A review on Heat Pipe

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Abstract: Heat pipe is an extremely good heat conducting component made from a combination of couple of materials in a specific manner which gives it a head start to conduct the heat from a heat source to heat sink with negligible amount of heat loss in between instantaneously. The study aimed to develop the knowledge of understanding heat pipes by collecting and designing the data available in all types of forms throughout the material spectrum and displaying in such a manner of order from basics to advanced information regarding heat pipe and contribute new insights into the proficiency of considerations while designing and fabrication of heat pipe and look into how change in diameter of heat pipe effects the performance. This paper presents a review of work done by various resaerchers in heat pipe in terms of their design and analysis.

Keywords: Heat pipe, Sink

Introduction: The history of heat pipe begins as original heat pipe operating principle developed by Richard S. Gauzgler of the General Motors Corporation in 1942. Modern heat pipe technology was originated from the Los Alamos Scientific Laboratory by George Grover in 1963. Later NASA picked up the principles and fundamentals of heat pipe and further developed the technology to the point it can even cool satellites electronics in zero gravity orbits.

The answer to the question what makes an heat pipe such an effective thermal conductor lies on what is inside the heat pipe as from the outside it just looks like a cylindrical or not necessarily a cylinder as is comes in different shapes which will be conversed further. Theoretically heat pipe is bisected into three regions namely evaporation state, adiabatic phase & condensation state. Heat pipe is a hollow tube sealed on both ends and around the inner diameter there is a material called wick in the form of fibrous material, sintered material or in the form of groves and its function is to hold the working fluid present in the tube and make it travel end to end while it is in liquid form.

Working principal: A **heat pipe** is a heat-transfer device that combines the principles of both **thermal conductivity** and **phase transition** to effectively transfer heat between two solid interfaces. The process of liquid to vapour and vice versa circulates between evaporation to condensation with the help of capillary action and that is the reason why heat pipes are irrelevant of inclination**. Heat pipe thermal cycle is as follows:**

1) Working fluid evaporates to vapour absorbing thermal energy.

2) Vapour migrates along cavity to lower temperature end.

3) Vapour condenses back to fluid and is absorbed by the wick, releasing thermal energy.

4) Working fluid flows back to the higher temperature end.

Advantages and limitations:

A major advantage of heat pipes is that they remain more cost-effective than vapor chamber cooling, thus making them more popular in numerous applications, including the conventional design of hardware components found in most desktop computers.

Heat pipes are also not ideal for situations that use high power and thus, have high cooling demand. The system would need multiple pipes to solve the thermal challenge, thus resulting in more costs and restricted design options. Vapour chambers are more suitable for high-power situations because they are more efficient.

Literature survey The work done by various resaerchers is shown below.

Sharmishtha Singh Hada et al. [1] stated that in electrical and electronic industry due to miniaturization of electronic components heat density increases which, in turns increases the heat flux inside it. They concluded that High Power input and low temperature at the source causes start up problem in operation while constant transport power and low temperature causes vapor velocity reach to sonic velocity. Orientation of heat pipe also affect the performance of pipe, so in horizontal plane highly efficient wick should be used and for pipe in vertical plane thermo syphon type heat pipe mostly used because gravitational force is responsible for returning action without the use of wick structure.

Stéphane Lips [2] reviewed and found that the development of predictive tools for the design of heat pipes remains challenging, even for conventional technologies. As a result, heat pipes are still the object of more than 250 scientific articles a year. Their review aims to identify and understand the current scientific approaches followed by scientists in heat pipe science. The different types of heat pipe are reviewed in order to identify the main phenomena involved in these systems. They concluded and gave a brief review of recent studies focused on heat pipes enables to highlight the main approaches used by the research teams to increase the understanding of the various types of systems. Both experimental and theoretical works were proposed and the scale of interest of the studies varies from the system size itself to the scale of the very thin liquid film present in the evaporation and condensation zones.

Kapil Dev et al. [3] have reviewed on heat pipes and found that it is a passive device with a very high thermal conductance. It is a closed evacuated tube or chamber of different shapes, the inner surfaces of which are lined with a porous capillary wick. They concluded that the heat pipe is a useful device that can be used in both heating and cooling applications. In this work, two- dimensional finite-element models are developed for the simulation of heat pipe in four different cases by using Ansys software.

Patrik Nemec et al. [4] have experimented and told that heat pipe is a device working on two phase change of working fluid inside. This phase change of working fluid lead to increasing heat transport efficiency of heat pipe. They concluded that from experimental measuring thermal performance of heat pipes are create graphic dependences average values of thermal performance from working position of heat pipe. Ideal working position of heat pipe is vertical position.

Rakesh K. Bumataria et al. [5] works on the technological development that leads to need of more compact thermal management system especially in electronic cooling systems. Heat pipe with the use of mono and hybrid Nano fluids are recent trends to satisfy the need of enhanced heat transfer and miniaturization in size. They gave an overview of thermal performance of heat pipe using mono and hybrid Nano fluids as working medium. Open literature shows great potential of mono and hybrid Nano fluids for the enhancement of heat transfer in heat pipe.

Juraj Kabat et al.[6] have investigated the heat performance of a Multi-Layered Oscillating Heat Pipes Heat Exchanger (ML-OHPHE) for the application of heat recovery in heating, ventilation and air conditioning systems (HVAC systems). They concluded that the possibility of using diethyl ether filled ML-OHP heat exchanger serving as a passive air-to-air heat recovery heat exchanger. The experiment results prove that onset of stable oscillations of the working fluid heavily increases the heat transfer performance compared to the empty heat exchanger.

Luca Pietrasanta et al. [7] have reviewed on the constant demand for innovation in heat transfer solutions for compact and more powerful electronics is driving the research towards new technologies able to dissipate more power in reduced dimensions. They concluded that the oscillating/pulsating thermally induced flow motion characteristic of Pulsating Heat Pipes is difficult to characterize due to its extremely complex dynamics linked to the evaporation and condensation of the working fluid.

H. R. Goshayeshi et al. [8] have experimented on the use of Fe_2O_3 nanoparticles added to kerosene as a working fluid, under magnetic field for Copper Oscillating Heat pipe with inclination angle of 0°(horizontal), 15°, 30°,45°, 60°,75° and 90° (vertical). They concluded that the thermal efficiency for a copper oscillating pipe under different angle with Fe_2O_3/Kerosene Nano fluids under different experimental conditions, the optimal thermal efficiency occurred at 75 degree inclination for copper oscillating heat pipe.

Sagar M. Shinde et al. [9] have done experimental investigation on the consumption of hot air which represents a significant part of the nation's energy consumption. One way of reducing the energy consumption involved, and hence the cost of that energy, is to reclaim heat from the waste warm air that is discharged to the sewer each day. They have done the experimental investigation on two phase closed thermo syphon heat pipe heat exchanger charged with BN/H20 Nano fluid. The effect of source temperature and mass flow rate of hot and cold air streams on effectiveness of Nano fluid charged heat pipe heat exchanger was experimentally investigated.

M. A. Boda et al.[10] provides a wide-ranging review of the state of the applications, performance and materials of current heat pipe heat transferring devices. Heat pipes are becoming increasingly popular as passive heat transfer technologies due to their high efficiency. According to them the most importance of the current study is to know how the thermal performance decreases or increases due change in the temperature difference between the evaporator and the condenser. How much effectively works the different working fluids in heat pipe works and the different application of heat pipe as a heat transfer device.

C.K. Loh et al.[11] have reviewed on the pressure drop across heat sink and found that it is one of the key variables that govern the thermal performance of the heat sink in forced convection environment. There are several analytical methods to estimate the heat sink pressure drop, however correctly selecting one that can represent the reality over a range of airflow found in typical electronics cooling application is difficult. In this paper, they proposed a modified analytical method to estimate the channel velocity and used it to calculate the total heat sink pressure drop through different theoretical pressure drop equations. The theoretical results produced from the theoretical equations were compared against results gathered from experimental study and numerical method.

H.Jouhara et al. [12] reviewed on heat pipes and told that these are becoming increasingly popular as passive heat transfer technologies due to their high efficiency. They provide a comprehensive review of the state-of-the-art applications, materials and performance of current heat pipe devices. They divided it into four main parts; low temperature heat pipes, high temperature heat pipes, thermal modeling of heat pipes and discussion. And concluded that the implementation of heat pipes is beneficial for multiple industries, and they can be applied to a range of operation temperatures from cryogenics to kilns. Although the range of applications is large, this also means that there is a significant amount of work to be conducted to make the system viable in every combination of temperature and application. There are obvious gaps in research for different temperatures and applications.

Conclusion

The above paper presents a review of work done by various researchers on the designing and parametric effect of heat pipe. It has been found by looking at the work done by various researchers that heat pipe is a passive technique for the transfer of heat. It has a very wide applications and there are many ways through which we can increase the thermal efficiency of a heat pipe. It is also concluded from the literature that heat pipe can be used for both the heating and cooling applications and still there is lot left to be explored in it.

References

[1]Sharmishtha Singh Hada,Sharmishtha Singh Hada,"Influence of Different Parameters on Heat Pipe Performance",Journal of Engineering Research and Applications www.ijera.com ISSN: 2248-9622, Vol. 5, Issue 10, (Part - 1) October 2015, pp.93-98.

[2]Stéphane Lips, Valérie Sartre, Frédéric Lefèvre, Sameer Khandekar, Jocelyn Bonjour,"Overview of heat pipe studies during the period 2010-2015",Department of Mechanical Engineering, Indian Institute of Technology.

[3] Kapil Dev , Balvinder Budania,''SIMULATION AND MODELING OF HEAT PIPE",International Journal of Technical Research (IJTR) Vol. 5, Issue 1, Mar-Apr 2016, ISSN 2278-5787.

[4] Patrik Nemec, Alexander Čaja, Milan Malcho,"THERMAL PERFORMANCE MEASUREMENT OF HEAT PIPE", Global Journal of Technology and optimization Volume 2, 2011, ISSN:2229-8711 Online Publication, June 2011.

[5**]** Rakesh K. Bumataria a , N.K. Chavda b , Hitesh Panchal,"Current research aspects in mono and hybrid nanofluid based heat pipe technologies", www.heliyon.com, https://doi.org/10.1016/j.heliyon.2019.e01627.

[6] Juraj Kabat, Stefan Guzela, and Peter Peciar,"HVAC Systems Heat Recovery with Multi-Layered Oscillating Heat Pipes", Journal of Mechanical Engineering strojinicky casopis, DOI: https://doi.org/10.247./scjme-2019-0004.

[7] Luca Pietrasanta, Prof. Marco Marengo, Dr. Nicolas Miche,"Experimental analysis of two-phase flows in the context of Pulsating Heat Pipes for space applications", Accepted Paper - 10th International Conference on Multiphase Flow, ICMF Rio de Janeiro, Brazil, May 19 – 24, 2019.

[8] H. R. Goshayeshi, M. Mansori, M. Ahmady, M. Khaloyi,"Experimental Investigation with Different Inclination Angles on Copper Oscillating Heat Pipes Performance Using Fe2O3/Kerosene under Magnetic Field", World Academy of Science, Engineering and Technology International Journal of Mechanical and Mechatronics Engineering Vol:9, No:11, 2015, scholar.waset.org/1307-6892/10002645.

[9] Sagar M. Shinde , Dr. R. R. Arakerimath , P.J. Bansod,"Performance Study of Heat Pipe Heat Exchanger Using Nanofluid (BN) Used in Boiler Plant- Experimental Study",International Journal of Innovative Research in Science, Engineering and Technology (A High Impact Factor, Monthly, Peer Reviewed Journal) Visit: www.ijirset.com Vol. 6, Issue 10, October 2017,DOI:10.15680/IJIRSET.2017.0610196.

[10] M. A. Boda, T. B. Shaikh, S. N. Sayyed,"INNOVATIVE DEVELOPMENTS AND HEAT TRANSFER APPLICATIONS OF HEAT PIPE", IJSDR1806050, International Journal of Scientific Development and Research (IJSDR) www.ijsdr.org, ISSN: 2455-2631 © June 2018 IJSDR | Volume 3, Issue 6.

[11] C.K. Loh, D.J. Chou ,"Comparative Analysis of Heat Sink Pressure Drop Using Different Methodologies",Enertron Inc. 100 W. Hoover Suite 5 Mesa, Arizona 85210 (480) 649-5400.

[12] H.JouharaA.ChauhanT.NannouS.AlmahmoudB.DelpechL.C.Wrobel,"Heat pipe based systems - Advances and applications",Energy,Volume 128, 1 June 2017, Pages 729-754.