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# EXPERIMENTAL STUDY FOR HEAT TRANSFER ENHANCEMENT OF A CAR RADIATOR USING TWISTED INSERTS WITH DIFFERENT COOLANTS

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**ABSTRACT:** The radiator is used for cooling the internal combustion engine cylinder with the help of different coolant fluids. It is an essential part for any IC engine for its proper and smooth operation. In radiator the coolant fluid absorb the heat from engine cylinder and finally rejects to surrounding air. It has been observed by various researchers that the enhancement of thermal performance of a radiator is a major problem. In this dissertation study of a car radiator is investigated to improve its thermal performance by increasing heat transfer rate. In present work the experimental work of three cases have been investigated for various mass flow rate for general heat exchange fluid of water and coolant with mixture (50% of ethylene glycol + 50%water).We have considered firstly by simple circular tube radiator and secondly the twisted wire inserted radiator and thirdly twisted tape inserted radiator for its experimental observation and performance by using two fluids as water and mixture (50% of ethylene glycol +50% of water).In this project work the Nusselt number and heat transfer coefficient and heat transfer have been calculated experimentally and then co- related with the available co-relation Dittuss-boelter's and Gnielinski. The first experiments have been done by using Coolant (water).It has seen that the 33.33% enhancement of Nusselt number and 40% enhancement of heat transfer by using twisted inserts in simple tube of radiator as compared to simple tube of in radiator at different mass flow rates. The second experiments have been done by using a coolant (with mixture of ethylene glycol + water (50:50) combination. So it is a biggest achievement of heat transfer rate in car radiator and better cooling effect and finally reduces spaces in car radiator tubes.

**KEYWORDS:** Car radiator, twisted inserts, heat transfer coefficient, Nusselt Number, turbulence, Reynolds Number and Prandtal Number, cooling performance.

## 1. INTRODUCTION

Radiator is the heat exchanger which is used to transfer thermal energy from one medium to another medium and perform aim of the cooling and heating. In automobiles with a liquid cooled internal combustion engine and radiator is connected to channels running through the engine and cylinder head, through which a liquid is pumped. It is liquid may also water but is more commonly a mixture of water and antifreeze in proportions appropriate to the climate. Antifreeze itself is usually ethylene or propylene glycol with a small amount of corrosion inhibitor.

## 2. EXPERIMENTAL SETUP

Experimental investigation of car radiator is carried out to get results on heat transfer parameters of car radiator made of Aluminum pipes and fins. Twisted inserts are also used to enhance heat transfer of car radiator. Experimental set up is made according to information available from literature review of published research work. Test set up is also follow ASHRAE (American Society of Heating, Refrigerating, and Air-Conditioning Engineers) standard to overcome issues involve in test rig. Important steps involved during setup working are followed in next section.

1. The car radiator should be preconditioned before experiments will be started. It is important because by doing this stagnation heat involved in non operational condition is controlled and there is no possibility to occur error in readings.
2. Size of test rig is another important factor for quality research. In present study general car radiator is selected from local market and diameter of pipe is standard diameter used for heat exchanger device.

3. During experimental work it is good to work in dry environment where heat loss due to environment is less and unwanted wind is not present.
4. Proper insulation is provided to test rig during experimental work to decrease heat loss from experimental work. This task is performed by using insulation material on heater and fluid pipe line of test rig.
5. Test is located at proper horizontal surface so there is no error in recorded data of experimental work.
6. Velocity measurement near test rig is good approach because high velocity can increase heat loss from set up, which increase error in data.
7. Fluid used in setup, is have constant initial temperature so there is no difference in inlet temperature of fluid.

### 2.1 Experimental Setup

The experimental test facility is designed according international standard. The main reference for setup making is taken from literature review. Length of car radiator is 55 mm with 4 mm diameter, having 50 tubes in it with fins attached to tubes. The thickness of tube is 0.5 mm and this tube is made of aluminum material. Test rig have temperature measuring devices, air velocity measuring devices, U tube manometer, insulation material, multi-meter. Thermal electrical insulation material is used for aluminum pipe to prevent heat loss energy from car radiator but allow thermal energy in tube. Glass wool is one good example of this category. Aluminum tube is connected to fluid pipe which carry water from pump to tube initial point without any leak. Local available heating Coil is used for heating the tube. It is made of high electrical conductor material. Internal section of tube is highly polished and it reduces turbulence of water flow, so roughness is increased by giving it rubbing with metal wires. Water leveling is used to maintain setup at true horizontal. Total five holes are drilled in aluminum tube. These holes are used for temperature measurement. Figure 3.6 and figure 2.1 shows schematic and Setup of radiator experiments.

TABLE 2.1 Specification of car radiator

| **Parameters** | **Values** |
|---|---|
| Length of car radiator | 55 mm |
| diameter | 4 mm |
| Number of tubes | 50 |
| Thickness of tube | 0.5 mm |

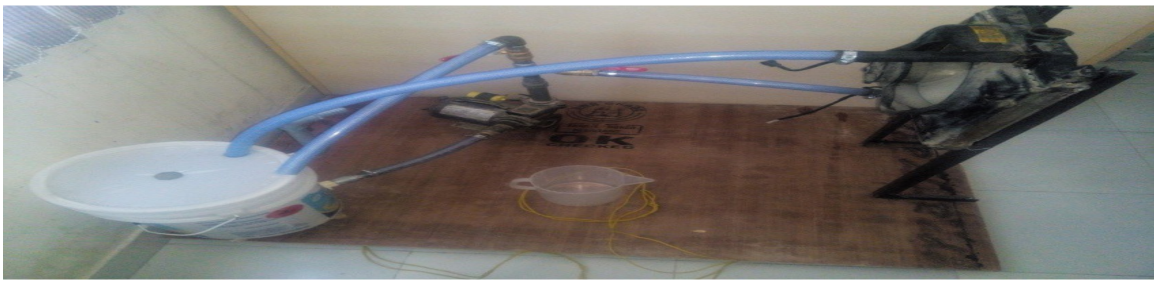

**Figure 2.1 Setup of radiator experiments**

In figure 3.7.The setup is shown in running condition, which means it work on car radiator. Thermocouples are permanent installed at holes so that there is no water loss from them. U tube manometer is also used to find out pressure drop. In simple case there is very less pressure drop. In U tube manometer heavy liquid is used.
In this study three designs of heat car radiator is used for heat transfer analysis, first is simple car radiator tube, second twisted wire and last design twisted tape is inserted in it. Experiments are carried out for all three cases, but in this study only design variations are not studied, also fluid effect is studied. Two different fluids are used for the study, namely water and ethylene glycol + water is mixture of 50%:50% in radiator.

## 3. EXPERIMENTAL OBSERVATION AND CALCULATIONS

### 3.1 Equations used for validation of the experiment result:

To obtain heat transfer coefficient and corresponding Nusselt number, the following procedure has been performed.
According to Newton's cooling law:
Equation used for energy supplied to car radiator [8]

$$Q = hA(T_b - T_w) \tag{3.1}$$

Equation used for heat transfer rate can be calculated as follows [8]

$$Q = m * C * (T_{in} - T_{out}) \tag{3.2}$$

Regarding the equality of Q in the above equations [8]

$$Nu = \frac{\dot{m}C_p(T_{in} - T_{out})}{A(T_b - T_w)} = \frac{h_{exp}d_{hy}}{K} \tag{3.3}$$

Equation used for Reynolds number [20]

$$R_e = \frac{4\dot{m}}{\pi D\mu} \tag{3.4}$$

Equation used for Nusselt number [20]

$$Nu = \frac{hd}{K} \tag{3.5}$$

Correlation equation for Nu number given by Dittus-Boeltler [8]

$$Nu = 0.024Re^{0.8}Pr^{0.3} \tag{3.6}$$

Correlation equation for Nu number given by Gnielinski [8]

$$Nu = \frac{\left(f/_8\right)(Re - 1000)\,Pr}{1 + 12.7\left(f/_8\right)^{0.5}(Pr^{0.67} - 1)} \tag{3.7}$$

Where f is friction factor and formula for **f** is given by Petukhov [8]

$$f = (0.79\ln(Re) - 1.64)^{-2} \tag{3.8}$$

**Table 3.1** Thermo physical properties of fluid [10]

| S.NO. | Properties | Water |
|---|---|---|
| **1.** | Thermal conductivity (W/m k) | 0.55 |
| **2.** | Specific heat (J/kg-K) | 4182 |
| **3.** | viscosity (N-s/$m^2$) | 0.00016 |
| **4.** | Density (Kg/$m^3$) | 997.10 |

**Table 3.2** Thermo physical properties of base fluid **[6]**

| S.NO. | Properties | Mixture of (water+ ethylene glycols) |
|---|---|---|
| **1.** | Thermal conductivity( W/m k) | 0.363 |
| **2.** | Specific heat (J/kg-K) | 3370 |
| **3.** | viscosity [μ] (N-s/$m^2$) | 0.0000465 |
| **4.** | Density (kg/$m^3$) | 1064 |

## 4. RESULTS AND DISCUSSION

In present study car radiator is investigated to improve thermal performance. For this task in present study two type of work is performed. In first study experimental work performed with water and applying insert-I and insert-II in radiator tube. In second study experimental work performed with (Water+ ethylene glycol is 50%:50%) and applying insert in radiator tube. Two factors are selected for this part of work. Factor one is mass flow rate and second factor is design insert. Most of the experimental work is discussed in previous chapter. So here in this chapter need not to discuss. In this chapter of important factors are discussed like heat transfer and its coefficient for working fluid and design of experiments based results .In Figure 4.1 effect on heat transfer rate on the basis of LPM (liter per minute)of water is studied and from this figure it is concluded that when twisted insert is applied in car radiator heat transfer rate is improved, the reason behind is improvement in turbulence and increment in turbulent kinematic energy.

*TABLE 4.1*
*RESULTING PARAMETER*

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| MFR Kg/sec | $T_{in}$ ($^0C$) Simple tube | $T_{out}$ ($^0C$) Simple tube | $T_{in}$ ($^0C$) Insert-I | $T_{out}$ ($^0C$) Insert I | $T_{in}$ ($^0C$) Insert-II | $T_{out}$ ($^0C$) Insert-II | Q (W) Simple tube | Q (W) Insert-I | Q (W) Insert-II |
|---|---|---|---|---|---|---|---|---|---|
| 0.17 | 45 | 44 | 45 | 43.6 | 48 | 46.9 | 710.94 | 995.31 | 782.03 |
| 0.20 | 46 | 45 | 47 | 45.5 | 48 | 46.8 | 830.40 | 1254.60 | 1003.68 |
| 0.25 | 46 | 45 | 48 | 46.6 | 47 | 45.8 | 1045.50 | 1463.70 | 1254.60 |
| 0.28 | 47 | 46 | 47 | 45.7 | 48 | 46.8 | 1170.96 | 1522.24 | 1405.15 |

**4.1 Heat transfer and mass flow rate.**

According to heat transfer equation the heat transfer rate increase with increase in mass flow rate in radiator .So In this experiments we have increasing mass flow rate in car radiator then heat transfer rate continuously improved with inserts used in car radiator tube , the reason behind is improvement in turbulence and increment in turbulent kinematic energy. According to table 5.1 it is clear that the enhancement of heat transfer rate is 40% by using twisted inserts-I in simple tube of radiator as compared to simple tube in car radiator. It has been successfully in my experimental work.

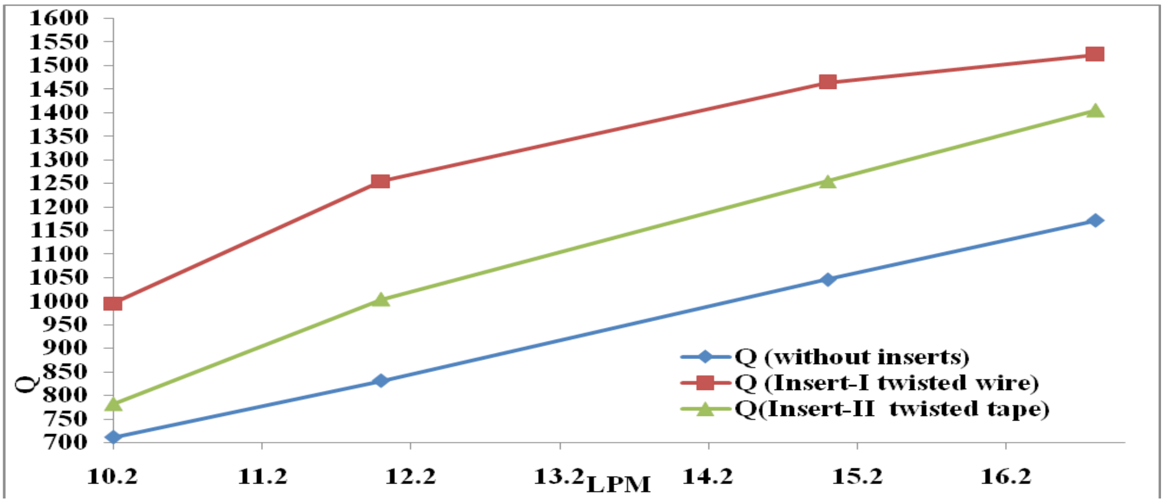


**Fig 4.1 Heat transfer and mass flow rate**

In Figure 4.2 effect on heat transfer rate on the basis of LPM (liter per minute)of (water+ ethylene glycol) is studied and from this figure it is concluded that when twisted insert is applied in car radiator heat transfer rate is improved, the reason behind is improvement in turbulence and increment in turbulent kinematic energy.

*TABLE 4.2*
*RESULTING PARAMETER*

| MFR | $T_{in}$($^0C$) Simple tube | $T_{out}$($^0C$) Simple tube | $T_{in}$($^0C$) Insert-I | $T_{out}$($^0C$) Insert-I | $T_{in}$($^0C$) Insert-II | $T_{out}$($^0C$) Insert-II | Q(W) Simple tube | Q(W) Insert-I | Q(W) Insert-II |
|---|---|---|---|---|---|---|---|---|---|
| .17 | 48 | 45.8 | 47 | 44.2 | 47 | 44.5 | 1564.06 | 1990.63 | 1777.35 |
| .20 | 47 | 44.9 | 46.8 | 44.3 | 47 | 44.6 | 1756.44 | 2091.00 | 2007.36 |
| .25 | 47 | 45 | 48 | 45 | 48 | 45.3 | 2091.00 | 3136.50 | 2822.85 |
| .28 | 47 | 44.9 | 47 | 44.2 | 47 | 45.5 | 2459.01 | 3278.68 | 2927.40 |

In this experiment we have increasing mass flow rate in car radiator then heat transfer rate continuously improved with inserts used in car radiator tube, the reason behind is improvement in turbulence and increment in turbulent kinematic energy. According to table 5.3 it is clear that the different mass flow rates (0.17kg/sec, 0.20kg/sec, 0.25kg/sec, 0.28kg/sec) at enhancement of heat transfer rates is 50% by using twisted insert-I in simple circular tube of radiator as compared to simple circular tube in car radiator the reason behind is improvement in turbulence and increment in turbulent kinematic energy. Now we have used twisted inserts-II in circular tube at different mass flow rates (0.17kg/sec, 0.20kg/sec,0.25kg/sec,0.28 kg/sec) than the enhancement of heat transfer rates is 34% as compared to simple circular tube in car radiator. So that insert-I is more effective as compared to insert-II, the reason behind is improvement in turbulence and increment in turbulent kinematic energy. It is big achievement successfully in my experimental work.

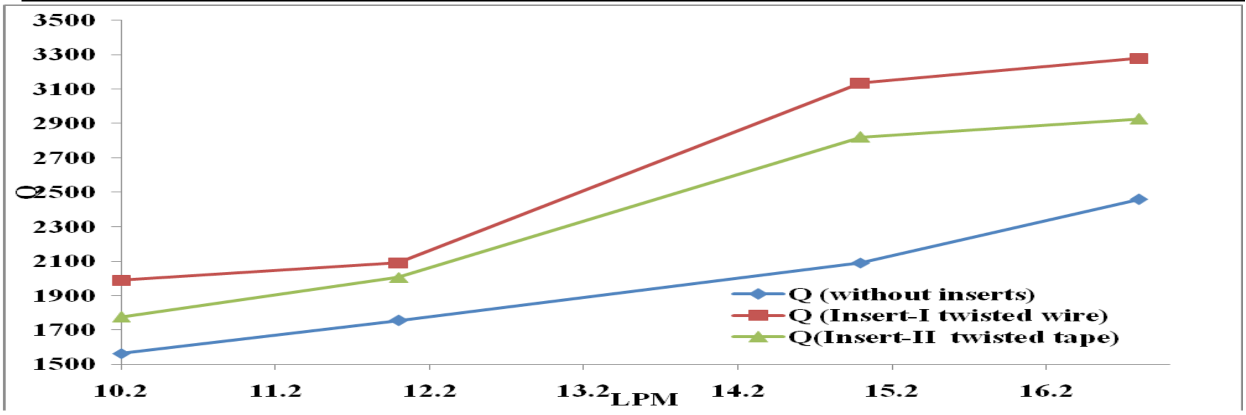


**Fig 4.2 Heat transfer rate and mass flow rate**

In figure 4.2 heat transfer rate coefficient is discussed and presented for all three designs which are investigated for current study. As seen in figure insert has highest values of heat transfer coefficient ‘h’ and this result show that by applying insert in car radiator heat transfer rate has improved results are presented in table

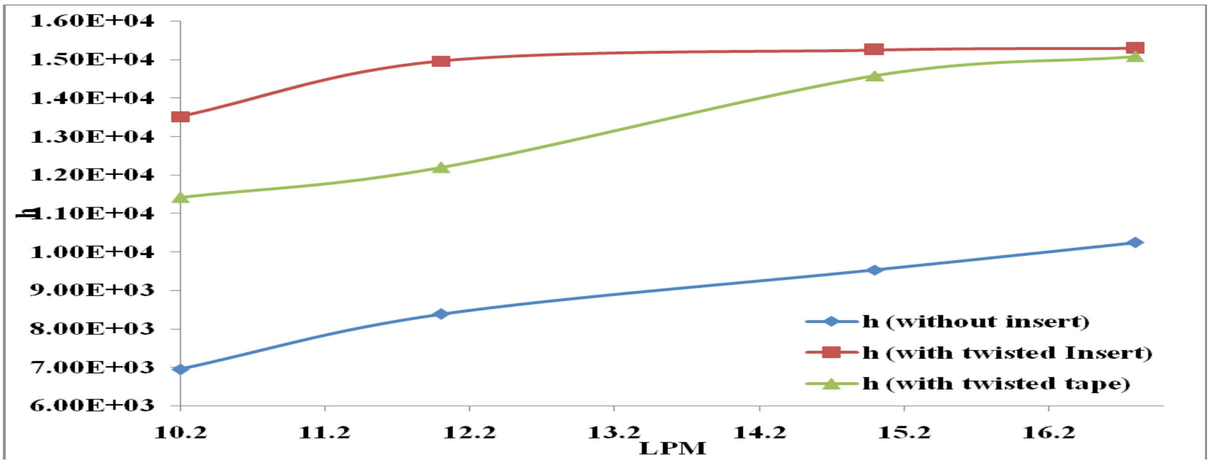


**Fig4.3 Convective transfer and mass flow rate**

## 5. CONCLUSION AND FUTURE SCOPE

In this experiment the convective heat transfer enhancement, Nusselt number and heat transfer rate of automobile radiator has been experimentally studied by using ethylene glycol and water at different flow rates and temperatures to study their behavior. Main conclusions of this study are presented here in detail.

1. Addition of water considerably enhancement of heat transfer rate is 40% by using twisted inserts in simple tube of radiator as compared to simple circular tube in car radiator at different mass flow rates and temperature.
2. Addition of (Water+ ethylene glycol) considerably enhancement of Nusselt number is 50.52% by using twisted inserts in simple tube of radiator as compared to simple tube in car radiator at different mass flow rates and temperature.
3. Addition of (Water+ ethylene glycol) considerably enhancement of heat transfer rate is 50% by using twisted inserts in simple circular tube of radiator as compared to simple circular tube in car radiator at different mass flow rates and temperature.
4. Addition of (Water+ ethylene glycol) considerably enhancement of convective heat transfer coefficient 48.12% by using twisted inserts in simple tube of radiator as compared to simple tube in car radiator at different mass flow rates and temperature.
5. Heat transfer rates are weakly dependent on the inlet fluid temperature. An increase in inlet temperature than increase in Nusselt number and heat transfer rate.

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