iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 11 **Issue:** V **Month of publication:** May 2023

DOI: https://doi.org/10.22214/ijraset.2023.52576

Design & Thermal Analysis of Heat Pipes

Shrinivas Saraf[1], Sudit Bhutada[2], Shubham Sindkhede[3], Tarush Srivatava[4]
[1, 2, 3, 4]Department of Mechanical Engineering, Vishwakarma Institute of Technology, Pune

Abstract: Heat pipes are a unique type of heat transfer device that can transport large amounts of heat through a small cross-sectional area, with minimal temperature differences. They offer high thermal conductance and low thermal impedance. In this study, we analyzed the impact of operating parameters on heat pipe performance and predicted optimal values for parameters such as temperature input, thermal expansion coefficient, and thermal conductivity. Our results demonstrate that these parameters have a significant impact on the performance of heat pipes. The material used here for the analysis is Copper alloy. The parameters were calculated and have done its Thermal analysis using ANSYS software.
Keywords: Heat Pipe, Heat Transfer, Thermal Analysis, Heat Flux, Thermal Stress, ANSYS.

I. INTRODUCTION

Having a higher heat conductivity, A heat pipe is a latent device. It is a closed, empty office or tube with a variety of forms. Its inside surfaces are stock-still and covered in a thin wick. There are currently a variety of applications connected to heat transfer where heat pipes are employed.

In ANSYS programming, the limited-component models are created to forecast the heat pipe temperature. How do heat pipes function? The fluid boils in the presence of heat, which forces the fluid vapour to the cooler part of the heat pipe. Condenser refers to the cooler area that is often connected to a heat sink.

The wall and wick of the heat pipe must be compatible with the working fluid since heat pipes are made to operate for an extended period of time without maintenance. Even though they might seem compatible, some materials and operating fluids may not be. For instance, putting water in an aluminium envelope might produce significant volumes of non-condensable gas within a few hours or days, which could interfere with the heat pipe's ability to function normally. Heat pipes use the vaporisation and condensation of a working fluid or coolant to transport thermal energy from one location to another. They depend on a temperature differential between the pipe's ends, therefore they are unable to drop temperatures at either end below the surrounding air's temperature, which tends to equalise the temperature inside the pipe. Choosing the right materials for constructing the heat pipe and selecting a compatible working fluid are essential for optimal performance and longevity. Different material and working fluid combinations can lead to issues such as non-condensable gas formation, corrosion, or other chemical reactions that can degrade the effectiveness of the heat pipe. Nonetheless, heat pipes are still considered a reliable and low-maintenance solution for transferring heat.

In this project, We have chosen the copper alloy as the material and we have allotted various parameters to the heat pipe and here our intention is to convection through the heat pipe. Here we have done thermal analysis of a small part of the heat pipe.

II. LITERATURE REVIEW

Many researchers are working on Thermal analysis and have worked on different techniques to achieve the optimum results. Here we are presenting a brief literature review of various papers that were we have gone through for the implementation for the course project. effectiveness than the other. These research papers helped us a lot to Get the results we were looking for.

Rajani Gupta, Kamlesh Ratre. A thermodynamic device with an extremely high thermal conductivity is the heat pipe pipe. Phase change and CFD heat transfer studies for heat pipes are presented in this paper. The article focuses on developing the foundation for the heat pipe's CFD model, which aims to simulate and depict the projected progression of the work fluid activity within the heat pipe. Due to the working fluid's increased volume from absorbing heat at one end, which results in the transfer of liquid and vapour slug, there is pressure change inside the tube.

Leonard L. Vasiliev. Whether it involves efficient thermal regulation, heat pipes are incredibly adaptable solutions. They are easily incorporated into desorption and vapour-compression heat pumps, the freezers, and other heat transfer devices as heat exchangers. This means that heat pipes act as highly effective heat transfer devices that can be quickly and readily integrated into various systems as thermal linkages and heat exchangers to achieve energy savings and environmental protection.

A. Chauhan. This page includes an in-depth review of the most modern heat pipe device applications, components, and performance. Low-temperature heat pipes, high-temperature heat pipes, thermal computational modelling of heat pipes, and discussion make up the four main elements. A comprehensive list for suitable working fluids, operating temperatures, and their compatibility with casing materials is offered in the low and high temperature sections. The article's concluding portion covers the drawbacks of heat pipes and the reasons they are not employed more frequently in various areas.

Masataka Mochizuki. Currently, computers and other electronic equipment are most frequently cooled by heat pipes; it is estimated that 10 million of these pipes are produced each month globally for this reason. However, heat pipes have a wide range of uses in industries including transportation, aviation, healthcare, energy efficiency, and mitigating climate change, among others.This article discusses the most recent advancements in heat pipe technology for improving thermal performance, including the implementation of ultra thin heat pipes with thicknesses of just 0.4 mm in mobile devices like smart phones and portable tablets. The old cooling techniques may not be suitable now. Consequently, a heat pipe cooling system is a desirable alternative technology that can offer an incredibly effective method of heat transmission.

Pinzhong chen. High thermal conductivity and reversible heat flow direction are two characteristics of flat heat pipes, among others. The authors of this study explore the impact of various microchannel forms and materials on heat transfer efficiency using a flat heat pipe model with several microchannels. According to the findings of fluid simulations, an improved hexagonal microchannel shape can boost the working fluid's flow velocity, resulting in better performance. Flat heat pipes with enhanced microchannel shapes could consequently serve as worthwhile in some applications.

Heat pipe-based coolers and substrates are exceptionally successful in dispersing heat, making them an increasingly common option for high power electronic device thermal control. The problem of working fluid charge and sealing is one of the fundamental obstacles to the fabrication of flat micro heat pipes (FMHPs). This article covers the design of the charging grooves for FMHPs and advocates the use of a low melting point alloy (LMPA) for charging and sealing FMHPs. This strategy enables the use of organic solvents as working fluids and increases the variety of viable working fluids that may be used in FMHPs by removing the obligation for adhesives or other materials.

III. METHODOLOGY/EXPERIMENTAL

In this project, The design of heat Pipes is done on the thermal considerations. For Thermal design of an Heat pipe Several factors were taken into the consideration Such as thermal conductivity of the material that should remain higher along with the Heat flux of the surface. A relatively immobile fluid layer between a heat dissemination surface involved the Film coefficient to secure thermal resistance. The most important thing that is passing through the pipe was decided as a ‘Steam’. The perfect convection is considered over here. Below table gives us the most important parameters of heat pipes are given:

Table 1

Length of Pipe	300mm
Young’s Modulus of elasticity of copper alloy[E]	100Gpa
Poison’s Ratio	0.34
Thermal conductivity	380 W/moC
Film coefficient interior	100 W/m2C
Film coefficient exterior	30 W/m2C
Density	Kg/m3

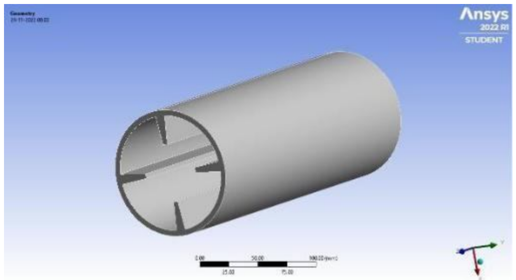


Fig. 1 3D model of Heat pipe

Thermal Analysis: The model's 3D geometry is then transferred to the ANSYS workbench, where the element sizes was set to 5 mm for creating a tiny mesh. The model's mesh is produced as a tetrahedron. The model then identifies the section names for computational reasons. The fin surface had been subjected to a steady state thermal study. The ambient temperature is provided to the system.

As mentioned earlier, we are interested in finding out the temperature distribution and total heat flux. After importing the model into ANSYS, meshing is generated as shown in figure below.

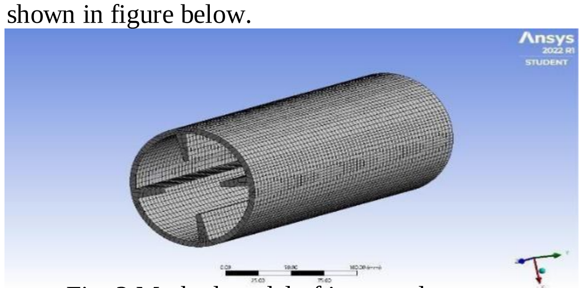


Fig. 2 Meshed model of imported geometry.

The steady state thermal temperature is specified by the inside wall of the Heat pipe. There are total 16 faces that are selected inside the geometry. inlet portion has a temperature of *80*°C. because we are assuming that Total steam is passing throught the inner surface. There is stagnant air surrounding the outside, which is *22*°C.

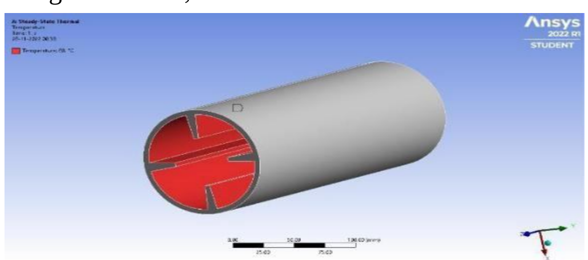


Fig. 3 Applied thermal conditions to the imported model.

The parameters were selected for inner surface and outer Heat flux is applied at both ends of the heat pipes and on the surface for convectional purposes. The Mangnitude for inner and outer convection 100W/m2C and 30W/m2C respectively & both the ends are fixed and insulated.

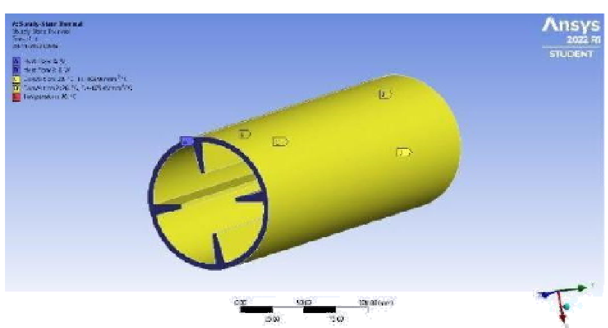


Fig. 4 Applied convection and heat flux to the body.

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue V May 2023- Available at www.ijraset.com

IV. RESULTS AND DISCUSSIONS

As mentioned earlier, Due to the flow of steam through the inner walls of the heat pipe, the rate of heat transfer through those walls is on the rise. Different boundary conditions were applied to the model which satisfies most of the desired properties such as thermal conductivity, total heat flux, etc. As seen earlier, copper is commonly used in such as Spacecrafts, computer system, and solar thermals etc.

For Temperature Difference, the temperature distribution using steady-state thermal analysis is carried out. Due to the particular heat conduction rate as well as the heat conductivity property, The temperature remains constant from inside to outside. The final result shows us the slightly decrease the temperature at the end of the pipes.

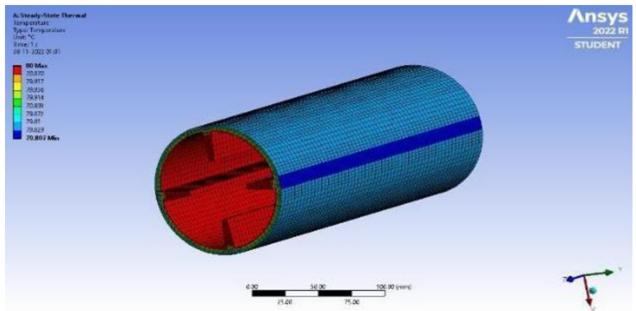


Fig. 5 Temperature distribution for Heat pipe

Total heat flux using steady-state thermal analysis is also carried out. The minimum heat flux for a heat pipe is at the inside surface where the maximum at outer area of the pipe and there magnitudes are 8.2416e-10W/mm2 and 0.0023159W/mm2 respectively.

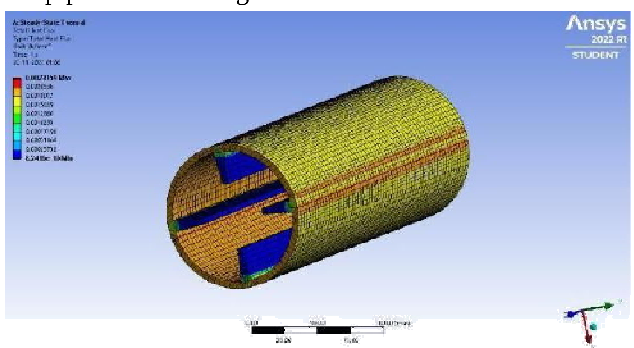


Fig. 6 Total heat flux obtained in heat pipe

The overall heat flux though the static structural it is observed that the total heat flux is flowing outside from the higher temperature to lower temperature. Its magnitude lies between 8.2416e-010 and 2.3159e-003

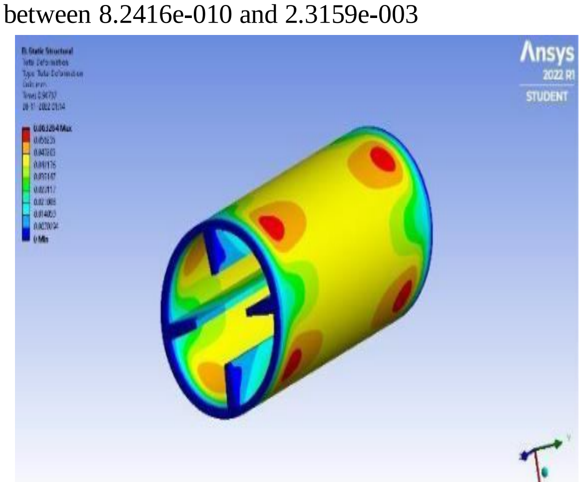


Fig. 7 Total heat flux in static structural

Further some boundary conditions are provided to the heat pipes. As mentioned earlier the both the ends of the heat pipes are fixed.

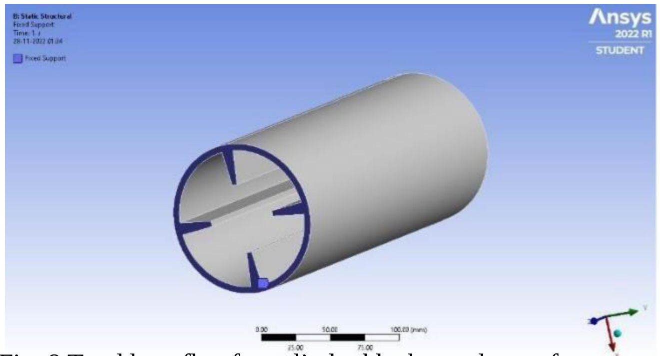


Fig. 8 Total heat flux for cylinder blocks made up of copper.

For Thermal stresses it is necessary to look for Total deformation. The minimum magnitude is 0mm whether the maximum value is 6.3264e-002mm.

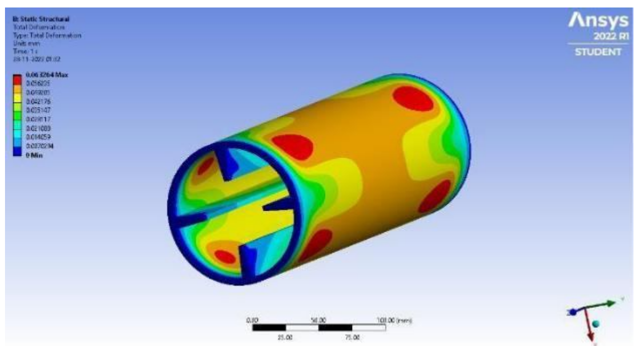


Fig. 9 Total deformation due to thermal stress

For Thermal stresses it is necessary to look for The equivalent stress that obtained is between 20.687MPa and 549.27MPa

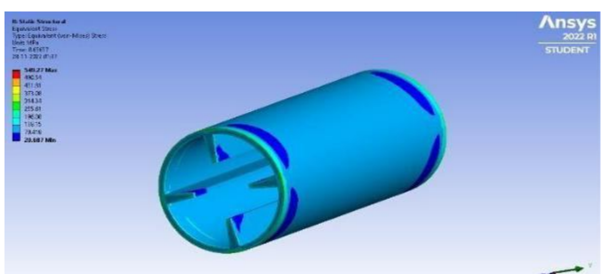


Fig. 10 Thermal Stress of heat pipe.

Table 2

Parameters	Values
Isotropic Secant Coefficient of Thermal Expansion	1.8e-05 1/°C
Isotropic Thermal Conductivity	0.401 W/mm·°C
Total Deformation(Average)	3.759e-002
Temperature Distribution(Average)	79.928
Thermal Stress (average)	148.1

V. CONCLUSION

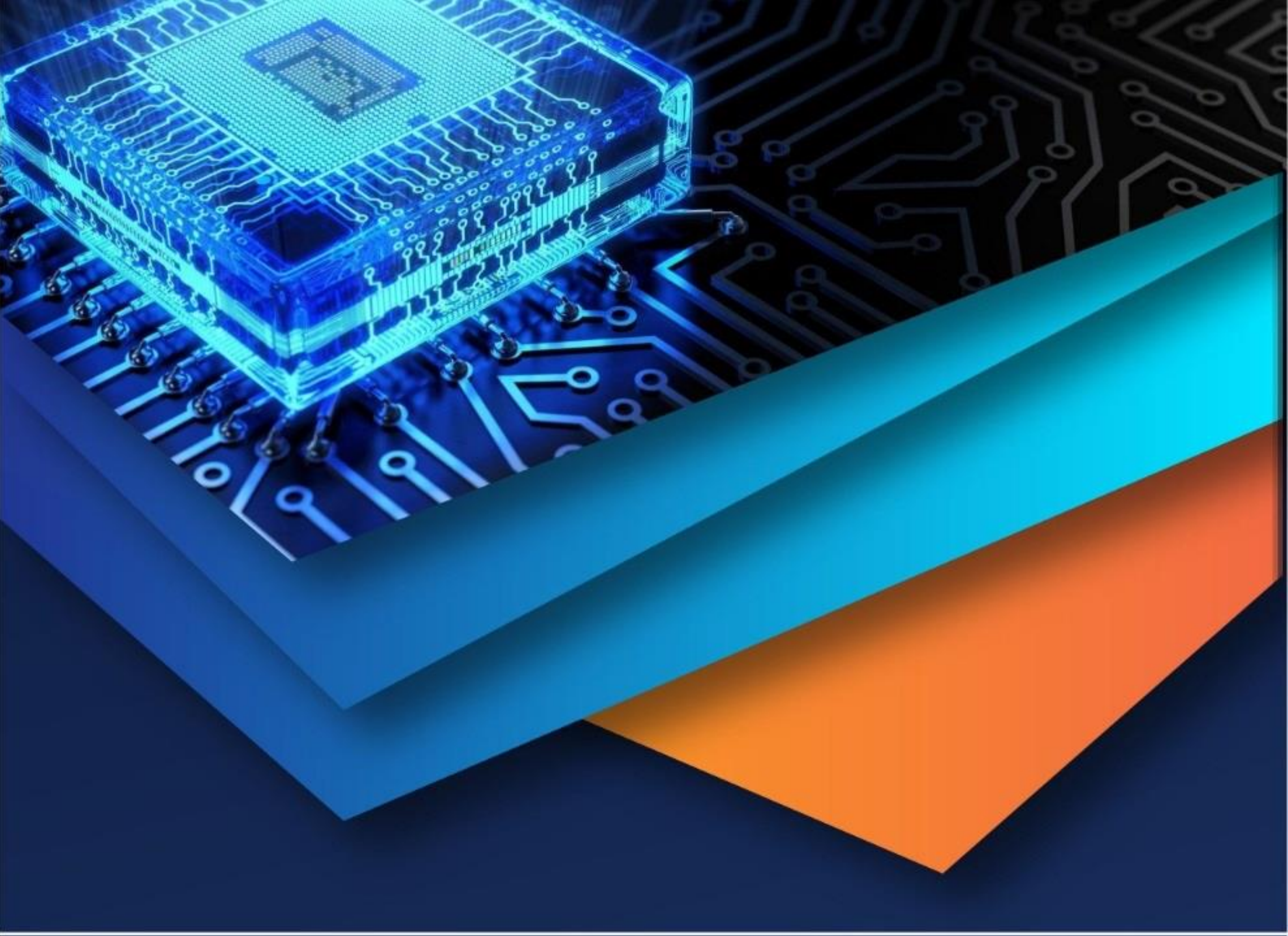
This project has reviewed, analysed and examined most of the current research on noteworthy thermal analysis of Heat pipes as such. As we saw earlier, this project is concerned with evaluating heat convection rate through the inside wall of the pipe . We have passed the steam. We have got the total deformation, Temperature Distribution and thermal stresses occurred in that Heat pipe of the copper alloy material selected. The magnitude of the average heat flow additionally points towards a potential material.We conclude that, since copper alloy is having suitable density among the Default material Structural steel considered in this study, it is best suited for the design of thermal thermal analysis of heat pipes.

VI. FUTURE SCOPE

By giving the statistical component of the project greater nuance, the project's scope may be expanded even more. For instance, there are usually certain aisles at supermarkets that are cold. The real cooled shelves, not the refrigeration units. In the past, this was accomplished by blowing cold air at the shelves and the items they held, which had the effect of making that section of the store seem incredibly chilly. The company's proprietary technology has a wide range of uses. Dehumidification and heat recovery solutions are particularly well received in commercial areas such cleanrooms, hospitals, hotels, and libraries.

REFERENCES

[1] Packaging flat micro heat pipe using low melting point alloy, Key Laboratory for Micro/Nano Technology and System of Liaoning Province Dalian University of Technology Dalian, China,2015
[2] Heat Transfer Analysis of Flat Heat Pipe With Enhanced Microchannel Shape, School of Physics and Telecommunication Engineering, South ChinaNormal University, Guangzhou, China,2018.
[3] Latest Development and Application of Heat Pipes for Electronics and Automotive, The Heat Pipes President Tokyo, Japan Mochizuki, M. (2017). Latest development and application of heat pipes for electronics and automotive. 2017 IEEE CPMT Symposium Japan (ICSJ).
[4] Heat pipe based systems - Advances and applications, Institute of Energy Futures, Brunel University London, Uxbridge, Middlesex UB8 3PH, London, UK, 24 April 2017
[5] https://www.skyfilabs.com/project-ideas/thermal-analysis-of-heat-pipes-in-ansys
[6] https://www.sciencedirect.com/science/article/pii/S036054421730593



10.22214/IJRASET

INDEX COPERNICUS
45.98

IMPACT FACTOR:
7.129

TOGETHER WE REACH THE GOAL
IMPACT FACTOR:
7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY