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Thermal Optimization of Fan assisted Heat Exchanger (Radiator) by Design Improvements

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ABSTRACT

The Heat Exchangers or Radiators used in automobiles/IC Engines are either rectangular or square in shape, but the air blown/sucked by means of the fan is in circular in area, developing low velocity zones in the corners-hence it is proposed to eliminate corners and develop circular radiators. The object of work is to have a circular radiator which is compact-made with minimum material-less costly-more efficient-that will work with minimum power consumption of fan and maximum utilization of air flow.

It is proposed to develop three different types of radiators and the results of one rectangular and two circular radiators will be compared. Here results like velocity, flow rate of water, and temperature at different points of the radiator are compared. After validating the present concept through actual manufacturing and mathematical calculations it can be commercially applied to applications such as automobile radiators, IC Engine radiators, heat exchangers used in refrigerators and air-conditioners etc.

Considering the number of vehicles, refrigerators, air-conditioners used at National and International level, a slight modification/improvement in efficiency and reduction in cost will add to the economy a great extent.

Keywords **– Circular radiator, smaller fins, thermal optimization, velocity, validation etc**

I. INTRODUCTION

The present manufacturing of heat exchangers commonly used in practice in Automobiles, Internal Combustion (IC) engines, Refrigeration systems, and Power plants emphasizes on production process, materials and spacing of fins.[1]

The proposed work aims at optimizing the fan assisted heat exchanger (radiator) by improvement in the design.

II. ORIGIN OF THE RESEARCH PROBLEM

The present heat exchangers/radiators are rectangular in shape. But the air blown by the fan is circular in area, developing low velocity area in the corners.[3] Therefore circular radiators which are compact are proposed to be developed and tested to improve the efficiency.

No significant work has been done in this area.

III. INDENTATIONS AND EQUATIONS

Figure1and 2 shows a rectangular/square-shaped heat exchanger with a fan provided to deliver air in a circular area.

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If the length and breadth of the heat exchanger is equal to D, the effective area of such heat exchanger will be equal to D^2.

While the flow of air from the fan (without shroud) will be of area $(\pi/4)\ D^2 = 0.76\ D^2$.

The difference in the area of the square and the circle would be $\{D^2 - (\pi/4)\ D^2\} = 0.24\ D^2$. [a]

IV. FIGURES

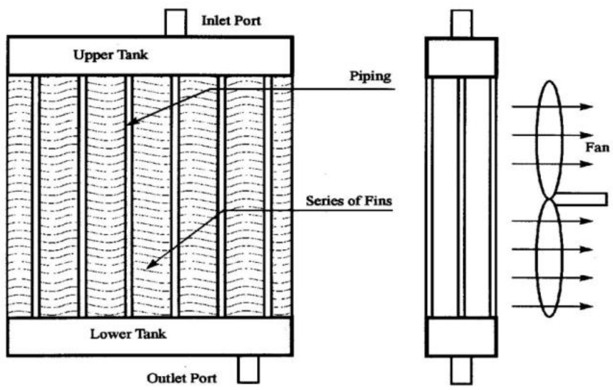

Fig 1: Existing rectangular radiator

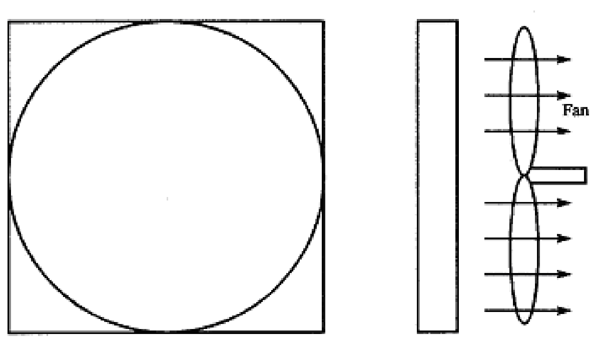

Fig 2: Air-cooled Square shaped heat exchanger

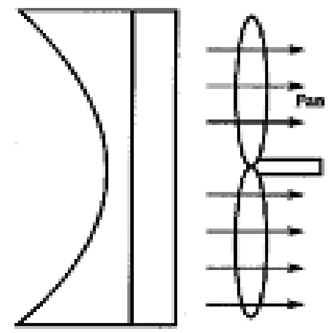

Fig 3: Velocity profile of an air-cooled heat exchanger using a fan

As shown in Fig (3) velocity of air generated by the fan is not constant along its axial direction. It is found to be almost zero at the centre and gradually increases at the rate of square of the radius towards the periphery [4].

V. FIN GEOMETRY FOR PROPOSED HEAT EXCHANGER

Since the velocity of air varies from centre outwards, smaller fins are provided at the centre and longer fins at the periphery. The length of fins are so adjusted that the velocity of air coming out of the heat exchanger remains constant over the effective area. (fig.4)

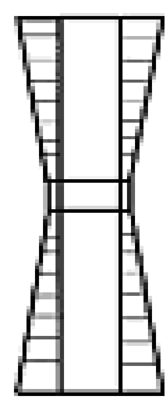

Fig 4: Fin geometry for proposed Heat Exanger

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It is proposed to develop 3 different types of radiators, one is almost square and two are circular.

1) First one is almost square shaped.

2) Circular first type –in this arrangement distance between the tubes is same but the fin size increases towards periphery.[5]

3) Circular second type –in this arrangement distance between the tubes decreases-i.e., more number of tubes are provided at the periphery and fin size is same.

All the 3 radiators will be manufactured out of,

a) Same material

b) Same tube size

c) Same fin thickness

Fig. 5 shows the proposed circular radiator.

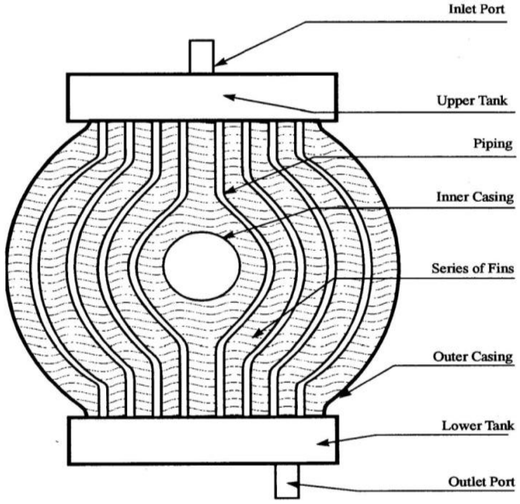

Fig 5: Proposed Heat Exchanger (Radiator)

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VI. PROPOSED TEST SET UP

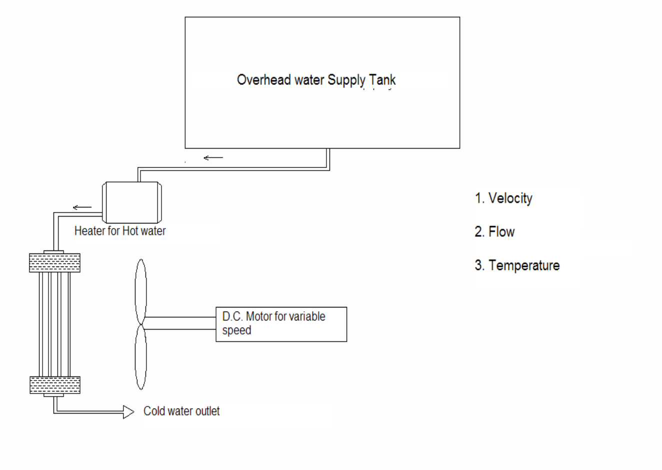

Fig 6: Proposed Test set up

It consists of,

1) Heater-to supply hot water to @ 70-80 ^{0}C.

2) Radiator –which can be changed.

3) D.C. motor for variable speed.

4) Velocity of air at different points is measured with Anemometer.

5) Flow rate of water is measured with Rotameter.

6) Temperature at various points is measured with Infrared Temperature measuring gun [b,c]

Journal Papers:

1. ASME 2002 International Mechanical Engineering Congress & Exposition Heat Transfer Vol 6, Nov 17-22, 2002 USA Paper No. IMECE 2002-33888
2. Optimization of Central heating radiator by Cihat Arslanturk & A. Feridum Ozguc. Applied Engg Vol 83, issue 11, Nov 2006, Pages 1190-1197.
3. Shape optimization of vehicle radiator using CFD by, Maddiptla, Sridhar, Guessous, Laila, American Physical Society, Division

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4. Parametric studies on Automotive Radiators by, C. Oliet, A. Oliva, J.Castro & C.D. Perege- Segarre; Applied Thermal Engg Journal vol 27, issue 11-12;Aug 2007, Pages 2033-2043.
5. Designing a more effective car radiator :Application note Maple soft, Maple Inc 2008
6. The Patent search carried by Patent attorney.

VII. Kinds Conclusion and their Expected Results

The new proposed heat exchanger will be,

1. Circular in shape
2. Compact
3. Less material requirement
4. Less power consumption for fan
5. More efficient
6. Since material saving is @ 24%, cost saving on mass scale production will be @ 20% once the dies are manufactured.

Books:

a) Heat Exchanger Design (II Edition) Arthur P Fraas. Published by John Wiley & Sons New York
b) Heat Exchangers, Selection, rating, & Thermal design (II edition) Sadik Kakak & Hongtan Lin
c) Fundamentals of Heat Exchanger Design Ramesh K Shah &Dusan P Sekulic
d) Heat Exchanger Design Handbook by T Kuppan