Effect of Various Filling Ratio in Thermal Performance of Heat Pipes in Grinding Wheel - Review Article

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Abstract- *The current advancements in the field of thermal engineering has led to many inventions which aid people with neophyte can acquire knowledge easily. One of such inventions is heat pipe which can give better thermal performance and high heat transfer in both open and closed loop operation. Even a heat pipe can operate in any of the positions like horizontal, vertical and zig-zag tubed structured which gives variable heat transfer according to working fluid motion. In this paper, Heat pipe is deployed inside a Grinding wheel and the various Thermal performances are found owing to the filling ratio.*

Keywords- Filling ratio, Heat pipe, Self-cooling, Thermal performance.

I. INTRODUCTION

In our modern world, Heat is a major factor that influences any system. It is important that to improve the heat transfer process and also to reduce the complexity of operation. A heat pipe is heat transfer device, works on the principle of thermal conductivity and phase transfer. The heat pipe consists three main section namely, evaporator, adiabatic and condenser section. In evaporator section, the thermally conducted working fluid will turn in to vapour phase, then the vapour phase will moves to condenser section for cold interface, then the vapor condenses back to liquid form in heat pipe operation. Initially, the working fluids turns to vapor phase either by gravity, centrifugal force (or) external action. Even though, the process of heat transfer is carried out regularly, the very high heat transfer co-efficient and thermal conductivity will condense the working fluid from vapor to liquid form at the condenser section of heat pipe.

II. LITERATURE REVIEW

1. **Jacob Perkins**, descendant of Angier March Perkins developed Perkins's tube. In Perkins tube water was used because the operating fluid that cosmopolitan from the evaporator and condenser sections through the twisted metal tubes. It was the fundamental 2 section heat transfer model for the vent of standard heat pipes (CHP). Actual development in standard heat pipe (CHP) began in 1960 many ballistic capsule industries started their analysis on heat pipes. They developed and used heat pipes for managing heat in are a craft.
2. **Akashi H** in 1990 developed new variety of heat pipe brought up as periodic heat pipe (OHP or PHP). OHP has big variety of applications in physical systems to its capability of dissipating high heat flux. This review can de- scribe the event and operation of periodic heat pipe and summarizes the work done by various researchers on periodic heat pipes for rising its potency. He has taken a traditional heat pipe consists of a sealed instrumentation, wick structure and dealing fluid. In heat pipes, primarily instrumentation having cylindrical structure is used but it square measures usually in any form and size. Heat pipe is divided into 3 main sections: Condenser, Evaporator and adiabatic section. On the inner bound of the instrumentation there is wick structure, which can be a porous structure through that operating fluid interprets from condenser to the evaporator and therefore the different method around.
3. **L.L. Vasiliev** had a variety of operating fluid primarily depends upon the temperature range that it is to be used. Adiabatic section primarily works as a transport passage for the operating fluid. OHP works on the principle of oscillation of operating fluid and natural action phenomena within a tube. This literary criticism primarily focuses on control system periodically on CLOHP. CLOHP consists of shut loop of indirect tubes, through that operating fluid flows for the heat transfers. Condenser section and middle adiabatic section. The operating fluid with applicable fill- ing magnitude relation (generally 30%-70%) is employed in CLOHP that circulates through all the 3 section of CLOHP. A vacuum is formed within associate OHP tubes followed by charging of operating fluid with correct filling ratio. When the charging gets complete, there is a definite proportion of liquid and vapor style of operating fluid,

that is understood as liquid slug and vapor bubbles are within the evaporation section heat is evaporated, with the assistance of that liquid slug gets reborn into vapor bubbles and pressure of vapor gets will increase. Vapor bubbles of fluid square measures and then transferred to the Condenser section through adiabatic section, which ends into pressure region and as a result liquid fluid once more come to evaporator section through the adiabatic section, during this method the cycle gets completed. The Operating fluid within the OHP oscillates from evaporator region to the condenser region primarily because of the pressure distinction created within the tubes by the formation and breaking of vapor bubbles that is the solely reason for the transfer of heat source from evaporator to the condenser section.

4. **Yuwen Zhang** and **Amir Faghri** terminated that when the OHP is equal throughout the region, the liquid and vapor phases of the OHP exist in equilibrium at a saturation pressure rather like the mounted equal temperature. In this operation, throughout there is a gradient between the evaporator and condenser that causes anon-equilibrium pressure condition. The hot section of the heat to the evaporator causes the bubbles at intervals the evaporator to grow endlessly and tries to exchange from higher section to lower section at the next pressure and temperature to the inner-connection of the tube. The motion from the liquid slugs and vapor bubbles at condenser section together finishes up within the motion of the slugs and bubbles in another section on the brink of the evaporator. The interaction between the driving and restoring forces finishes up within the oscillation of vapor bubbles and liquid slugs at intervals the axial direction. However, not like ancient heat pipes, it is not do able for associate operative OHP to attain steady-state pressure equilibrium.
5. **Lin et al.** examined the effect of heat transfer length and inner diameter on the heat transport capability of oscillating heat pipes. They designed four different heat pipes with the different diameters and with the different lengths. By increasing inner diameter or decreasing heat transfer length is profitable for the setup of OHP (or) PHP. It is also for high heating power, the thermal performance of OHP can only come close up to that of sintered heat pipes in horizontal heating mode, while it exceeds in vertical bottom heating mode.
6. **Honghai Yang**, **S. Khandekar** and **M. Groll** investigated that Work done on heat pipes are suggest that the working fluid employed for oscillating heat pipes should have Dynamic viscosity should be small so that, it will generate very lower shear stress. Bythe usage of high specific heat, can be rounding off by low latent heat of working fluid. In addition to the low surface tension may create further pressure drop. When the Latent heat of working fluid is low then there will quick bubble formation and collapsing occurs, it also acknowledges that sensible heat is the predominant heat transfer condition.
7. **Mohammad B. Shafii, Amir Faghri** and **Yuwen Zhang** examined that analytical models for each un- loop and Closed PHP heat pipes with multiple liquid slugs and vapor plugs. He resolved by governing equations victimizing a precise finite distinction theme to forecast the behaviour of vapor plugs and liquid slugs. He knows that gravity doesn't have vital impact on the performance of unlooped PHP with higher heat mode. Heat transfer in every closed and unlooped PHP is especially with the exchange of vast heat and with performance of the PHPs, whereas it involves in the participation every evaporation and condensation method. During this case the oscillation of liquid slugs and by increasing the diameter of each PHPs, will increase the overall average heat transfer.
8. **Tung et al.** devised an oscillating heat pipe. He also surveyed the heat transfer performance and effect of inclinations. They identified that heat transfer performance of the heat pipe with 100% of filling charge ratio is greater than that of 30% of filling charge ratio. The effective thermal conductivity of oscillating heat pipe with the 100% of filling charge ratio was 18958W/mK, that was loftier than that of 30% of filling charge ratio. The effective thermal conductivity of oscillating heat pipe with the 100% of filling charge ratio was 18958 W/mK, that was loftier than that of copper with (401W/mK) 47 times. By his observation, vertical OHP can run with fewer turns but horizontal OHP needs a greater number of turns to work congruously.
9. **Wilson et al.** experimented with 4 OHP to observe fluid flow of vapor bubbles and liquid slug. He had identified the effect on the temperature distribution and heat transfer performance in 4 OHP. He had taken both open loop and closed loop OHP by experimenting with working fluids such as acetone and water. He examined that in closed loop OHP, both working fluids acetone and water has predominantly decreased the movement with the connecting turns. He had concluded that, to inflate the performance of OHPs, flow in connecting turns should be reinforced.
10. **Pranab K. Barua, D. Deka and U.S. Dixit** had done a Mathematical Modelling by observing that, change in temperature in a Pulsating Heat Pipe with numerous (or) multiple turns. He had taken two postulations. The first postulation for multiple(or)numerous turns are temperature(T) decreases exponentially with time (τ), where α and β are constants with condition $\alpha > 0$ and $\beta < 0$. He concluded that, temperature decreases exponentially

with time in numerous turns of the evaporator section. He also identified that the instantaneous failure rate υ = - β rises when the number of turns in the evaporator section also increased gradually. The second postulation is that by incrementing in exponential is common, but with the aid of log linear regression equation is mandatory. He concluded statistically that, if the number of turns increases then rapidly failure rate is also raised simultaneously.

11. **Nannan Zhao, Dianli Zhao** and **H.B Ma** described on heat transfer and ultrasonic sound effect with oscillating motion in OHP. He exercised the piezoelectric ceramics for the creation of ultrasonic sound. He observed the ultra-sonic sound in OHP, with a total electric power of 4.48 mW is identified. The actual input power required to initiate the oscillating motion in OHP is from 30W to 18W. The effective thermal conductivity ranges from 672.8 W/mK to 1254.7 W/mK.
12. **Sakulchangsatjatai et al.** carved the heat transfer characteristics equations of a Closed End and Closed Loop OHP. In normal working condition, he used the explicit finite element method. He also taken mass, momentum and energy equation with some assumptions on each and every separate vapor bubbles and liquid slug. The principle of internal friction flow, basic governing equations and a finite difference method were introduced to measure the heat transfer rate. The forecasted heat transfer rate is calculated from the model, then it was compared with the existing experimental data and analysis report. He also analysed the results of effect of the working fluid like water and acetone, evaporator length, internal and external diameter of both Closed End OHP and Closed Loop OHP respectively.
13. **Sejung Kim, Yuwen Zhang** and **Jongwook Choi** investigated on the fluctuation of temperature in both heating and cooling section of PHP and also, he studied the effects in the performance of pulsating heat pipe. He had exercised the periodic and random noise fluctuations by ranging the temperature difference in both heating and cooling sections. He additionally introduced the temporary fluctuations of the periodic components in heating section and some standard fluctuation of the random components in cooling section. He concluded by the research that, by decreasing the frequency of liquid slug oscillation proportionally amplitude of periodic fluctuation of the wall temperature increases. However, the change in different standard deviations will not affect in performance of the pulsating heat pipes (PHP).
14. **Launay et al.** introduced a transient model to forecast both the thermal and hydrodynamic behaviour of a oscillating heat pipe. He had introduced this transient model with the help of analytical models which is researched by author shafii for both unlooped and looped PHPs. The transient model of the loop is further sub-divided into two systems, in which primarily transient laws like conservation of mass, energy and conservation of momentum is applied. Then secondarily the model will assume the frequency range, amplitude wave form and various design parameters like length, diameter and thickness of heat pipe. He mainly observed that the periodic exchange of sensible heat in heat pipe under the evaporation and condensation section. Further, in his research he concluded that oscillation of liquid slugs will not affect the performance of oscillating heat pipes by using various design parameters respectively.
15. **Wannapakhe et al.** investigated by working fluid as silver nano-fluid under different concentration ratios instead of using water and acetone etc. In Computational Fluid Dynamics (CFD), nano-fluids are considered to be single-phase in nature. The distributing of a nano-fluid droplets is added by the solid-like ordering structure of nano particles collected near the contact line by diffusion process, which it further gives rise to a structural disjoining pressure at the vicinity of the contact lines of heat pipes. He had examined that the heat transfer rate of silver nano-fluid as working fluid is much greater in performance than the heat transfer rate of pure water in CLOHP. In addition to that the silver nano-fluid increases the heat flux by 10% superior than other working fluids such as water, acetone, etc.
16. **Charoensawan et al.** researched on the effects of internal and external diameter, surface gravity, oscillation of working fluid, number of turns and thermal performance of oscillating (or) pulsating heat pipe (PHP). He identified that, surface gravity of heat pipe will definitely affect the thermal performance of oscillating heat pipe in evaporator section, and also number of turns in heat pipe will reduce the bridge gap between vertical and horizontal direction of working fluid oscillation in OHP. The change in parameters will cause effect in performance of heat pipe with higher flux values. He also noticed that, if the diameter of heat pipe is not sequentially positioned then the dissipation of heat transfer at condenser section will be affected.
17. **Vinod Kotebavi et al.** investigated on the experimental study solar heat pipes. He observed that the working fluid, filling amount, mode of collector and inclination angles made a consequential effect on the performance of solar heat pipe. Solar heat pipe with evacuated tubes flaunted a better performance than the parabolic collectors in nature. By using evacuated tubes as collector, the temperature increases by 30^0 C from its static temperature. While increasing the level of the working fluid in evaporator section to about 25% from its nominal volume, the heat

exhibited were given the maximum efficiency and high heat transfer rate. Even though a quick response were shown by acetone and methanol primarily, but at the end they obtained almost equal value of temperature likely as water. In addition to that, it was very clear that, the solar heat pipe is very sensitive to the angle of position. A 60^0 angle is proved to be more efficient and accurate in performance of heat pipe than 35^0 angles of inclination.

18. **Kuo-Hsiang Chien et al.** made his study on a novel design of pulsating heat pipes with non-uniform channel pattern. He introduced that, the unbalanced capillary force in heat pipes will settle the flaws of fewer turns subjected to horizontal structured PHP. The experimental outcome shown that, by increasing the circulating speed of working fluid, the thermal resistance and heat transfer rate increases gradually in PHPs. While in increasing the angle of inclination in tubes, the thermal resistance is reduced owing to gravity effect. Although, it shows that the uniform tubes pattern in PHP is more perspective to inclination, but it is not for horizontal configuration.
19. **Dharmapal A Baitule, Pramod R Pachghare** done an experimental study of filling ratio in pulsating Heat Pipe. Filling ratio is one of the critical parameters of heat pipe, which is commonly used to achieve maximum thermal performance and minimum thermal resistance in Closed Loop Pulsating Heat Pipe (CLPHP). According to his experimental setup, he stated that by filling 60% of working fluid at evaporator section will gives finest result in Pulsating Heat Pipes. He noticed that, the experimental result of working fluids in the sequence of $R_{acetone} < R_{methanol} < R_{ethanol} < R_{water}$. This sequence of process is maintained up to 48 W and then the thermal Resistance of Acetone gets increases scarcely. By increasing of heat input of PHP, the thermal resistance will abruptly decreases.
20. **Harshal Gamit et al.** presented a paper on experimental performance of the Closed Loop Pulsating Heat Pipes. He observed that the system works superior in low filling ratio with the same input heat flux at steady state evaporator temperature section. By increasing the heat flux gradually, then the difference in evaporator temperature and Condensation temperature will be identified. As the heat input expands, the thermal resistance of working fluid movement will reduces at condensation section. While the input from heat flux gets increases, the difference between steady state evaporation temperature (T_e) and steady state condensation temperature (T_c)gets thrives periodically.
21. **Shekhar G Khedkar et al.** presented the experimental analysis of PHP under different working fluid conditions. Normally, Pulsating Heat Pipes will have higher fetching heat transfer elements. By using simpler design, PHP gives splendid thermal performance in many closed loop PHP applications. In his analysis, he used three different refrigerants as working fluids like R 134a, R-22, R 600a respectively. From this experiment analysis, he noticed that the thermal resistance (Rth) of PHP with the boiling point and latent heat of R600a is more than R22 and R134a, in the sequence of R22<R134a<R600a. If the evaporator temperature (T_e) of R600a is more than R134a and R22, then the results is like T_e = R22<R134a<R600a. He also calculated the efficiency of PHP, results in the ranges like η= R22>R134a>R600a.
22. **Krunal B Gaywala, Hiren A Shah** designed and fabricated the experimental prototype to examine the performance of heat pipe with ethanol, methanol and acetone as a working fluid. He noticed that, by using thermodynamic relations of heat supply in heat pipe, the quantity of water can be determined easily. In this experiment, he had taken the continuity equation of mass flow rate of water and the operating temperature of both evaporator and condensation section. In the midst of ethanol, methanol and acetone, Acetone is the best and effective refrigerant for good thermal performance of heat pipe. Comparatively, all water, methanol and acetone has the best thermal performance at their particular operating temperature range.
23. **Jaydeep et al.** made an experimental analysis on the effect of different working fluid application in L-Shaped heat pipe. It consists of disparate wick structure, modification in wick thickness are used to identify the performance of L-shaped heat pipe with various heat inputs. He had concluded from his experiment that, the usage of ethanol as working fluid combined with screen mesh as wick structure resulted the best than the performance of acetone and screen mesh wick. For low heat input with sintered powder and low thickness, acetone gives better result and for higher heat input ethanol performed well.
24. **Barot et al.** investigated on the experiment of thermal performance of Micro Heat Pipe (MHP) is carried out with varying flow rates of working fluids and heat inputs. He concluded that, working fluid flow rate has a fundamental effect on the performance of Micro Heat Pipes. The given heat input also has the noteworthy effect on the performance of micro heat pipes. In additionally, he found that, if the heat input is higher, then the overall heat transfer coefficient also increases.
25. **Syahrul Muhammaddiyah et al.** made his study on Heat Pipe and Heat Exchanger by changing the both evaporator inlet air temperature and inlet air velocity periodically. From his experimental result, he identified that the combined Heat Pipe and heat Exchanger module will be able to reveal its operation as a heat recovery process

inside the system. This module shows intently reduced energy use in High Vacuum Air Conditioning systems. It can be only applied to such systems, especially in operating rooms only. In his research, he noticed that if the highest heat recovery value is attained only by supplying consummate air-mass flow rate and high inlet air temperature. It can be laid out that particular heat recovery effect will be achieved only from the Heat Pipe Heat Exchanger module with wavy fins.

26. **Sadey et al.** researched on two different types of aluminium heat pipes with experimental analysis of using Ammonia as its working fluid. The two aluminium pipes consist of one is with-wick and other is without wick heat pipes respectively. The with-wick heat pipe is made up of screen mesh. This with-wick heat pipe is placed at same angle of inclination in the horizontal direction. He noted from his experimental analysis that, the amount of heat transfer (Q) for ordinary heat pipe is 12567 J and the amount of heat transfer (Q) for both with-wick and without wick aluminium pipe is 8374 J. He concluded that, the heat transfer for heat pipe is higher when stack up against with the aluminium heat pipe, but the temperature gradient is low for heat pipe when stack up against with the aluminium pipe.
27. **Jafari et al.** proposed the study on a detailed experimental analysis and results about the heat transfer performances of a Heat pipe constructed for a specific solar application. His experimental outfit is developed to notice the thermal performance of a cylindrical copper Heat pipes by using water as a working fluid. In the cylindrical heat pipe, the axial distribution of the wall temperature are measured in both evaporation and condensation section. By testing on different heat inputs under both steady-state and transient conditions, it was noticed that the temperature variation along the walls of the evaporator section of the heat pipe is nearly reduced at the adiabatic section. After the analysis of results, the author made the evaluation of the maximum heat transfer capacity of Heat Pipe by changing the parameters like multiple filling ratios (10-50%), angle of inclination (0-90˚) and different cooling water temperatures (25-90˚C) respectively.
28. **Mobin Arab**and **Ali Abbas** developed a complete model for a furrowed type evacuated tube solar heat pipe. The substantiated solar heat pipe used working fluids like acetone, water and methanol. He observed that, the 3 modified theoretical working fluids are used to measure the contact of working fluid with respect to the change in a real evacuated tube solar heat pipe. He concluded that, by independently changing the working fluid properties, simultaneously higher performance of solar heat pipe (up to 84%) is feasible. By altering the working fluid, it will give about 50% development in the economy of the solar heat pipe.
29. **Taoufik Brahim et al.** made a comparison with both solar heat pipe and conventional flat plate solar heat pipe systems. The conventional flat plate solar heat pipe has the benefit of active as good thermal diode. Some of the factors considered while measuring the solar heatpipes are weather conditions, instrumentation, measurement techniques and testing procedure. His solar heat pipe experimental setup was steered with outdoor conditions. By increasing the manifold position, the heat transfer coefficient increases by convection through the entire system. He noticed that, to increase the limitations of operation in heat pipe with increase in mesh screen number in solar heat pipe is mandatory. He had concluded that, by using various fluids methanol plays a vital role in thermal performance of solar flat plate heat pipe.
30. **Manimaran et al.** reviewed on the heat pipe working and effects on the boiling and capillary constraints. The fluid assail has a direct impact on the internal dimension and design parameter if the evaporator section deviates periodically. He noticed that, heat pipe shows greater improvement in heat transfer while the filling ratio is in the range of 40% to 85%. He observed that, the wick structure in heat pipe has main effect on the heat pipe performance that gives capillary pressure difference for the liquid–vapor flow in both evaporator and condenser sections. The working fluids druthers mainly on the operating vapor temperature range. He noticed that nano-fluids has better thermal performance in improving the thermal efficiency of the heat pipe.
31. **Tenga et al.** investigated on the filling ratio of working fluid in the heat pipe under working condition. He had in experiments with the two postulations of working fluids filling ratio range. In the first postulation, at the 0% filling ratio, heat pipe is having conduction mode of heat transfer inside the device with very high infelicitous thermal resistance. By the second postulation, at the 100% fully filled filling ratio of heat pipe is similar in operation with that of single-phase thermosiphon. The thermosiphon action is very high for a vertical heat pipe than horizontal heat pipe and here heat transfer done only in axial conduction.
32. **Jian et al.** studied about the heat transfer performance and effect of aluminium oxide mixture with water in Oscillating Heat Pipe. He observed that, the conspicuously improvement in heat transfer rate after the addition of aluminium oxide (Al_2O_3) with water in the working fluid. He had noticed the comparison of aluminium oxide (Al_2O_3) with the pure water as working fluid. In his observation, the consummate reduction of thermal resistance of about 32.5 % which occurs only at

70% of filling ratio in working fluid mixture and thereby if 0.9% mass fraction is obtained only with the power input of 58.8 W respectively.

33. **Yu-Hsing Lin et al.** investigated on the effects and thermal performance of silver nano-fluid on pulsating heat pipe. In Pulsating heat pipe, substantially the higher filling ratio of working fluid will obstruct the pulsation of the bubbles inside the adiabatic and condenser section. He also observed that the efficiency of the heat transfer in PHP will not be useful for obtaining better thermal performance. He had noticed from his experimental setup that, the low filling ratio will easily carry out the pulsation of the bubble, but as soon as it gets dry out abruptly in condenser section. He had concluded that, the silver nano-fluid in oscillating heat pipe should be properly filled with filling ratio in between 40%-60% to obtain good thermal performance.
34. **Hussain H. Ahmad and Raqeeb H. Rajeb** researched on the study of parameters of working fluids affecting a heat pipe. From his experimental result, we know that the filling ratio and heat input are the two important parameters which affects the thermal performance of heat pipe. At 50^0 angles of inclination, the optimum thermal performance of heat pipe is obtained with the filling ratio in the range of 50–75%. At 25^0 angles of inclination, the minimum thermal performance of heat pipe is obtained with the filling ratio is about 25%.
35. **Wen Kang et al.** observed that effects of nano-fluids thermal performance of heat pipe. He had taken assumptions that, in the first assumption, the selection of a suitable working fluid in the operating temperature range within 50^0C -1500^0C. Some of the primary parameters are heat pipe material, thermal stability, vapor pressure, high latent heat and thermal conductivity. In his second assumption, by increasing wall temperature difference is lower than that of pure water filled in heat pipe under different heat inputs with silver nano particles scattered in working fluid.
36. **Ali.A.Dehoff et al.** investigated on the first wicked heat pipe which is discovered in 1963. Later, the heat pipe in early 1990's had initiated to be utilized in very high-volume electronics devices. Today, heat pipes are used as a thermal management tool used in every power supplies and heat exchangers units. It is due to the better thermal performance and heat transfer in the entire system. Nearly, every computer and other electronics are using a heat pipe to transfer of heat from CPU to the EMI bulwark of the keyboard. He concluded that, only by natural convection the evaporation is carried out at evaporator section and radiation takes place while conversion of working fluid in condenser section. While in low CPUs, the passive design of heat pipe gives better thermal performance than other heat pipe designs.
37. **Tun-Ping Tenga et al.** made an experimental investigation on the thermal efficiency of heat pipe with alumina nano-fluid. He observed that, if the thermal efficiency turned is lower in concentration of about 1.0 wt.%, then the concentration of added nano-particles will be about 3.0 wt.%. From his experimental analysis, we know that by adding too many nano-particles to the working fluid will tends to change the working fluid property into solid phase at the evaporator section. By altering the internal design of heat pipe made lead to reduce the thermal efficiency at entire operating system of heat pipe.
38. **Morjan et al.** made a comparison and analysis of water with the thermosyphon heat pipe. From his experimental analysis, he noticed that by adding the iron oxide (FeO) nano-particles with thermosyphon heat pipe at multiple concentration levels, shows drastically increase in heat transfer rate in heat pipe. For example, let us consider if the 2% iron oxide (FeO) nano-particles is added with thermosyphon in heat pipe results in increase with the heat transfer rate of about 19%. He concluded that, when the inclination angle of heat pipe is about 90, then there will be increase in heat transfer rate of 39% in 2% iron oxide nano-particles.
39. **Paisarn Naphon et al.** made an analysis on the titanium nano-fluids working on the heat pipe for better thermal efficiency. He had noticed that, by gradually increasing angle of inclination with the gravitational force has a significant effect on the flow of working fluid in between the evaporator and condenser section with increases in heat pipe efficiency. But, if heat pipe angle of inclination exceeds above 60° for water and 45° angle of inclination for alcohol, then tends to decrease in heat pipe thermal efficiency.
40. **Senthil kumar et al.** investigated on the performance of Heat Pipe Using Copper Nano-fluid with Aqueous Solution of n-butanol. He observed that, if the angle of inclination increases then simultaneously the thermal efficiency of heat pipe increases. From his experimental results, he concluded that if the heat pipe angle exceeds above 30° for water and exceeds 45° angle of inclination for copper nano-fluid, then copper nano-fluid mixes as solute for an aqueous solution of n-butanol. If the n-butanol aqueous solution is saturated more than saturation level, then the thermal efficiency of heat pipe has a propensity to decrease.
41. **Hiren A Shah et al.** done an experimental investigation and Analysis of Heat Pipe for Methanol, Ethanol and Acetone as a Working Fluid. A water-to-water Heat Pipe is constructed and experiment is carried out. Acetone is

proved to be efficient refrigerant amongst ethanol, methanol and acetone. Similarly, all refrigerant is suitably the best at their operating temperature range conditions.

42. **Barot Deep et al.** designed and fabricated a Heat pipe (MHP). The experiment of investigating thermal performance of MHP is done by varying the coolant flow rates, working fluids and heat inputs. From the results the following conclusion can be made. Coolant flow rate has a significant effect on the performance of MHP. Heat input has significant effect on the performance of MHP. It is found that overall heat transfer coefficient is higher for higher heat input. In spite of reducing the size of the micro heat pipe, here the size of the micro heat pipe is increased.
43. **D Jafari et al.** designed and done an experimental analysis of a screened heat pipe for solar applications. The study proposed in this paper presents a detailed experimental apparatus and preliminary experimental results about the heat transfer performances of a HP designed for a particular solar application. The experimental apparatus has been developed to investigate the thermal performance of a cylindrical copper HP using water as a working fluid. Transient experiments were performed using a uniformly heated evaporator section and a convectively cooled condenser section (temperature of 24.8˚C). The results obtained are in very good agreement with data obtained by a numerical HP model previously presented by the authors. After these preliminary results, the authors will further develop the experimental analysis to evaluate the maximum heat transfer capacity of HP for different filling ratios (10-50%), inclination angles (0-90˚) and low-to-medium cooling water temperatures (25-90˚C).
44. **Harshal Gamit et al.** have done an Experimental investigation on pulsating Heat Pipe. Steady state evaporator temperature *Te* is observed to increase with increase in FR for the same heat input values. Difference between steady state evaporator temperature *Te* and steady state condenser temperature *Tc* increased with increase in input heat flux. For the same heat input values, system took longer time to reach steady state with increase in FR.
45. **Jentung Ku et al.** made an advanced Loop Heat Pipe for Cryogenic Applications. Several CLHPs have been built and tested using nitrogen and hydrogen as working fluids, and these CLHPs demonstrated excellent performance in thermal vacuum tests. Hydrogen CLHP in thermal vacuum testing is described.
46. **Tien-Chien Jen et al.** done an Experimental Study of Thermosyphon Cooling for Drilling Operation. Concluded with the advantages of the use of a thermosyphon or a heat pipe to cool a drill.
47. **Qingshan He et al.** illustrated heat pipe principle and making process about heat pipe grinding wheel. During the grinding titanium alloy Ti-6Al-4V experiments, results show that using the HPGW can maintain grinding temperature at a low level below 100℃. Compared with the non-HPGW, the grinding temperature can reach up 700℃ at the same grinding condition. Meanwhile, it confirms that the HPGW has a significant heat transfer capacity to reduce grinding temperature and prevent the burnout.
48. **Jiajia Chen et al.** Have done a study on thermal performance of revolving heat pipe grinding wheel. The simulations were performed for different input heat flux, filling ratio and rotational speed. The model predictions for the relationship between *Nu* and *Ra* in the evaporator were in good agreement with existing experimental data.
49. **Stephane Lips et al.** Have done a study on Combined effects of the filling ratio and the vapour space thickness on the performance of a flat heat pipe. A theoretical model has been developed in non-working conditions to analyse these experimental data. A perspective of this paper is to extend this model in working conditions.
50. **Bhojani Milan et al.** Have Designed and Simulated a Heat Pipe in Grinding Wheel. The performance of Rotating Grinding Wheel Heat Pipe mainly depends on the types of working fluid, material of container material and design consideration of heat pipe. The surface temperature of Grinding Wheel decreases sharply with using heat pipe rather than an assembly without heat pipe.

III. PROBLEM IDENFICATION

- Next generation space infrared sensing instruments and spacecraft will require drastic improvements in cryocooling technology in terms of performance and ease of integration.
- By experimenting on different heat loads under steady-state and transient conditions, it was observed that the temperature variation along the wall surface of the evaporator section of the HP was nearly uniform and decreased slightly along the adiabatic section.
- Difference between steady state evaporator temperature and steady state condenser temperature increased with increase in input heat flux. For the same heat input values, system took longer time to reach steady state with increase in FR.
- The groove structure inside the evaporator had great influences on the heat transfer performance of the ULHP system.
- The heat leakage was reduced by improving the structure. Effectively reducing the heat leakage can result in a significant evaporator temperature drop and faster started-

up. Both increasing the length of the entrance section and adjusting the groove structure inside evaporator were valid measures.

- The heat pipe can be constructed with different wick structures and various available working fluids.
- Nanofluids can be used as working fluid.
- Heat pipes are getting replaced by micro heat pipes in many of the electronic equipment cooling.
- Optimization can be performed between various heat pipe models, shapes, working fluids, wick structures, fill ratios, tilt angles and heat inputs. Even different phase change materials can be used along with the heat sink.
- When using coolant, there was severe plastic deformation and grain refinement beneath the work piece surface.
- An increase of rotational speed will decrease the heat transfer coefficient due to suppression of nucleate boiling.
- The effect of stress concentration factor is not considered which comes into the picture when the number of heat pipes inside the grinding wheel increases.

IV. CONCLUSION

Based on our research work, many hindrances are identified in Machining Operations. One among them is cooling. Especially between the work piece and tool. Coolants are supplied with the application of external energy. Our ideology is to create a natural cooling system without external energy. Our objectives are;

- To Design a Grinding Wheel that consist of in-built Heat pipe cooling system.
- To study the Effects of filling ratio on Thermal Performance of the Grinding Wheel Heat Pipe.
- To simulate the Grinding Wheel under working conditions.

We hope that by the end of this research, we would have created an efficient way for cooling the space between the work piece and the Grinding wheel in such a way that self-cooling is established.

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