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DESIGN AND ANALYSIS OF AUTOMOBILE CIRCULAR RADIATOR (HEAT EXCHANGER) PROPOSED WITH ANSYS SOFTWARE

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ABSTRACT

Radiators are heat exchangers used to transfer thermal energy from one medium to another for the purpose of cooling and heating. Radiators are used for cooling internal combustion engines, mainly in automobiles but also in piston-engine aircraft, railway locomotives, stationary generating plant or any similar use of such an engine. Also, to reduce fuel consumption along with controlling engine emission to mitigate environmental pollution norms.

In this paper we mainly focused on the change of design from existing radiator to increase the efficiency of water cooling in automobile radiators.

The model creating in CREO parametric software both existing & proposed model (circular radiator). Furthermore, analysis both the model based on computational fluid dynamics in ANSYS software. To check both the model temperature difference and choose the better radiator model with help of ANSYS software.

***Keywords**: ANSYS software , CREO parametric software, Heat Exchanger, Radiator, Temperature*

I. INTRODUCTION

The work proposed relates to an improved heat exchanger (Radiator) design for either heating or cooling of a fluid. Also, it deals with the work particularly which relates to an improved fan assisted air-cooled heat exchanger used in Automobiles, Internal Combustion (IC) engines, Refrigeration system, and Power plants.

Different types of heat exchangers are known, in which air is used as heat transfer medium as it is freely and abundantly available, without any disposal issues. In known heat exchangers, flow of air is induced naturally or is aided by the use of one or more fans. The use of fan reduces the size and the cost of the equipment, which makes it more compact. Hence, fan assisted air cooled heat exchangers are more popular than others. In known air-cooled heat exchangers, the fan either forces or draws the air through the heat exchanger, some of which are described herein below by way of examples.

In present system, the fans are placed behind the heat exchangers to force/ draw the atmospheric air. These exchangers use a shroud. This directs the air over the entire area of the heat exchanger. A study was undertaken to find out the distribution of airflow and variation of its temperature.

Generally, all conventional heat exchangers are either square or rectangular in shape and the fans with circular blades are used to create the flow of air through them. For the present heat exchangers, there are several drawbacks or disadvantages which can be classified as follows –

Fans with circular blades deliver air in a circular area even when the heat exchangers are square in shape.

The velocity of the air flow generated by the fan is not constant or uniform along its entire axial direction. It is almost zero at the centre and gradually increases at the rate of square of the radius.

When the thickness of the heat exchanger is constant, there has been no attempt to increase the heat transfer area at the periphery of such heat exchanger. The heat transfer area near the hub of the fan should be zero. Since this is not the case with present heat exchangers, they do not offer optimum utilization of material and air velocity

A square or rectangular shroud were provided for the fan to convert the circular flow of air into the required shape.

Further the known equipment consumes more power, more material and are therefore not cost effective.

Therefore, it has been proposed to develop a new heat exchanger, which would avoid all the disadvantages of the known equipment.

II. POWER CONSUMED BY FAN

The radiator in automobile sometimes needs additional airflow through it to prevent the engine from overheating. This usually occurs at idle and slow speed. At higher vehicle speeds, the air flows through the radiator by the forward motion of vehicle provide all the cooling that is needed. An engine fan or cooling fan pulls the additional air through the radiator. The fan may be either a mechanical fan or an electric fan.

Engines mounted longitudinally in rear- drive vehicles usually have a mechanical fan that mounts to the water pump shaft. The fan is made of sheet steel or moulded plastic. It has four to seven blades and turns with the water pump impeller. A fan shroud around the fan directs the airflow. This increases the efficiency of the fan.

Transverse engines in front-drive vehicles usually have an electric fan. An electric motor turns the blades. A thermostatic switch turns on the fan only when needed. Generally, the switch turns on the fan when the coolant reaches 70^0-80^0 C. It turns off the fan if the coolant drops below this temperature.

On the experimental trial setup of Petrol Engine and Diesel Engine, trials are conducted in the college laboratory with fan and without fan. It is observed that power consumed by the fan is of considerable magnitude and is about 2% to 5% of total power developed by the engine. Any saving in the fan power is directly the saving of precious fuel.

Also, BHP of the engine will be mentioned by the manufacturer or it can be calculated. Also, it is observed from following examples that,

Cummins engine make,1645 BHP required 42 HP for fan i.e., 2.55% of engine power.

Cummins engine make,600 BHP required 17 HP for fan i.e., 2.83% of engine power.

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III. COST OF RADIATORS

The smaller radiators may cost less but will consume more power; hence we have to optimize the design. Cost of radiators, heat transferred per unit area by radiator varies according to size, capacity and materials used for radiator and fins. Standard materials generally used are aluminium, copper, steel, alloys etc. as per the cost and capacity.

IV. EXISTING RECTANGULAR / SQUARE AND OTHER RADIATOR

(i)Rectangular Radiator

Rectangular Radiator

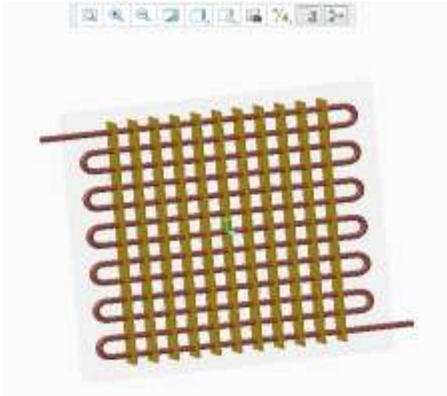


Figure 1

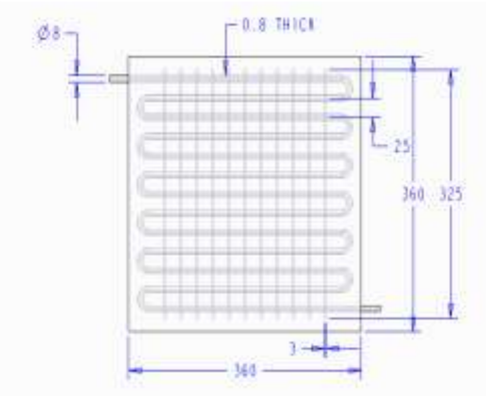


Figure 2

This existing design is most popularly used in the current applications. As shown in figure 2 hot water is allowed to flow through the inlet port, to upper tank where the hot water is distributed through a system of tubing. These tubes are surrounded and connected by a number of fins along the entire length of said tubes as shown. A fan is mounted on a shaft which causes a circulation or draught of air through the radiator and the fins. A shroud is adopted to regulate the flow of air from the fan so that it minimizes the quantity of air flow to escape. The atmospheric air collects the heat from the hot water as it flows over said system of tubes. The fins provided over the tubes increases the heat transfer area. The water entering through the inlet is allowed to flow the system of tubing before it gets cooled by the air and ultimately it comes out through an outlet port, after passing through the lower tank as shown.

(ii)Heat Exchanger for Air Conditioner

Heat exchanger for air conditioner

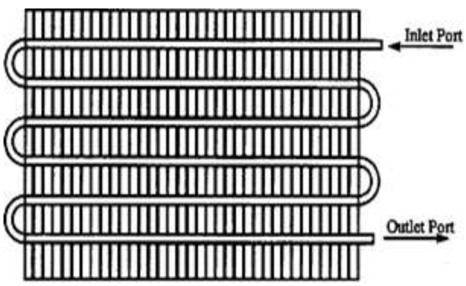


Figure 3

Figure 3 shows a heat exchanger used in air conditioner, where the refrigerant enters the heat exchanger through an inlet port and it passes through a system of tubing. The flow of refrigerant takes place through the tubing. The tubing transfer heat to the air through a series of fins attached to the tubing's. The refrigerant ultimately escapes out through an outlet port. As shown figure 3, in this case also a fan is provided to facilitate the air flow for enhancing the cooling / heating of refrigerant.

(iii)Square Shaped Heat Exchanger

This also is one of the constructional types of radiator existing in current market.

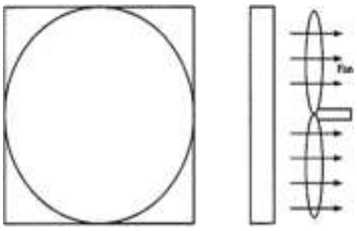


Figure 4

(iv)Air-Cooled Square Shaped Heat Exchanger

Figure 4 shows a square-shaped heat exchanger with a fan provided to deliver air in a circular area. 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 $(\pi/4)\ D^2 = O.76\ D^2$. The difference in the area of the square and the circle would be $\{D^2 - (\pi/4)\ D^2\} = 0.24\ D^2$.

V. OBJECTIVES OF PRESENT WORK

- To optimize the fan assisted heat exchanger (radiator) by improvement in design.
- To provide a heat exchanger that will be more efficient and compact.
- To provide a heat exchanger that will work with minimum power consumption for the fan and with maximum utilization of air flow.
- To have a heat exchanger with minimum material and will thus be less costly.
- Excluding the central hub area, the material saving is @ 24%, saving in the cost of production on mass scale basis once the dies are manufactured will be about 20 %.
- Considering the number of vehicles, refrigerators and air conditioners used at national and international levels, slight improvement in efficiency and reduction in cost will add to the economy to a great extent.

VI. CAD MODEL OF RADIATOR

Material of tubes: Aluminum number of tubes: 20

Inner Diameter of Tube: 10mm outer diameter of tube: 11.25 mm Material of fin: Aluminum Thickness of fin: 0.16 mm

Rectangular Radiator

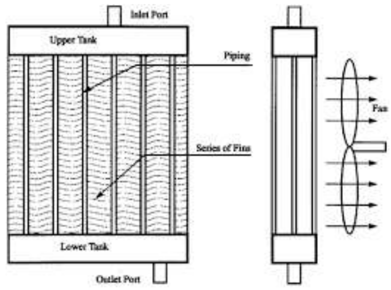
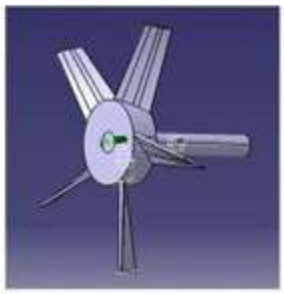


Figure 5

VII. GEOMERIC MODELING OF FAN

CFD analysis of the radiator, it is necessary to create a geometric model of the system. A model of the radiator and the fan was made in CATIA V5 and then exported to CFD analysis software.



Fan Model Radiator Model

Figure 6&5

VIII. PROPOSED HEAT EXCHANGER

To overcome the drawbacks of this current and conventional design, a new design with geometrical modifications is proposed to obtain efficient working of the radiator.

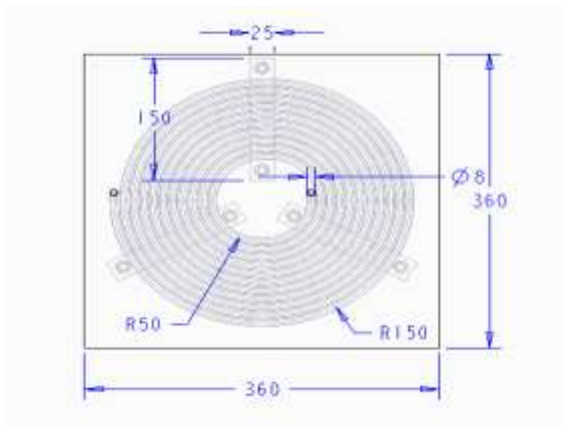
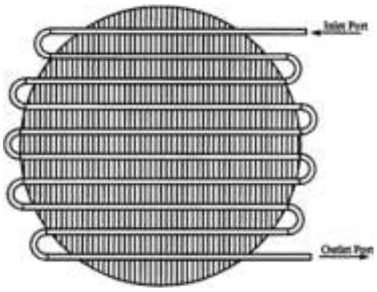


Figure 7

In the existing design, there is no heat transfer area at the centre where the flow of air is almost zero.

In the proposed design the tubes and the fins are so arranged that the outlet air has nearly constant velocity.

Heat exchanger for the refrigeration air conditioning system



Heat Exchanger for the Refrigeration Air Conditioning

Figure 8

IX. HEAT EXCHANGER FOR THE REFRIGERATION AIR CONDITIONING

The Heat exchanger for the refrigeration air conditioning system is provided with a number of fins of varying depth, maximum depth at the outer periphery and the reducing depth along the inner periphery. It is found that the new heat exchanger as described herein above has better performance level in its application. Further it consumes less power and it is thus more economical.

X. LIMITATIONS

- Inserting of fins in the tubes.
- Bending of tubes in circular shape.
- Dies are to be manufactured for circular radiators which are exorbitantly costly.

IX. CONCLUSIONS

1. Design is compact
2. For optimum efficiency eliminate corners and develop radiator of Circular shape.
3. Low velocity zones and high temperature regions (low heat transfer regions) are identified in corners we observe that velocity increases with the increase in rpm of radiator fan.
4. Less material requirement
5. Less power consumption for fan.
6. More efficient.
7. Since material saving is about 24%, cost saving on mass scale production will be about 20% , once the dies are manufactured

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