Review on Pin Fin Heat Exchanger

Bhupendra Kumar[1] Ashwini Bhoi[2]
[1]Research Scholar [2]Assistant Professor
[1,2]Department of Mechanical Engineering
[1,2]Raipur Institute of Technology, Raipur, India

Abstract— The pin fin geometry finds its application in electronic chips and heat exchangers. The current work studies the various researches conducted in optimizing design and material of pin fin geometry to improve its overall performance. The paper also discusses about numerical, experimental and analytical methods used in the study of pin fin heat exchanger.

Keywords: Pin Fin, Design Optimization, Numerical Method

I. Introduction

Pin-Fin technology has shown its excellent characteristic in heat transfer in electronics cooling and it seems that its time to use this technology in conventional heat exchangers used in industrial application. The usage of this technology in tubes will overcome the problems that other heat transfer enhancement tubes could not solved for long time, i. e. large pressure loss and low total heat transfer efficiency. Its unique finned structure greatly increases heat exchanging area both inside and outside the tube with dramatically reduced thickness of boundary layers. Some of the features are presented below:

1) Convection heat exchanging coefficient for single-phase fluid is 2.5 to 6 times higher than that of the plane tube.
2) Boiling heat transfer coefficient is 2 to 5 times higher than that of the plane tube.
3) Condensing heat transfer coefficient is 3 to 6 times higher than that of the plane tube.
4) Unique self-cleaning feature greatly reduces maintenance cost of heat exchangers.

II. Literature review

Sahitiet. al. [1] studied heat transfer enhancement is an active and important field of engineering research since increases in the effectiveness of heat exchangers through suitable heat transfer augmentation techniques can be result in considerable technical advantages and saving of cost. This work was used small cylindrical pins on surface of heat exchangers. A partly quantitative theoretical treatment of the proposed method was presented. As results discuss the heat flux varies with the velocity approximately as $Q \approx u0.5$ whereas the pressure drop varies as $\Delta p \approx u2$. Thus, due to an increased in velocity and Reynolds number the pressure losses would rise faster than the rise of heat flux. According to author, it will encourage the development of simple and cheap procedures to build pin fin heat exchanger for industrial application

PaisarnNaphonet. al. [2] in this study, experimental and numerical result of the heat transfer characteristics of the in line and staggered tapper pin fin heat sink under constant heat flux conditions are presented. Experiment performed by various air Reynolds number in range of 1000-9000 and heat fluxes in range of 0.91-3.64 kW/m2. A finite volume method with an unstructured non uniform grid system is employed for solving the model.It was found that when the inlet air temperature is kept constant the outlet air temperature decreases with increasing Reynolds number. Reasonable agreement is obtained from the comparison between the predicted result and the measured ones.

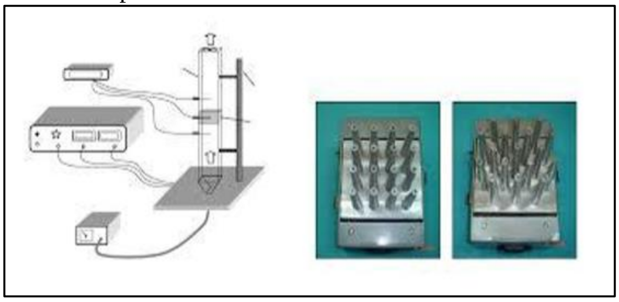

Fig. 1: Schematic of experimental set up

Lawson etal. [4] Pin fin arrays increases heat transfer by increasing the flow turbulence and surface area of the air foil exposed to the coolant. This study experiments were conducted to determine the effects of pin spacing on heat transfer and pressure loss through pin fin arrays for a range of Reynolds number between 5000 to 30000.

Hafiz et al. [5] experimental data are reported for condensation of ethylene glycol at near atmospheric pressure and low velocity on 11 different 3- dimensional pin-fin tubes tested individually. The heat transfer enhancement was approximately twice the active area enhancement was found to increase with increasing pin height and decrease circumferential pin spacing. This study experimental method was used to analyse problem.

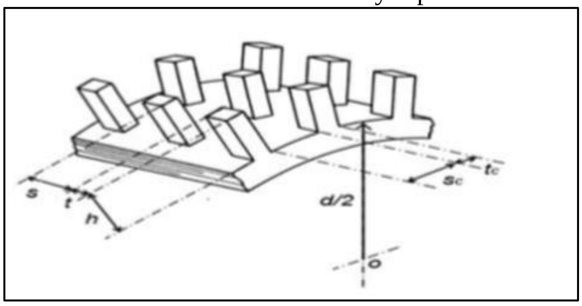

Fig. 2: Idealized pin fin tube

Sahrayet.al. [6] studied deeper understanding of heat transfer from horizontal-base pin-fin heat sinks with exposed edges in free convection of air. The effects of fin height and fin population density are studied experimentally and numerically. Result discussed by author that heat transfer enhancement due to the fins is not monotonic also analysed the heat flux distribution at the edge and center of the sink.

U. V. Awasarmolet. al.[7] outcome of this paper based on experimental study is conducted to comparison of rate of heat transfer with solid and permeable fins and the effect of angle of inclination of fins. As compared to result the temperature of solid fins are more elevated to permeable fins. There was net increase in heat transfer rate of the block with permeable fins as compared to that of the fin block with solid fins.

Yang et.al. [8] the forced convective heat transfer in three –dimensional porous pin fin channels is numerically studied in this paper. The Forchheimer – Brinkman extended Darcy model and two equation energy models are adopted to describe the flow and heat transfer in porous media. Both air water are used as cold fluids and the effects of Reynolds number, density and pin fin form are investigated. The overall heat transfer efficiencies in porous pin fin channels are much higher than those in solid pin fin cannels which are 119.5% and 37.9% higher for air and water cases at Re = 229

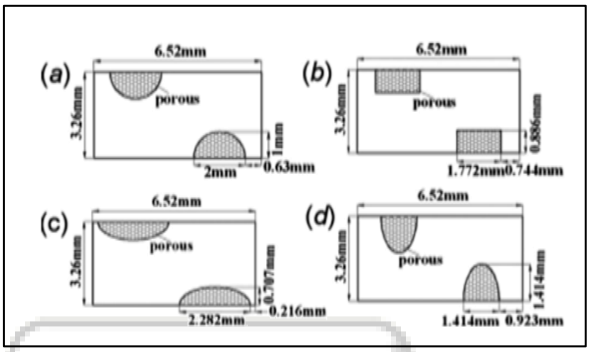

Fig. 3: Different forms of porous pin fin cross-section

Kundu et al. [9] this Paper wants to express an analytical model for thermal performance and optimization of constructional fin subject to variable thermal conductivity of fin material and convective heat transfer coefficient over the fin surface. The new analytical method is based on the domain decomposition method has been established for the solution process. A finite difference scheme has been adopted for the numerical result obtained through a numerical analysis

Mehdi Anbarloei et.al. [10] in this paper, the non-linear fin problem with temperature dependent thermal conductivity and heat transfer coefficient is restricted. It is show that governing non-linear differential equation is exactly solvable. They obtained three possible methods to solve this problem, but the solution is unique. They discussed the existence of domain of the solution and multiplicity of them. Also gave some results about fin efficiency of non-linear problem.

Woodcock et.al.[11] in this study a comparative study of flow boiling in a micro channel with piranha pin fins. These piranha pin-fins are called as an advanced micro scale heat sink as per their research. These surface temperature, pressure drop, heat transfer coefficient and critical heat flux conditions were experimentally obtained and discussed. They concluded that heat transfer coefficient depends strongly on mass flux in both single phase and boiling regimes and critical heat flux varies with differential devices and different flow conditions. Critical heat flux under high pressure can be longer than under low pressure.

III. Conclusion

The current study presents researches conducted on pin fin heat sink, micro, and channel with piranha pin fins, solid and permeable fins using experimental and numerical techniques. The findings have shown that fin geometry, fin array and fin material have significant effect on heat transfer characteristics like temperature, heat flux and heat dissipation rate.

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