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# Basics of Radiator and Improvement Techniques

Kaustubh Wani[1], Kounal Sose[2], Mangesh Shitole[3], Pradnya Kokad[4], N.R. Patil[5]
Student[(1, 2, 3, 4)], Assistant Professor[5]
Department of Mechanical Engineering, P.E.S's Modern College of Engineering, Pune, India[(1, 2, 3, 4, 5)]

**Abstract:- Engine produces high amount of heat while running. This may increase the engine temperature to such a level where, it can damage the engine components if temperature is not controlled. Radiator plays an important role in engine cooling system. Radiators are heat exchangers used to transfer thermal energy from one medium to another for the purpose of heating and cooling. As there is transfer of energy from one medium to another, some amount of energy is lost. Due to limited resources, economic factors and various other restrictions, there is sometimes a compromise between either the efficiency of the radiator or the various above mentioned factors. There is substantial and constant research to improve the efficiency of the radiator to avoid any compromise of any kind. In this paper we hope to provide few improvement techniques which will help researchers and students to use the techniques for their research, project or any academic work and to help them be updated with the current progress in this field.**

***Keywords:-*** *Radiators, Nanofluids, Turbulence, Carbon Foam.*

## I. INTRODUCTION

A radiator is a heat exchanging device. It is used in automobiles and diesel generators: for cooling the engine, in households: to heat buildings, in electronics: to cool the circuitry. The basic working principle of radiator is convection. It means most of the heat is transferred by convection and only a small amount of heat is transferred by radiation. Heat in a radiator is transferred in the following manner in a automobile radiator:

Hot liquid (coolant) to metal tube to cold air. The mode of heat transfer is as follows:
Conduction – convection + radiation – convection.

### *A. Working*

A radiator has a inlet and a outlet for fluid to flow. The number of passes (number of times the liquid passes in the tubes or number of pipes passing through the tube) are generally multiple to give the required heat dissipation and for the radiator to work efficiently.

Fig. 1:- A Typical Radiator

*[The following type of radiator explained is specifically used in automobiles and diesel generators.]*

The hot fluid enters in the tubes from the inlet channel. The working fluid is generally 50-5- mix of water and ethylene glycol. The liquid is cooled either by natural or forced convection. The flowing air, which moves through the radiator transfers hear from coolant to air. Thus temperature of air increases resulting in reduced temperature of the coolant. This cold liquid is sent for the required application, here, to cool the engine. After cooling the engine, the liquid gains heat and its temperature rises. It is then circulated by a suitable mechanism back to the radiator for cooling and the cycle continues. The tubes are now-a-days finned to increase the surface area for heat dissipation.

### *B. Construction And Material*

- There are two materials used for making radiators they are copper and aluminium. Copper is a better conductor of heat than aluminium. But the problem in these radiators is only tubes and fins are made from copper and they are joined together with lead which has very poor heat transfer capabilities. The end tanks are made from brass and the side channels are of steel. These all reduces heat transfer capacity of copper radiator.
- The aluminium radiator is 100% aluminium furnace brazed without any insulating solder. This is the reason why aluminium radiators perform better than copper ones and is best material for generator radiators also.

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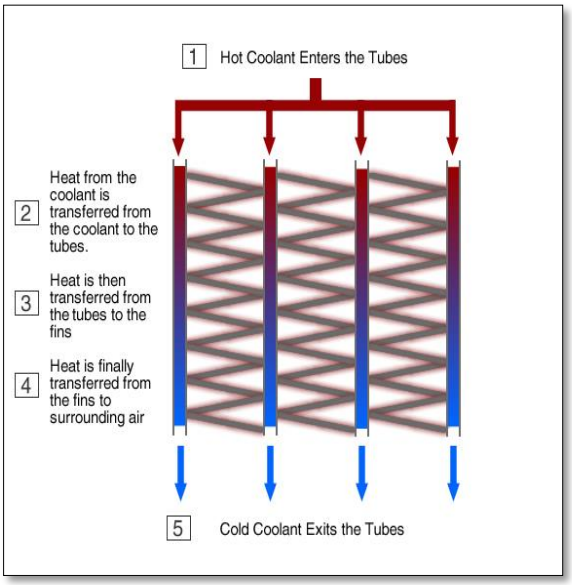


Fig. 2:- Heat Transfer Through Fins.

Fig. 3:- Tubes and Fins.

*C. Terminologies*

- *Coolant:*

A coolant is a fluid that reduces the temperature of a system.

- *Fins:*

A fin is a thin component or appendage extended from a body or structure. They are used to increase surface areas for heat transfer purposes.

- *Conduction:*

Conduction is the transfer of heat between solids, from higher temperature to lower temperature, due to internal atomic movement.

- *Convection:*

Convection is the heat transfer between solids and fluids due to movement of particles and formation of natural current.

- *Radiation:*

Thermal radiation is heat transfer due to radiation of electromagnetic waves which is possessed by any body having temperature above absolute zero.

- *Nanofluids:*

They are fluids which contain nano-meter sized particles which possess enhanced properties, useful, mostly for heat transfer.

## II. IMPROVEMENT TECHNIQUES APPLIED TO THE RADIATOR

The standard radiator used in any application is finned to increase the area of heat dissipation from the cooling liquid. Efficiency of radiator can be improved by changing its geometrical parameters like diameter of tubes or number of tubes, by varying coolant used or by varying radiator material. This type of radiator is enough or suitable for a general purpose application. With emerging advanced techniques the need of a cheap, more efficient and a economical system is required. This can and is being satisfied by constant study and consequently improving the system for best results. There are a few ways explained to improve the efficiency of a radiator, they are mentioned below in brief:

- By increasing the air velocity, by changing the fin configuration.
- Use of nanofluids.
- S-Shaped Fins.
- Increasing turbulence of coolants.
- Use of carbon-foams fins.

*A. By Increasing Air Velocity*

Air velocity can be increased by creating a nozzle. The nozzle can be created in various ways, one maybe by using two flat plates. This nozzle helps in increasing velocity and hence pressure decreases. This decreases temperature as pressure is directly proportional to temperature.

*B. Use of Nano Fluids*

Nanofluids are fluids which consist of a base fluid with nano sized particles (1-100 nm) suspended within them. These particles, generally a metal or metal oxide, increase conduction and convection coefficients, allowing for more heat transfer out of the coolant. Nanofluids are more stable and can be used in real world applications, due to the recent progress in the field. These properties would be very beneficial to allow for an increased amount of heat to be removed from the engine. This is useful in such a way that, it may permit the fluid to sustain higher loads for cooling. However, these nanofluids do not show considerable improvement in heat transfer when used with current radiator designs. This is because there are several limitations to current radiator designs.

*C. S-Shaped Fins*

Numerical studies have showed that the fin shape affects the thermal-hydraulic characteristics of the radiator with S-shaped fins. Various fin parameters were studied. Narrower fins produce more heat transfer area per unit volume but worsen the fin efficiency more than the wider fins. It is seen that, the largest heat transfer rate was showed by the narrowest fins. A longer fin length reduces the stream bend and pressure drop that occurs because of the stream bend. Fin roundness at the head and tail edge of the fins minimally affect the heat transfer performance but greatly affect the pressure drop performance. From the real fin shape manufactured by chemical etching, the pressure drop is increased by about 30%. To obtain minimum pressure drop, it would be wise to choose the fin roundness with the minimum value.

*D. Increasing Turbulence of Coolants*

It is observed that higher turbulence will increase the radiator effectiveness. After investigating the heat transfer in plain fin arrangements was, to determine the influence of corner radii of bent metal sheets of the ribs, the Reynolds number range extended from 500 to 3000, and at Re=2000, transition from laminar to turbulent flow was observed. The ducts with the smallest radii resulted in the highest Nusselt number for a given Reynolds number. However, a comparison of the investigated geometries in terms of the volume.

*E. Use of Carbon Foam Fins*

Replacing aluminium fins with carbon foam channels, is a technique which can be employed for improving the radiator working. Due to the thermal properties of carbon foam (k = 175-180 W/mK for carbon foam with 70% porosity), along with increasing the amount of heat rejected, we will be able to reduce the overall size of the radiator while simultaneously increasing the surface area exposed to the air, thus reducing the air side resistance. The carbon foam has channels in a corrugated pattern. This corrugation channels air into the slots and forces the air through the carbon foam. Many parallelly arranged tubes, provide support for the carbon foam as well as contain the necessary volume of coolant. The end caps are made out of aluminium and also provide structural support and mounting locations. Overall, this design concept is a simple design which will meet most of our customer requirements.

## III. CONCLUSION

This article can be used as a reliable initial study material by any researcher studying on radiator selection, its working and efficiency improvement techniques by improving the overall working conditions of a radiator. It will also help engineering students who are trying to understand the current progress in the field of heat exchangers. The information in this paper is not only restricted to radiators but, can also be applied to different, but relevant heat exchanger studies.

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