pulsating heat pipe is a type of Pulsating heat pipe, family of heat pipe in which heat pipe is a wickless structure. Akachi [1-3], Japanese researcher taken patent in 1990's. Pulsating heat pipe is of two type's open and closed loop as shown in fig 1. In Thermal management heat removing from an object is necessary to save the equipment with cracks, wear and tear. Heat pipe is a device to remove heat from a system and is developed by R. S. Gaugler [4]. Previously so many researchers are done so much research namely Angier March Perkins [5] Jacob Perkins [6], F.W. Gay [7], and L. Trefethen [8]. Grover [9] who named as heat pipe with wick structure. Difference between heat pipe and Pulsating heat pipe is a wick structure where the vapour returns in a wick structure in heat pipe and there is no wick structure and the fluid returns directly in pulsating heat pipe. Pulsating heat pipe is also known as Osculation heat pipe. Different types of PHP [10], there are so many parameters which effects pulsating heat pipe [11]. Experiments research [12-19] gives the basic information for the pulsating heat pipe.

EXPERIMENTAL SET-UP DESCRIPTION:

Fabrication of PHP (20-21), Visualization (22) can observe. CLPHP is made up of copper pipe with ID 2 mm and OD 6 mm. FR 50%, increased the heat input of 10W up to 80W. L_e = evaporator length= 285 mm, L_c = condenser length =160 mm and L_a= adiabatic length = 576 mm. Mass flow rate in the condenser is maintain constant as 0.004 kg/sec. Temperatures in evaporator as T_1, T_2, T_3 and T_4 and temperatures in the condenser section are T_5, T_6, T_7 and T_8. The inlet and outlet temperature are T_9 and T_{10} respectively and these temperature are read by thermocouples directly.

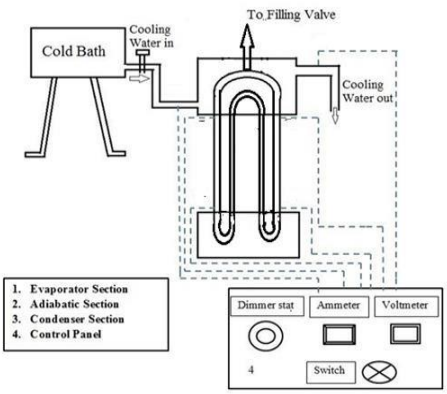

Figure 2: Line diagram of PHP

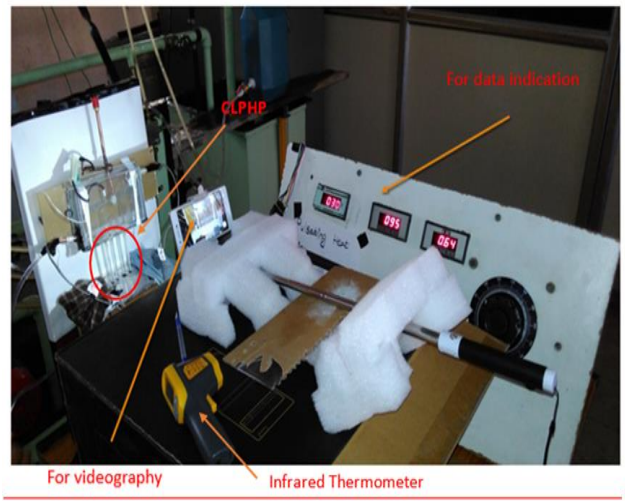

Figure 3: Experimental setup

Results and Discussions:

1) At 20W input: The evaporator temperatures are 36.75, 37.17, 38.57, and 37.42. Average temperature of condenser is 37.477. The Condenser temperatures are 35.62, 34.92, 35.40 and 35.315. Average condenser temperature is 35.31. Difference between condenser and evaporator is 2.162. The behaviour of temperature in graph is shown below. These results ties with the study [23-

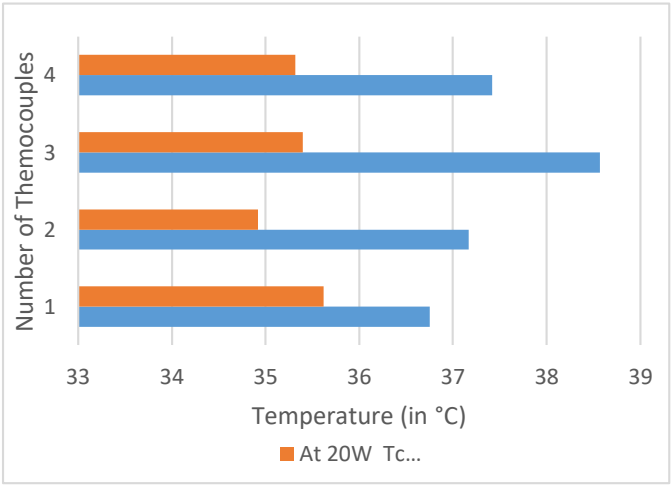

Figure 4: The behaviour of temperature at 20W

2) At 30W input: The evaporator temperatures are 40.20, 48.67, 50.72 and 50.77. Average temperature of evaporator is 47.59. . The condenser temperature are 35.70, 37.95, 44.37 and 44.37. Average condenser temperature is 35.31. Difference between condenser and evaporator is 6.99. It is nearly equals to 7. Difference between evaporator and condenser is increased. The behaviour of temperature in graphs are shown below

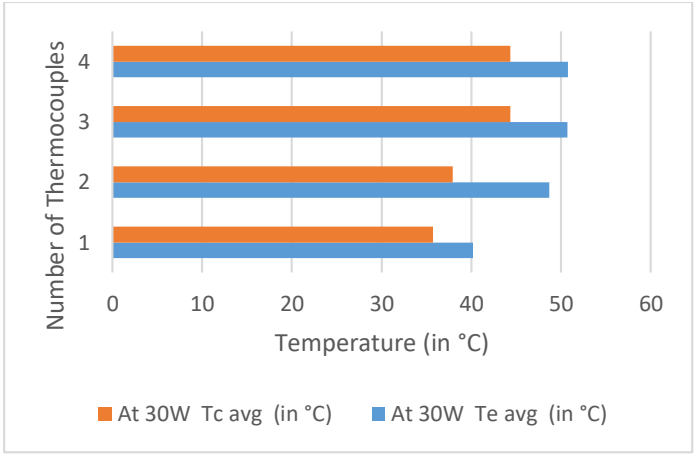

Figure 5: The behaviour of temperature at 30W

3) At 40W input: The evaporator temperatures are 53.25, 53.47, 56.07 and 58.32. Average temperature of evaporator is 55.27. The condenser temperature are 44.72, 44.90, 43.67 and 47.97. Average condenser temperature is 45.31. Difference between condenser and evaporator is 9.96. It is nearly equals to 10. Difference between evaporator and condenser is increased. The behaviour of temperature in graphs are shown below

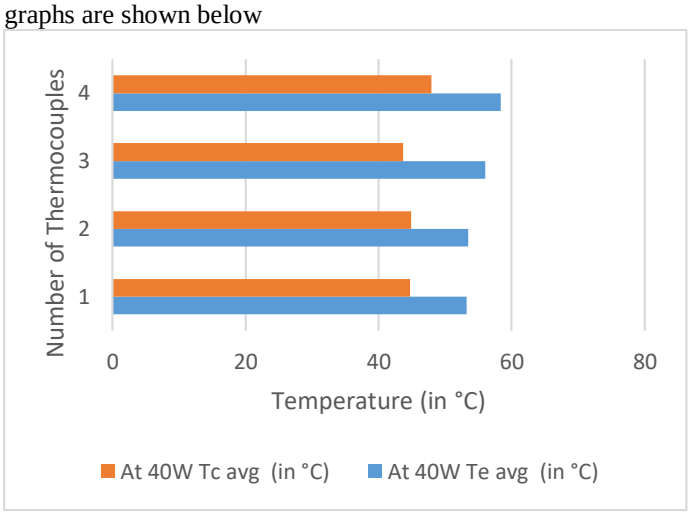

Figure 6: The behaviour of temperature at 40W

4) At 50W input: The evaporator temperatures are 56.69, 59.54, 59.72 and 62.47. Average temperature of evaporator is 59.60. The condenser temperature are 45.72, 46.52, 49.57 and 50.34. Average condenser temperature is 48.03. Difference between condenser and evaporator is 11.56. Difference between evaporator and condenser is increased. The behaviour of temperature in graphs are shown below

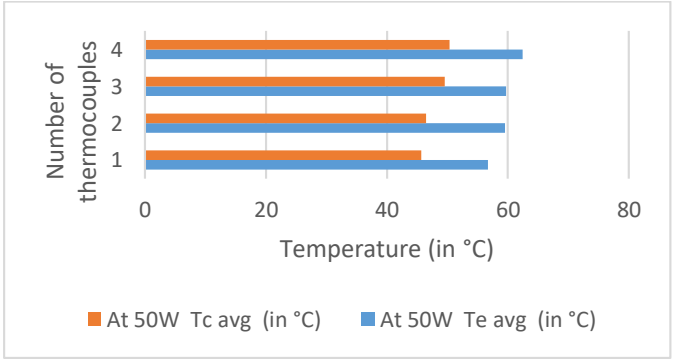

Figure 7: The behaviour of temperature at 50W

5) At 60W input: The evaporator temperatures are 61.19, 66.57, 64.47 and 66.91.Average temperature of evaporator is 64.78. The condenser temperature are 47.95, 48.87, 49.75 and 51.12. Average condenser temperature is 49.42. Difference between condenser and evaporator is 15.36. Difference between evaporator and condenser is increased. The behaviour of temperature in graphs are shown below

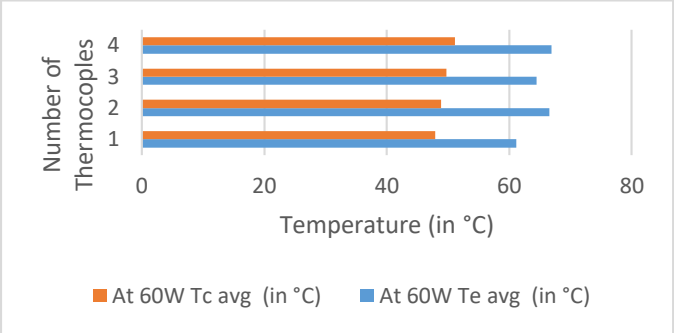

Figure 8: The behaviour of temperature at 60W

6) At 70W input: The evaporator temperatures are 66.60, 66.32, 67.62 and 69.45. Average temperature of evaporator is 67.49. The condenser temperature are 49.27, 52.27, 51.12 and 54.05. Average condenser temperature is 51.67. Difference between condenser and evaporator is 15.82. Difference between evaporator and condenser is increased. The behaviour of temperature in graphs are shown below

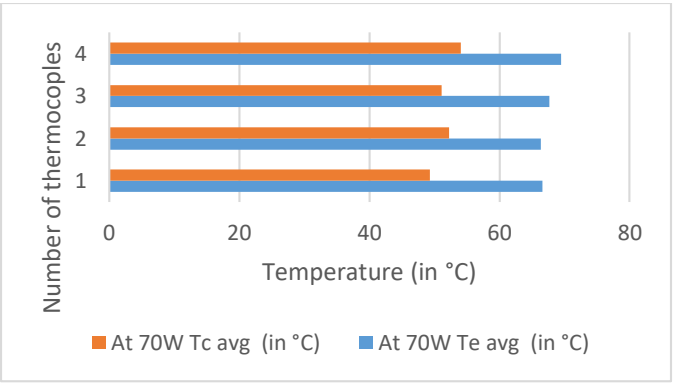

Figure 9: The behaviour of temperature at 70W

7) At 80W input: The evaporator temperatures are 66.05, 66.77, 75.62 and 57.07. Average temperature of evaporator is 70.66. The condenser temperature are 58.15, 58.60, 60.55 and 57.07. Average condenser temperature is 58.59. Difference between condenser and evaporator is 12.07. Difference between evaporator and condenser is increased. The behaviour of temperature in graphs are shown below

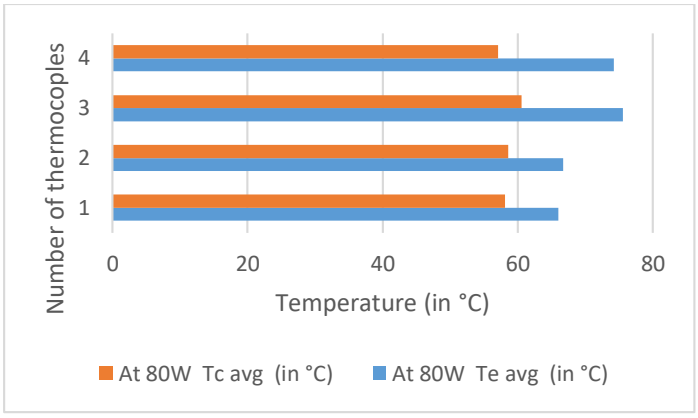

Figure 10: The behaviour of temperature at 80W

8) Average Temperature of Condenser and Evaporator at Inputs:

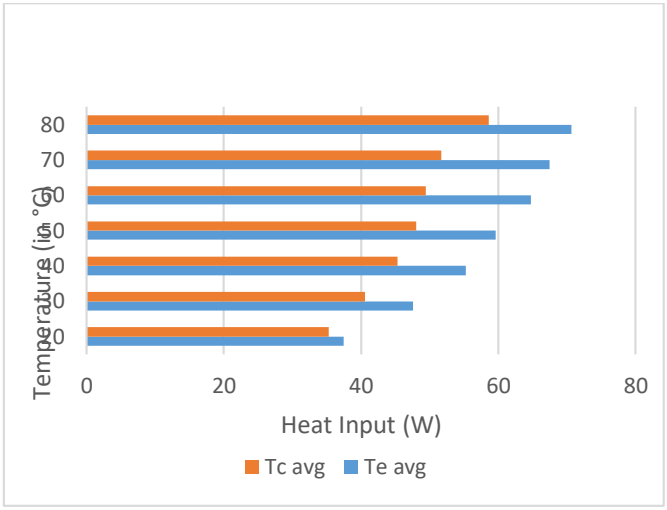

Figure 10: Heat Input vs Average Temperature of Condenser and Evaporator

Differences of temperature between Condenser and Evaporator:

The difference between the Condenser and Evaporator temperature in graph is shown below:

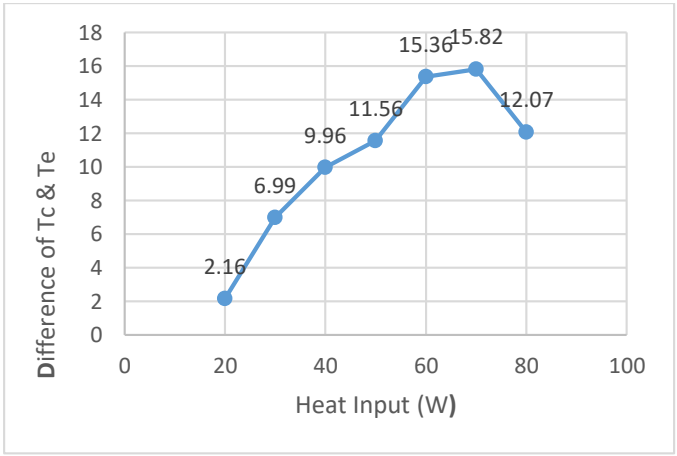

Figure 11: Heat Input vs Difference of Temperature between Condenser and Evaporator

Conclusions:

1. When the temperature of the condenser increases the difference if the temperature increases.
2. Difference of the temperature is more at 70W input.
3. Even in the increase of evaporator temperature, the cooling (condenser) temperature is slowly increased.
4. Thermal resistance is mainly based on the condenser and evaporator temperature.
5. Temperature differences are increased up to 70W and then decreased and need further research.

References:

1. Akachi, H., 1990, "Structure of a heat pipe," U.S. Patent 4,921,041.
2. Akachi, H., "Looped Capillary Heat Pipe," Japanese Patent No. 697147, 1994.
3. Akachi, H., Polášek, F., Štulc, P., 1996. "Pulsating Heat Pipes," *Proceedings of the fifth International Heat Pipe Symposium*,208–217.
4. Gaugler, R. S., *"Heat Transfer Device"*, June 1944, U. S. Patent 2,350,348.
5. Perkins, Angier March ("A.M."), "hermetic heating tubes" a.k.a. "Perkins System", 1831 UK Patent 6146.
6. Perkins, Jacob, "Perkins Tube", April 1936 UK Patent 7059
7. Gay, Frazier W. ("FW"), *"Heat transfer means",* August 1942, United States Patent 1725906
8. Trefethen, L., "On the Surface Tension Pumping of Liquids or a Possible Role of the Candlewick in Space Exploration", G. E. Tech. Info., Ser. No. 615 D114, Feb. 1962.
9. Grover, G. M., Cotter, T. P. and Erikson, G. F., "Structures of Very High Thermal Conductivity", J. *Appl. Phys.*, 35, 1990 (1964)
10. P. Charoensawan, S. Khandekar and M. Groll, "Closed Loop and Open Loop Pulsating Heat Pipes", 13th International Heat Pipe Conference, Shanghai, China, 2004, pp. 21-25.
11. Bukke Nagamuni Naik, P. R. Pachghare " Major Ten Parameters", *Information Technology in Industry* Vol. 9, No.2, 2021
12. P. Pachghare M., Mahalle, Khedkar, S., "Effect of Working Fluid on Thermal Performance of Closed Loop Pulsating Heat Pipe: A Review," *International Journal of Computer Applications*, 9, 2012, pp. 27-31.
13. J. Wang, H. Ma, Q. Zhu, Effects of the evaporator and condenser length on the performance of pulsating heat pipes, *Applied Thermal Engineering* 91 (2015) 1018-1025.
14. P. Charoensawan, S. Khandekar, M. Groll and P. Terdtoom, "Closed Loop Pulsating Heat Pipes Part A: Parametric Experimental Investigations", *Applied Thermal Engineering*, Vol. 23/16, 2003, pp. 2009-2020.
15. S. Khandekar, N. Dollinger, and M. Groll, "Understanding Operational Regimes of Pulsating Heat Pipes: An Experimental Study", *Applied Thermal Engineering*, ISSN 1359- 4311, Vol. 23/6, 2003, pp. 707-719.
16. D.A. Baitule, P.R. Pachghare, "Experimental analysis of closed loop pulsating heat pipe with variable filling ratio", *International Journal of Mechanical Engineering and Robotics Research* 2(3) (2013) 113-121
17. P. Pachghare, M. Mahalle, "Thermal performance of closed loop pulsating heat pipe using pure and binary working fluids," *Frontiers in Heat Pipes* (FHP), 3, 2012, pp. 2-6
18. Manfred Groll, Sameer Khandekar, "An insight in to thermo-hydrodynamic coupling in closed loop pulsating heat pipes", *International Journal of Thermal Sciences* 43 (2004) 13–20.
19. S. Khandekar, 'Insights into the performance modes of closed loop pulsating heat pipe and pulsating heat pipe and some design hints', *Heat and Mass Conference*, January 2006, PP. 11.
20. Chuljae Jung, Jonghyun Lim, SungJin Kim, "Fabrication and evaluation of a high-performance flexible pulsating heat pipe hermetically sealed with metal", *International Journal of Heat and Mass Transfer* 149 (2020) 119180.
21. N Santhi Sree, N V V S Sudheer, P.Bhramara, "Experimental Set up of Two Closed Loop Pulsating Heat Pipe (CLPHP) with Water base Fluids", *International Journal of Innovative Technology and Exploring Engineering (IJITEE*), ISSN: 2278-3075, Volume-8, Issue-12S, October 2019.
22. Bukke Nagamuni Naik, P. R. Pachghare, "Thermodynamic Analysis and Visualization of Closed Loop Pulsating Heat Pipe", *AIP Conference Proceedings* 2421, 060007 (2022).
23. Lawankar, S. M., Shoeb J. Inamdar, and Shubham K. Changole. "Performance Analysis of Photovoltaic Module Using Microchannels and Nanofluids." Smart Technologies for Energy, Environment and Sustainable Development, Vol 2. Springer, Singapore, 2022. 469-485.
24. Inamdar, Shoeb J., and H. S. Farkade. "Performance enhancement of refrigeration cycle by employing a heat exchanger." International Journal of Engineering Research and Advanced Technology (IJERAT) 2.11 (2016).
25. Shoeb J. Inamdar, Umesh Patil and Hrishabh Lodam, "Thermal Energy Storage System using Bamboo in Combination with PCM." Int. J. Eng. Adv. Technol 8 (2019): 865-869.
26. Inamdar, Shoeb J., A. Junghare, and P. Kale. "Performance enhancement of evaporative cooling by using bamboo." Int. J. Eng. Adv. Technol 8 (2019): 856-860.