Heat Transfer Through Porous Material

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Abstract- *Now a days manufacturing technology develops new materials for thermal applications which are light in weight. Investigation of thermal properties for such materials is desirable. On the other hand, it is recognized that there are different thermal management issues. Heat transfer through porous materials has gained significance in industrial applications based research. In this paper the research on heat transfer through porous material, mostly chip matrix heat exchanger, has been reviewed. This paper aims to get state of information in the field of porous materials as well as various research carried out on heat transfer and fluid flow through porous materials. The forced convection has been reviewed extensively. At the end, aspects which require further research have been identified The experiments shows that heat transfer rate increases with mass flow rate and decreases with porosity.*

Keywords- Forced Convection, Heat Exchanger, Heat transfer, porous materials

I. INTRODUCTION

Heat transfer through porous material has a great scope in chemical, mechanical, aerospace, medical, biological engineering, materials sciences & many more fields. Due to increase in contact surface with fluid and efficient heat transfer property, Porous material being a part of interest of many researches. Number of Experiments, analytical work, researches has been done to investigate heat transfer phenomena through porous materials such as sintered metals, foams (metal or polymeric), ceramics, etc.

Recent advances in electronic system, heat exchangers, chemical reactors, etc; have lead to dramatic increases in heat flux. Heat transfer through porous media is being explored to thermal management of such systems. Many studies & experimental work have reported that Heat transfer through porous media is more efficient techniques than traditional one.

Enhancement in heat transfer depends upon porosity of material as well as other thermodynamic parameters. The porosity is characterized by volumetric amount, size and shape of pores, cellular structure, and is typically homogeneous and uniformly distributed. The porous media can be *naturally formed* (e.g., rocks, sand beds, sponges, woods) or *fabricated* (e.g., catalytic pellets, wicks, insulations)

II. LITERATURE REVIEW

1.Tsotsas (2010b) has also well summarized the effective thermal conductivity models for the packed beds. It shows that, the effective thermal conductivity of packed beds is related to a variety of factors, including thermal conductivities of particles and fluid, porosity of packed bed, particle shape, particle size distribution, mechanical properties of particles, thermodynamic properties of fluid, etc.

2.Lanfrey et al. (2010) recently have developed a theoretical model for the tortuosity of fixed bed randomly packed with identical particles. They found that, the tortuosity was proportional to a packing structure factor, which could well capture the balancing effect between porosity and particles phericity. As porosity or particles phericity decreased, the tortuosity increased and it did not depend on the particle size.

3.Nijemeisland and Dixon (2004) and Reddy and Joshi (2010) reported some other recent studies for random packing. On the other hand, the investigations for structured packing were also popular, and the flow and heat transfer characteristics were found to be quite different.

4.A.P. Collier et. al studied that the heat transfer coefficient has been measured for a heated phosphor-bronze sphere (diam. 2.0, 3.0 or 5.56 mm) added to a bed of larger particles, through which air at room temperature was passed. The bronze heat transfer sphere was attached to a very thin, flexible thermocouple and was heated in a flame to 140 ◦C before being immersed in the bed. The conclusion of this study is that for the commoner situation of ds/db, h rises to a maximum, when U slightly exceeds Umf .

III. PROBLEM DEFINITION & SCOPE

Flow through porous material is of interest in many fields of engineering such as Heat exchangers, boilers, electronic systems, chemical reactors, aerospace, jet engines etc.

A porous medium is a solid with pores or voids in it. Because of the pores inside the material, contact surface area of material is increases with flowing fluid. As surface contact area increases with cooling medium, considerable amount of heat can be removed to thermal management of system.

The rate of heat transfer is depends upon various parameters; but the porosity of material having a great impact on heat transfer phenomena. So the porosity of the material has a huge scope in the area of heat transfer.

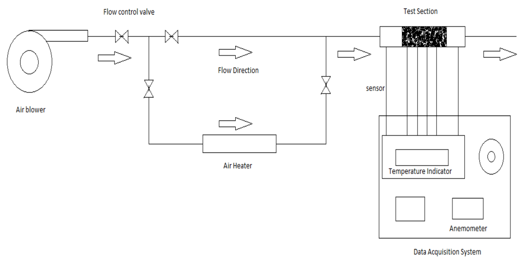
IV. OBJECTIVES

The main objective of this experimental investigation is to study the heat transfer rate & pressure drop of an air when passing through the porous material having different porosity.

Also, examine the effect of different porosity on heat transfer phenomena.

V. DESIGN AND DEVELOPMENT OF TEST SETUP

The experimental system for investigation of heat transfer performances is shown in Fig. It consists of an air flow circuit, a test section and several instruments. In the present study, air will be induced to the wind tunnel by a centrifugal suction blower and the inlet temperature is read by a thermometer. Before entering the test packed bed, the air flow will be heated by passing through a removable electric heater and then the particles inside will be heated by the hot air. When the packed bed temperature will be stabilized, the cold air will be passed into the channel and the packed bed is cooled down until its temperature decreases to the ambient temperature. During the cooling process, the experimental data will be measured and recorded simultaneously. The volumetric flow rate through the test section will be measured by a parallel flow meter system, which will be situated at the downstream of the test section. This flow meter system is composed with rotameter. The static pressure difference across the test section will be displayed by a micro-differential meter combined with a U-tube water column manometer. The air flow and particle temperatures will be measured by PT100 thermocouples.



Block Diagram

VI. TEST SECTION

VII. EXPERIMENTAL SETUP INSTRUMENTATIONS

Proposed experimental system for Performance investigation of heat recovery heat pipe heat exchanger by using nanofluid with variable source temperature consists of the instruments like Voltmeter, Ammeter, Transformer, Temperature sensors, Temperature indicator, Insulating materials, air vane anemometer etc.

VIII. ADVANTAGES

- Fast cooling rate
- Low mfg cost
- Less heat losses
- Max heat transfer

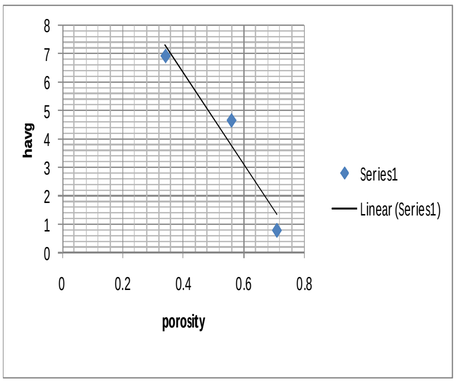
IX. APPLICATIONS

- Microelectronic cooling system
- Filtering devices
- Chemical industries
- Radiators in cars
- Heat exchanger in power plant
- Boilers

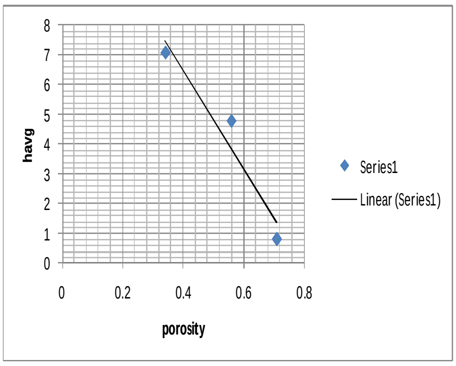
X. RESULT

The heat transfer rate is calculated for different porosities and different mass flow rate.

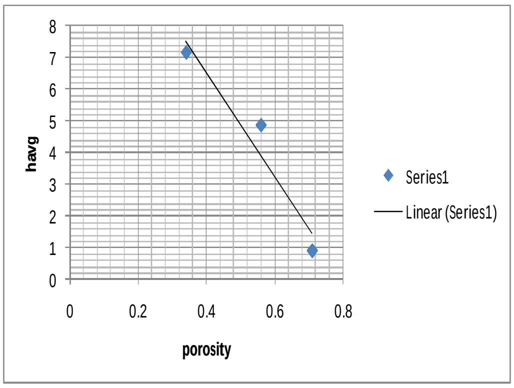
For 200 lph (flow rate)



For 400 lph (flow rate)

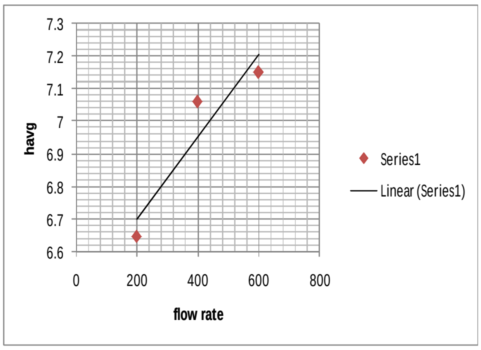


For 600 lph (flow rate)

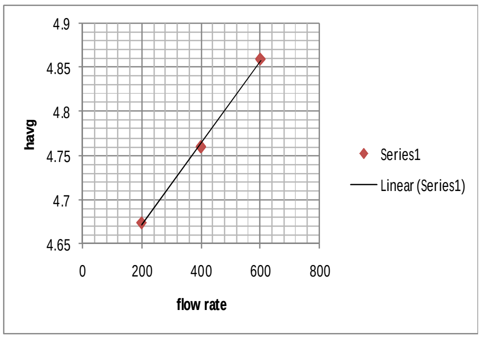


Another graph is also plots for porosity vs heat transfer rate for different mass flow rate.

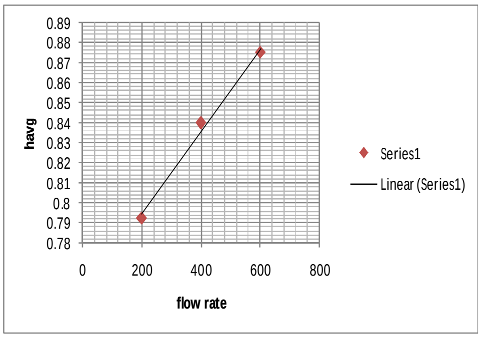
For porosity=0.34



For porosity=0.56



For porosity=0.71



X. CONCLUSION

After investigating the present study and plotting graphs we can conclude that;

1. Heat transfer rate is increase with decrease in porosity.
2. As flow rate is increase heat transfer rate is also increase.

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