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Survey: Development of test rig for estimating fin performance

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Abstract*—The main purpose of this setup is to give an overview of pin fins of different materials which are used for increasing the heat transfer rate. In past years the concept of fin was not much clear to the people due to which the efficiency of the appliances which generated heat while operating decreased with time. There are many devices which generate heat and thus to increase their thermal efficiency they needed a cooling system. For that purpose we had to increase the heat transfer rate by providing fins (extended surfaces). It was observed that performance of pin fin is better than other fin configurations. In this study we are using circular pin fins of finite length and of different materials namely aluminium and brass with the help of which we can compare their performances and select suitable fin material as per their applications.*

Keywords— Thermal analysis, Pin-Fin, Heat Transfer, ANSYS, Material Selection

I. INTRODUCTION

Thermal management is a critical aspect of the design process and, as demand for component density and miniaturization continues to increase, engineers need cooling solutions that fit into small spaces, will not cause project cost overruns, and will provide the best heat transfer possible for today‟s modern appliances. When the available surface is not capable of transferring the required quantity of heat with available temperature drop and convective heat transfer coefficient, extended surfaces or fins are used. In practice all kinds of shapes and sizes are used but we are focusing on the performance characteristics of pin fins. Pin Fins are designed to meet the requirements of modern electronics cooling with little extra cost added. In particular, the pin fin geometry is designed to provide increased surface area for heat transfer and work in environments where the direction of airflow is ambiguous. As we know there are two types of convections are as follows:

1. Natural convection

2. Forced convection

In this experimental setup we are going to use forced convection for heat transfer through circular fins. Forced convection is heat transfer in which fluid is forced to flow over a surface or in a duct by external means such as blower. Convection heat transfer between a hot surface and the surrounding fluid deals with the Newton‟s Law of Cooling which states that, "The rate of convection heat transfer is directly proportional to the area of contact or exposure between them. We know that Newton‟s Law of Cooling is expressed as

$$Q = h\,A\,(Ts - T\infty)$$

Where,

h=convective heat transfer coefficient

A= area of contact

Ts=hot surface temperature

From the above formula we can find a few ways to increase the heat transfer rates.

i) Increase the convection heat transfer coefficient "h"

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ii) Increase the surface area "A"

iii) Increase temp difference

But increasing heat transfer coefficient „h" may require the installation of a blower. In natural convection, it is not possible to increase the convective heat transfer coefficient. Sometimes it is not possible and feasible to change the first two options. Then there is only one possible way by increasing the surface area using different types of fins. This is the only economical and feasible way to increase the heat transfer rate.

II. METHODOLOGY

In recent years, cooling advanced devices such as crucial components of personal computers or internal combustion engines has become a major challenge. Conventional heat sinks are inadequate for advanced devices which generate and dissipate astonishing levels of heat and power. Pin fins are widely used in heat sinks and fan sinks So for cooling especially electronic components is vital consideration of this study. Thus we have to determine optimum pin fin material. In the experiment different materials such as copper, aluminum, mild steel, brass, and stainless steel are analyzed.

Objectives:

1. To calculate the effectiveness and efficiency of pin fin

2. To develop experimental setup for educational and research purpose.

3. For selecting suitable materials used in various heat transfer applications

4. To determine the temperature of a pin fin for forced convection.

5. Develop a pin fin apparatus at moderate cost.

Fins are analyzed by taking into consideration uniform heat transfer coefficient on its surface. However, studies by various researchers show that it varies along the fin length. To dissipate the heat of very high heat flux densities, the required fins must often be larger than the device. As a result, the pin fins performance is reduced. In the present research work, actual experiments and analysis of the forced convection heat transfer characteristics of circular pin fin will be carried, by varying the materials. Results will be validated by CFD (Software preferably by ANSYS CFX). The fin is fitted into the duct and air through the blower is forced on the fin. At the base of each fin heating coil is provided for heating. Experiments will be run for different heater inputs and different air flow rates.

The proposed work consists of:

i) Fabricating and assembling of the experimental setup, fabricating the various types of pin fin required for experimental investigation.

ii) Conducting the experiment and noting down the steady state readings on various pin fins. i.e,circular pin fins of different materials.

iii) Plotting performance characteristics of pin fins of various materials from obtained results.

iv) Comparisons between various pin fins will be carried.

v) CFD simulation and analysis of two pin fins will be executed and will be validated with the experimental results

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III. ANALYSIS TABLE

Sr. No.	Title Of Paper	Technique Used	Limitations
1	Thermal and parametric analysis of fin	Testing of various parameters of the manufactured fins	Due to manufacturing constraints we can't manufacture circular and hollow pin fin
2	Thermal Analysis Of Perforated Pin Fins Heat Sink Under Forced Convection Condition	Perforated pin fins increase 1-4% thermal efficiency compared to solid pin fins	-------
3	Experimental Investigation of Convective Heat Transfer through Rough and Smooth Surfaced Aluminium 6063 Pin-Fin Apparatus	-------	Surface roughness affects fins efficincy
4	Experimental Investigation Of Heat Transfer By Using Pin Fin Of Different Materials In Forced Convection .	Brass material has a higher heat transfer coefficient than others.	As the reynold number increases, the efficiency of pin fin decreases.
5	Experimental Study On Performance Evaluation Of Pin Fins	The results show efficiency of Aluminium is highest followed by Brass and steel respectively.	The results show the efficiency of Aluminium is highest followed by Brass and steel respectively. .
6	Experimental Investigation Of Heat Transfer By Pin Fins	efficiency and heat transfer coefficient is greater of aluminium fins than brass fins with dimples	-------

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7	Natural Convection Heat Transfer From Square Pin Fin Heat Sinks Subject To The Influence Of Orientation	Upward facing orientation of fins yields highest heat transfer coefficient followed by sidewards facing and downward facing orientation .	------
8	Optimal Pin Fin Arrangement Of Heat Sink Design And Thermal Analysis Of Cpu	Linear arrangement of pin fin that able to give 2.84% and 0.63%better thermal performance compared to the conventional design .	-------
9	Experiment On Heat Transfer Through Fins Having Different Notches	Providing notches to the fins not only results into increase in Heat Transfer Coefficient but also it saves the fin material.	. -------
10	Numerical investigation of pin-fin thermal performance for staggered and inline arrays at low Reynolds number	An increment in Nusselt number is observed with increasing Reynolds Number for each of the arrangements and fin geometries	-------

IV. CONCLUSION

In this project we are going to develop a test rig for analyzing performance characteristics of pin fins used in various heat transfer applications and based on these analyses we are further going to comment on which material is best to be used as a fin in dynamic conditions. For this project we have studied several research papers and based on the comments and results of the respective authors and also using our academic knowledge we are going to develop this test rig. Once this test rig is developed it will be more convenient to decide which material to be used while manufacturing fins. This test rig can also be used by various engineering institutes and heat transfer research industries for enhancing their knowledge, for better understanding of heat transfer through pin fins and also getting the experience regarding the workability of the fins in actual environmental conditions and push their interest in the subject of heat transfer. Thus this study aims towards determining the most effective as well as efficient pin fin and developing the test rig considering the performance as well as the economic aspects.

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