Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 127 (2015) 333 – 339

Procedia Engineering

www.elsevier.com/locate/procedia

International Conference on Computational Heat and Mass Transfer-2015

Heat Transfer Studies on Air Cooled Spiral Radiator with Circumferential Fins

Akhilnandh Ramesh*, M. Jaya Arun Prasanth, A.Kirthivasan, M.Suresh

Department Of Mechanical EngineeringSSN College Of Engineering Kalavakkam, Kanchipuram District-603110

Tamilnadu, India

Abstract

Heat exchangers find use in several applications such as in automobiles, refrigeration, air conditioning, and water treatment plants. Radiators are a class of heat exchangers in which heat transfer occurs by means of air flowing across a series of finned tubes, eventually decreasing the temperature of the fluid to be cooled. The energy crises of recent times have necessitated improved heat transfer rates and at the same time the need for making heat exchangers smaller and more energy efficient. A simple modification has been carried out in the existing configuration of radiators, with a view to improve its efficiency and has resulted in the development of a compact spiral radiator against a standard air cooled fin and tube radiators used commonly especially in automobiles. In this configuration, water flows through spiral tubes, which are fitted with circumferential fins and air flows across the tubes for bringing about heat transfer.A numerical investigation has been carried out on the spiral radiator to study flow characteristics and thermal performance by means of local element by element analysis utilizing ε-NTU method. Experiments were performed and the results after comparison with the theoretical values were found to be promising. From the experimental data, a correlation among the important dimensionless numbers has been obtained using GARCH tool.

Peer-review under responsibility of the organizing committee of ICCHMT – 2015

*Keywords:*Spiral configuration; Radiators; Circumferential fins; Empirical Correlation; Regression; Nusselt Number.

1. Introduction

Over the recent years, various configurations of heat exchangers have been developed with a view of maximizing the heat transfer rates and reducing the effective space occupied by it. One such configuration involves fluids

* Corresponding author. Tel.: +91-9962927309.
*E-mail address:*akhilnandh12006@mech.ssn.edu.in

Peer-review under responsibility of the organizing committee of ICCHMT – 2015
doi:10.1016/j.proeng.2015.11.378

flowing in a spiral path. The spiral path can either be a helix or a coil of bent tubes. Spiral heat exchangers find a lot of application in preheating, reheating, pasteurization of fluids etc. Apart from these applications, heat exchangers with spiral profile can emerge as a suitable alternative to existing class of radiators, widely used in refrigeration, air conditioning and automobiles. This can be attributed to the fact that the spiral profile makes more effective utilization of air flow area ofthe fan, as the circular profile of the spiral more closely matches the circular air flow area of the fan. In addition, spiral heat exchangers also possess certain inherent advantages. Spiral heat exchangers are more compact and have lesser space requirements than other types of heat exchangers.Furthermore, spiral profile produces lower pressure drop and requires lesser pumping energy compared to other heat exchangers for same capacity, have self- cleansing ability, as the spiral path causes localized increase in drag force over fouled surface, dislodging any sludge formed. Naphon and Wongwises [1] studied the heat transfer characteristics of spiral coil heat exchanger under wet surface conditions where a factor of humidity was taken into account. They had used a 9.27mm diameter straight copper tube, bent into a spiral coil of 5 turns, with air and water being used as the two fluids for heat transfer and 6 such coils being stacked one behind the other. The researchers concluded that the mass flow rate of air and air inlet temperature play a role in affecting heat transfer characteristics such as outlet temperatures, whilst an increase in water flow rate caused a decrease in outlet temperatures. Poon et al [2] patented a spiral engine oil cooler for commercial vehicles, which incorporated a series of spiral plates surrounding a tubular oil filter, allowing oil to flow in a spiral manner. Bosch and Haasch [3] patented a spiral finned tube heat exchanger for the purpose of oil cooling. Their invention consists of a pair of juxtaposed tubes, forming concentric passages for fluid flow. The fluids enter and leave the heat exchanger through inlet and outlet located peripherally. Their invention has superior heat transfer rates, and better antifouling capabilities. Dobbs et al [4] patented a swirl type heat exchanger in which one of the fluid flows in reverse spiral flow configuration, while other fluid flows across it, in a cross flow configuration. This configuration, allows for easier accessibility and mounting of the runners supplying the fluids. Their invention also consists of a series of such configurations stacked one behind the other, improving the heat transfer rate.

While several methods are available for designing and simulating such heat exchanger, a novel method for designing the same was adopted by Bidabadi et al. [5]. They used an optimization technique known as Genetic Algorithm (GA) for spiral heat exchangers. This technique was used to obtain the geometrical parameters which lead to minimum pressure drop and maximum heat transfer. An elemental approach can also be adopted for numerical simulation. This is a control volume approach in which the entire spiral is divided into a large number of small elements, each being treated as individual control volume. Characteristics such as heat loss, temperature difference, pressure drop are evaluated for each small control volume and then summed up, after iterative methods, to calculate the same for the entire heat exchanger. Such an approach was adopted by Naphon and Wongwises [6,7] for numerical simulation of the spiral configuration. In addition to it, they have also developed correlations for studying the average heat drop characteristics for spiral heat exchangers under dehumidifying and humidifying conditions.

Bhavsar et al [8] analysed the performance of a spiral tube heat exchanger, in comparison with shell and tube heat exchanger. Their optimized spiral design revealed that, heat transfer is enhanced compared to the shell and tube heat exchanger. Their studies also revealed that fluid, in a spiral tends to be more turbulent, at a lower velocity, thus helping in producing more drag forces and hence eliminating sludge formation.

This paper discusses the results of both numerical and experimental studies carried out on a spiral radiator fitted with circumferential fins. The fabricated radiator consists of two parallel spiral coils brazed centrally. On to the periphery, a large number of circumferential fins have been fitted, aiding in increased heat transfer. Characteristics such as temperature, pressure drop of water were determined, for different flow rates of water. These characteristics were used to deduce the dimensionless numbers like Reynolds number, Nusselt number, Prandtl number using MATLAB. An empirical correlation was developed between the non-dimensional quantities, for the configuration.