iJRASET
International Journal For Research in
Applied Science and Engineering Technology

# INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

**Volume:** 6 **Issue:** II **Month of publication:** February 2018

**DOI:**

www.ijraset.com

Call: 08813907089 | E-mail ID: ijraset@gmail.com

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue II, February 2018- Available at www.ijraset.com

# Performance of Heat Input and Angle of Inclination of the Heat Pipe

Muthukumar M[1], Senthilkumar R[2], Manikandan K[2]
[1]Research scholar, Department of Mechanical Engineering, Annamalai University, Annamalai Nagar – 608 002,
[2]Assistant Professor in Mechanical Engineering, Annamalai University, Annamalai Nagar – 608 002

***Abstract: A heat pipe is a self – contained wick structure which achieves very high thermal conductance by means of two – phase fluid flow of the working fluid with capillary circulation, in this analysis, the thermal efficiency of the heat pipe using De-Ionized water (DI water) as the working fluid. The parameters considered in this study are heat input, angle of inclination and filling ratio of the working fluid. The inputs considered as 30, 40, 50, 60 and 70 W. The angles of inclinations are $0^0$, $15^0$, $30^0$, $45^0$, $60^0$, $75^0$ and $90^0$ with respects to horizontal direction. Filling ratios used in this work are 20%, 40%, 60%, 80% and 100% of the evaporator volume. The experimental results are evaluated in terms of its terms of its terms of its thermal efficiency. The results show that the thermal efficiency is maximum at 80% filling ratio, $30^0$ inclination of the heat pipe and 70W heat input.***
***Keywords: Heat pipe, filling ratio, heat input, angle of inclination, thermal efficiency.***

## I. INTRODUCTION

The increasing development of electronics leads to higher constraints regarding their thermal management, Two-phase passive system and among these systems heat pipes in particular become more and more attractive because they offer thermal efficiency, reliability and larger implementation flexibility, simple construction, and easy control with no external pumping power. Heat pipe is one of the equipment used for removing waste heat from the equipment with high thermal transfer. When the heat is connected to the evaporator, the working fluid available in the heat pipe is got heated up and vapour formed travels to the condenser section and vapour is condensed and returned back to the evaporator with the help of wick structure present in the heat pipe which induces the capillary action inside the pipe. Heat pipe science also provides an opportunity for scientists and engineers to apply a variety of complex physical phenomena and fundamental laws in the thermal – fluids area to a relatively simple system, such as the heat pipe. Cotter [2] recognition of the heat pipe as a reliable thermal device was initially due to the preliminary theoretical results and design tools that were reported. The heat pipe are more advantageous in heat recovery systems, solar energy, electronics cooling, ocean thermal energy conversion, air craft cooling, geothermal conversion and light water nuclear reactors [3-5].

## II. EXPERIMENTAL PROCEDURE

The schematic diagram of the experimental setup is shown in the Figure 1. The specifications of heat pipe are tabulated in Table 1. Heat input was given at the evaporator section by means of electrical supply through the heater which is attached to it with proper electrical insulation. The desired heat input was supplied to the evaporator end of the heat pipe by adjusting the varies. Water jacket is provided at the condenser end to remove the heat from the heat pipe. The heat pipe has the ability to transfer the heat through the internal structure. As a result, sudden rise in wall temperature occurs which could damage the heat pipe if the heat was not released at the condenser properly. Therefore, before heat was supplied to the evaporator, the cooling water was first circulated through the condenser jacket. The power input was gradually raised to the desired power level.

The surface temperatures at ten different locations along the heat pipe were measured using T – type thermocouple at a regular time interval of five minutes until heat pipe reaches steady state condition. Out of ten, three thermocouples are located in the evaporator, three on the condenser and remaining at the evaporator section. Two more thermocouples were used to measure the water inlet and outlet temperatures in the condenser section. Once steady state was reached, the input power was turned off a cooling water was allowed to flow through the condenser to cool the heat pipe in order to make it ready for further experimental purpose. Then the power was increased to the next level and the heat pipe was tested for its performance. Experimental procedures were repeated for different filling ratios, different flow rates and different inclinations of the heat pipe with respect to the horizontal and observations were recorded.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
*ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887*
*Volume 6 Issue II, February 2018- Available at www.ijraset.com*

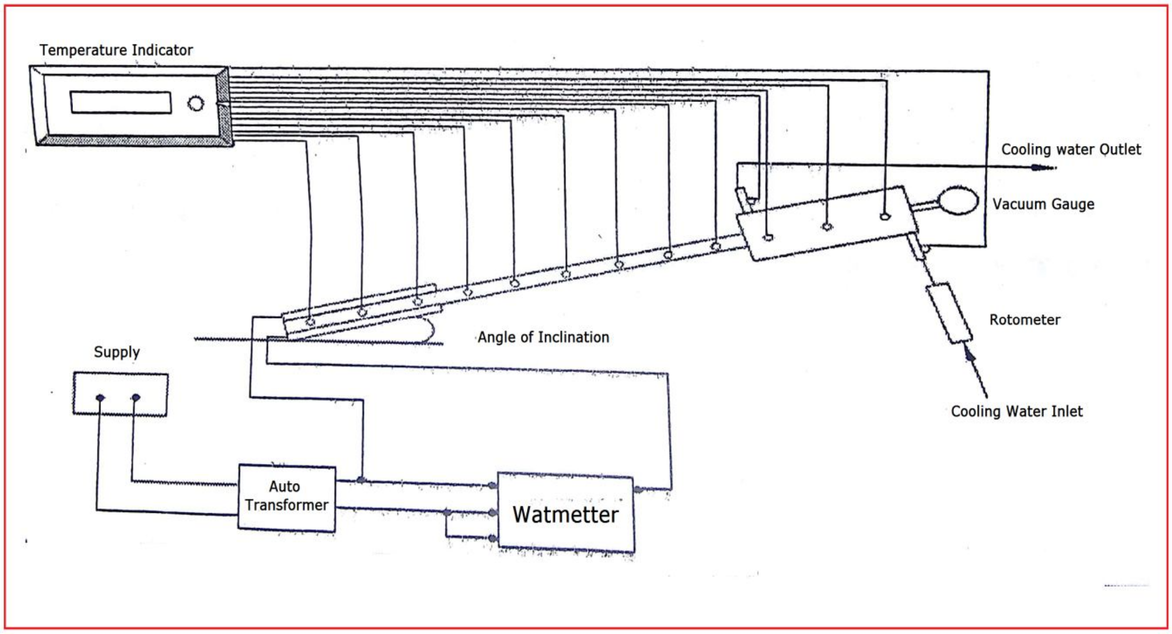



Figure 1. Schematic diagram of experimental setup.

| Specification | Dimensions |
|---|---|
| Outside diameter, m | 0.020 |
| Inside diameter, m | 0.0176 |
| Evaporator length, m | 0.150 |
| Condenser length, m | 0.150 |
| Adiabatic length, m | 0.300 |
| Total length, m | 0.600 |
| Working Fluid | DI Water |
| Wick mesh size, | 80 per Sq. inch |
| No. of layers of wick | 2 |

Table 1. Specifications of heat pipe

## III. RESULTS AND DISCUSSIONS

The thermal efficiency of the heat pipe is calculated from the ratio of the cooling capacity rate of water at the condenser section to the supplied power at the evaporator section. Figure 2 – 6 show the variation of thermal efficiency of the heat pipe with respect to the various heat inputs, various angles of heat pipe inclination and different heat inputs. From all the figures, it is clear that the thermal efficiency of heat pipe increases with increasing values of the angle of inclination up to $45^0$ for all filling ratios of the working fluid. It is due to the fact that, the temperature of the working medium increases and hence more amount of heat can be removed in the condenser section. It is not only due to the capillary action of wick but the gravitational force also has considerable cause on the flow of working fluid between the evaporator section and the condenser section. Also the formation of the liquid film in the inner side of condenser section which is at higher rate results in the increased values of the thermal resistance between the vapor of the working gluid and the cooling medium in the condenser, conversely, when the angle of inclination of heat pipe exceeds $30^0$, the heat pipe thermal efficiency starts to decrease from its value. It is due to the higher rate formation of liquid film inside the condenser resulting in the increased value of the thermal resistance. The thermal efficiency of the heat pipe is maximum for 80% filling ratio of the working fluid in the heat pipe than the other filling ratios.

The thermal efficiency increases with increase of heat input in the evaporator. The thermal efficiency of the heat pipe increases with increasing heat flux, due to the fact that the temperature difference between the evaporator and condenser sections increases which results in higher evaporation heat transfer rate of working fluid. At higher heat input in the evaporator section, the heat transfer from its surface to the working medium is higher and it causes the working medium which is in the form of vapour to move vigorously into the condenser section.

The thermal efficiency increases with increases in the filling ration of working fluid in the evaporator up to 80% of the evaporator volume, afterwards it tends to decrease because the space available for the flow of vapour and liquid gets reduced. As a result of that thermal efficiency gets reduced when filling ratio exceeds above 80%.

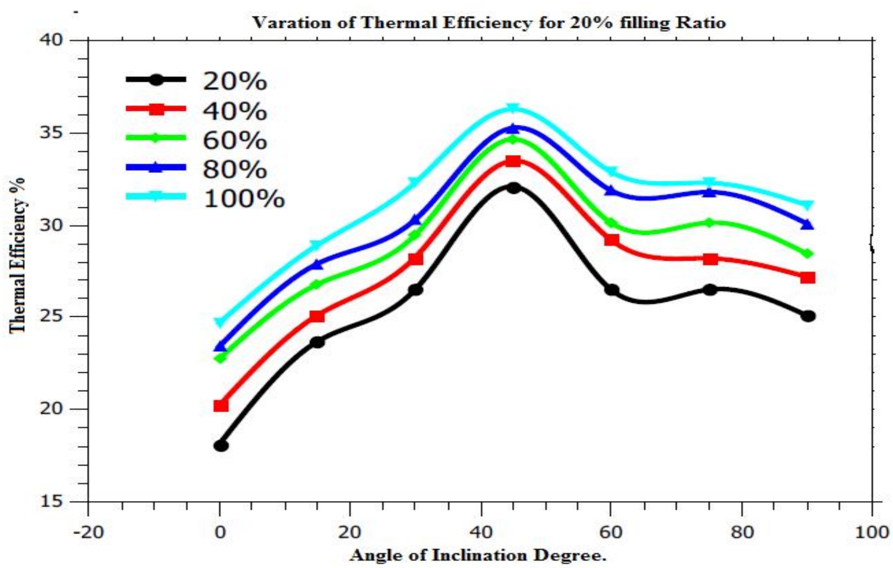



Figure 2. Variations of thermal efficiency for 20% filling ratio

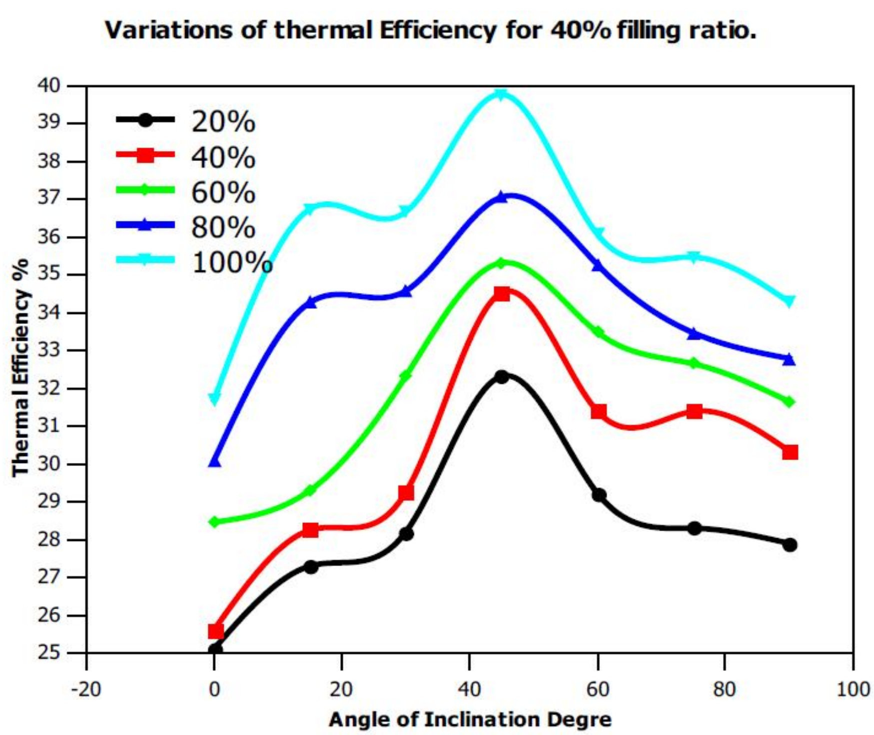



Figure 3. Variations of thermal efficiency for 40% filling ratio

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
*ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887*
*Volume 6 Issue II, February 2018- Available at www.ijraset.com*

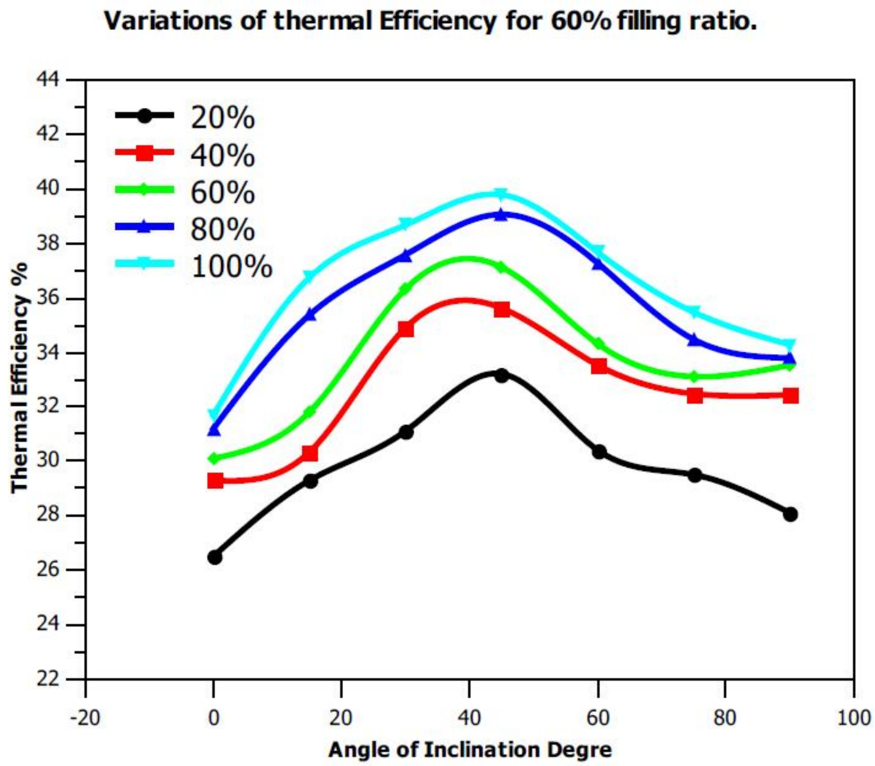



Figure 4. Variations of thermal efficiency for 60% filling ratio

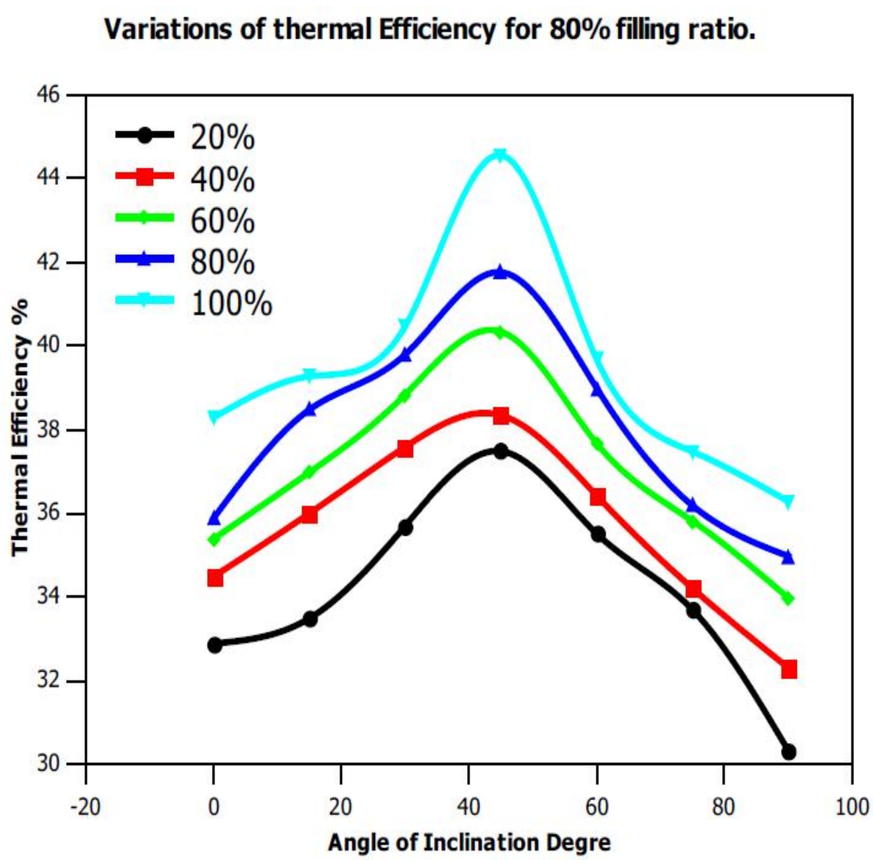



Figure 5. Variations of thermal efficiency for 80% filling ratio

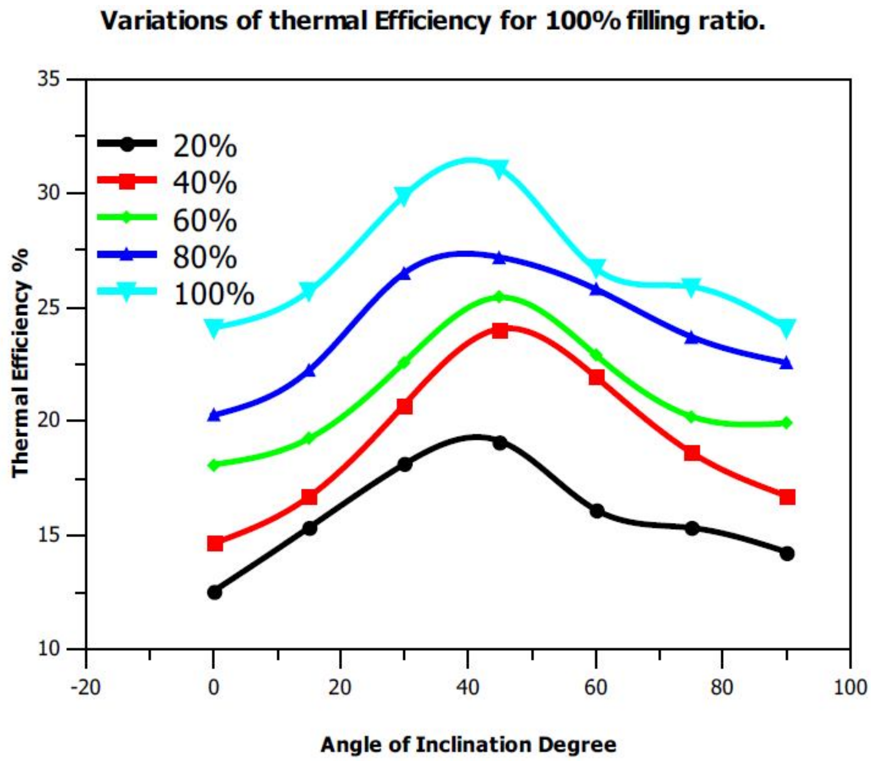



Figure 6. Variations of thermal efficiency for 100% filling ratio

## IV. CONCLUSION

*A. The Experimental Investigation of This Analysis Reveals The Following Salient Points*

*1)* The experiments show that the efficiency of heat pipe is a function of heat input, inclination angle and filling ratio of the working fluid.

*2)* The heat pipe with new working fluid gives the better performance at $30^0$ inclination of the heat pipe with respect to horizontal direction.

*3)* The wick temperatures at adiabatic regime are almost uniform for all the experiments.

*4)* The heat transfer efficiency gets reduced, when the heat pipe is inclined at $90^0$ and the heat input is increased.

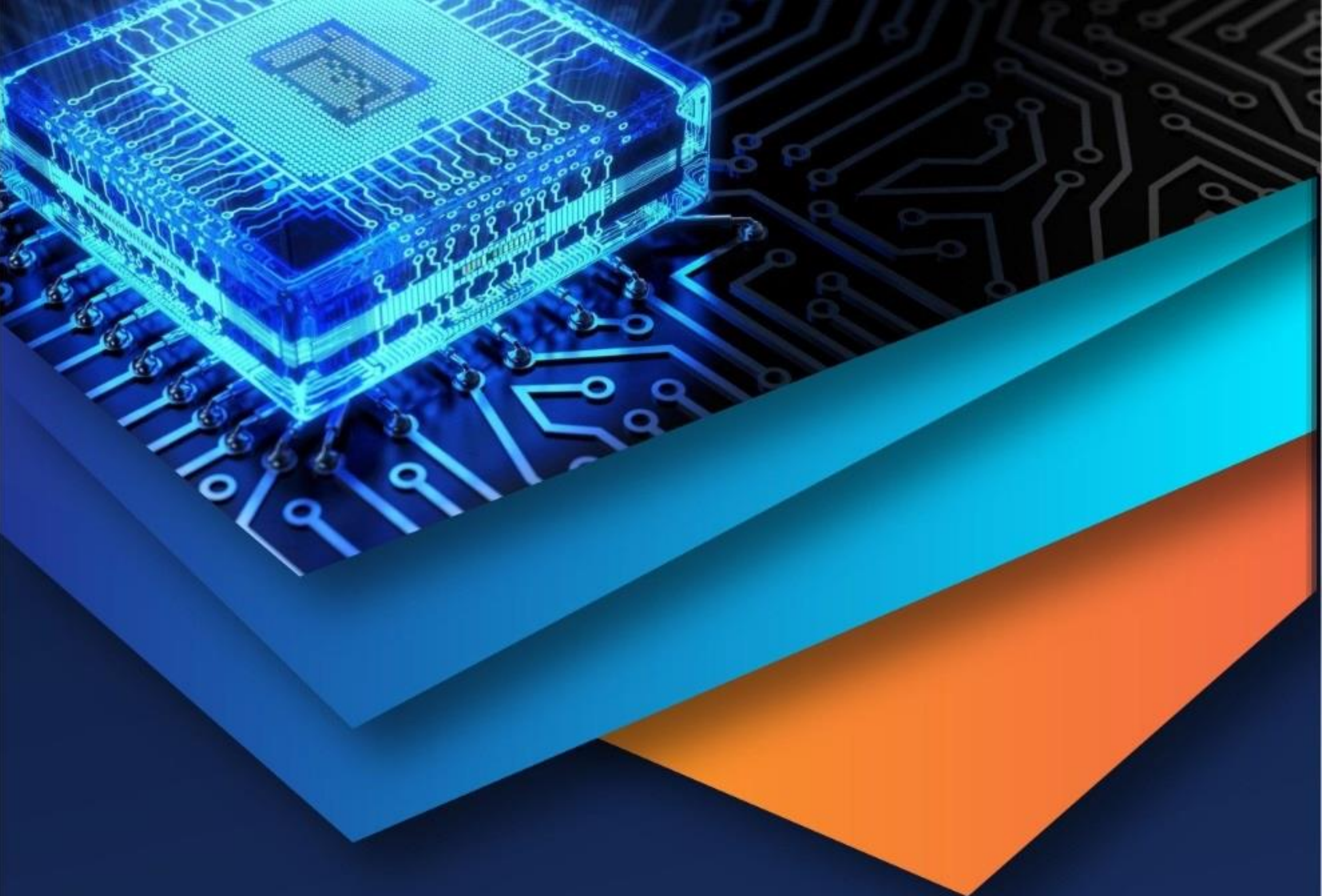
*5)* The trail results reveal that the heat pipe efficiency gets reduced when the heat pipe is kept in vertical direction. The gravitational forces which assist the flow of working fluid back to the evaporator may accelerate the process which may hinder the heat transfer process at the condenser end and the fluid might have returned to the evaporator section with higher temperature end.

## V. ACKNOWLEDGEMENT

The authors thank the authorities of Annamalai University for providing the necessary facilities in order to accomplish this piece of work.

## REFERENCE

[1] Faghri, A., Heat pipe Science and Technology, 1st ed., Taylor & Francis, Washington, D.C, 1995.
[2] Cotter, T.P., Theory of Heat Pipes, Los Almos Scienctific Laboratory Report No. LA-3246-MS, 1965.
[3] Bloem H, De-Grijis J. C, An evacuated tubular solar collector incorporating a heat pipe, Philips Technical Rev. 40, pp 181-191, 1982.
[4] Chandourene S, Gruss A, Theoretical and experimental study of high temperature heat pipe heat exchanger application to 1300kW respirator, Sixth international heat pipe Conference Grenoffle France, 1987.
[5] Sona R, Harmand S, Pelle J, Leger D, Fakes M, Transient thermal and hydrodynamic model of flat heat pipe for the cooling of electronic components, international Journal of Heat and Mass Transfer 51, pp 6006-6017, 2008.




10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429


# INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY