

Design Modification and Analysis of Helical Fins Used in Locomotive Engines Radiator

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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. The majority of radiators are constructed to function in automobiles, buildings, and electronics. In this project, locomotive engine radiators are focused. The fins are the main component in the radiators to cool the hot fluid to cold. Generally the fins are placed in the radiators like the zigzag triangle structure. Instead of that, fins are modified to helical spring shaped fins. By this modification the contact area on the radiator fins are increased and chance to cool high optimum rate or faster cooler. The parametric 3d modelling software CREO 3.0 is used for designing of the model.

KEYWORDS: Automobile Radiator, Helical Fins, CREO 3.0 and Ansys Fluent 15.0.

I. INTRODUCTION

The radiator is always a source of heat to its environment, although this may be for either the purpose of heating this environment, or for cooling the fluid or coolant supplied to it, as for engine cooling. One might expect the term "radiator" to apply to devices that transfer heat primarily by thermal radiation, while a device which relied primarily on natural or forced convection would be called a "convector". In practice, the term "radiator" refers to any of a number of devices in which a liquid circulates through exposed pipes (often with fins or other means of increasing surface area). The term "convector" refers to a class of devices in which the source of heat is not directly exposed.

In this Project, to get the better efficiency for the engine cooling system, the modification is targeted on the fins. Normally the fins are designed as zigzag triangle shape type. The wavy type radiator fins also used but they are not more efficient than Zigzag type fins. Helical fins are also available but they are failure project for the engine cooling system and they are used for the boiler cooling system. So the new concept is taken down for the cooling system by the modification of fins like helical fins but this type of fins are designed like a spring shaped to make the air swirl between the fins. By this modification, the contact area of the air is greatly increased and chanced to cool optimum higher rate or fast cooler. The concept design is done using the standard parametric design software CREO and theoretical solution is calculated for this project.

II. ENGINE COOLING

Radiators are used for cooling internal combustion engines, mainly in automobiles but also in piston-engine aircraft, locomotives, motorcycles, stationary generating plants and other places where such engines are used. To cool down the engine, a coolant is passed through the engine block, where it absorbs heat from the engine. The hot coolant is then fed into the inlet tank of the radiator (located either on the top of the radiator, or along one side), from which it is distributed across the radiator core through tubes to another tank on the opposite end of the radiator. As the coolant passes through the radiator tubes on its way to the opposite tank, it transfers much of its heat to the tubes which, in turn,

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transfer the heat to the fins that are lodged between each row of tubes. The fins then release the heat to the ambient air. Fins are used to greatly increase the contact surface of the tubes to the air, thus increasing the exchange efficiency. The cooled coolant is fed back to the engine, and the cycle repeats. Normally, the radiator does not reduce the temperature of the coolant back to ambient air temperature, but it is still sufficiently cooled to keep the engine from overheating.

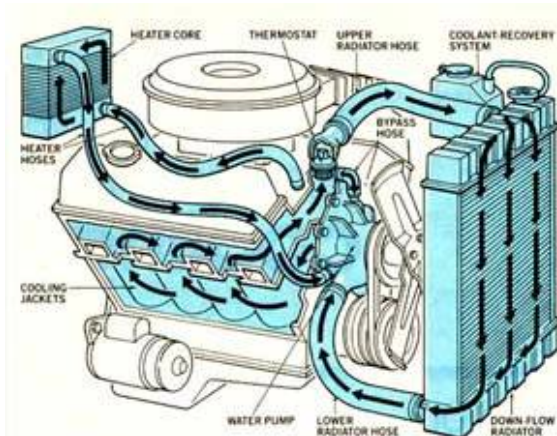


Figure 1: Engine Cooling System

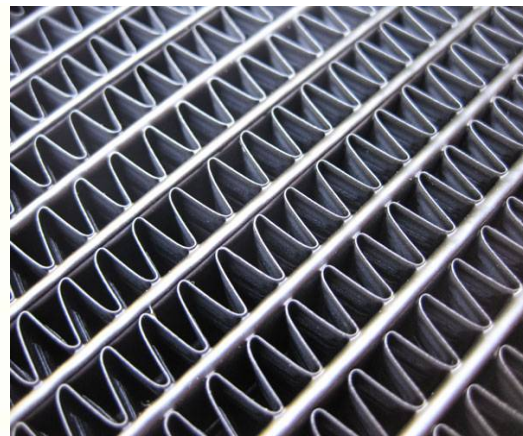


Figure 2: ZIGZAG type Fins



Figure 3: Cooling System in Locomotive Engine

The design for Locomotive Engine Cooling System because,

- Locomotive engines are high speed Engines.
- Due to heavy load capacity it needs more power to operate engines.
- So the huge type of engines are used for locomotive Engines, because of that radiators consists more space to cool them.
- By this design the surface area is increased and may be the chance to cool is optimized.

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- The modification is done to make the air swirl. So the area of contact is greatly increased between the fins.
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III. PARAMETRIC 3D MODELING

For the design modification standard design tool is used. The model is based on the concept design.



Figure 4: Helical Fin (Front View)



Figure 5: Helical Fin (Top View)

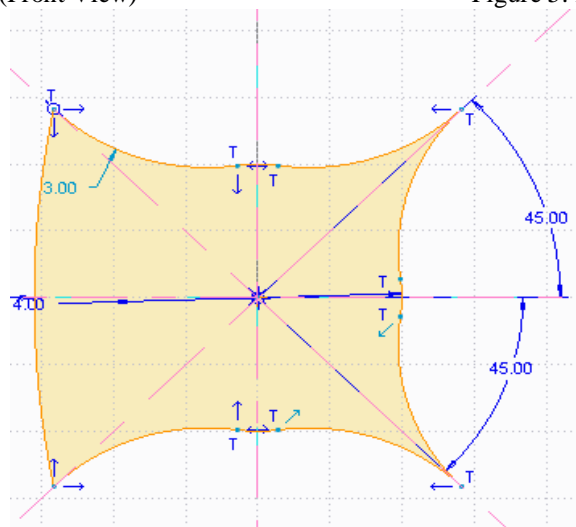


Figure 6: Cross Sectional View of Fin

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IV.FIN EQUATION

$$\dot{Q}_x = -KA_c \frac{dT}{dx}$$

$$\dot{Q}_{x+dx} = \dot{Q}_x + \frac{d\dot{Q}_x}{dx} dx$$

$$d\dot{Q}_{conv} = h dA_s (T - T_\infty)$$

ENERGY BALANCE

$$\dot{Q}_x = \dot{Q}_{x+dx} + d\dot{Q}_{conv} = \dot{Q}_x + \frac{d\dot{Q}_x}{dx} dx + h dA_s (T - T_\infty)$$

$$\frac{d}{dx} \left(A_c \frac{dT}{dx} \right) - \frac{h}{K} \frac{dA_s}{dx} (T - T_\infty) = 0$$

$$\frac{d^2 T}{dx^2} + \frac{1}{Ac} \frac{dAs}{dx} \left(\frac{dT}{dx} \right) - \left(\frac{1}{Ac} \frac{h}{K} \frac{dAs}{dx} \right) (T - T_\infty) = 0$$

FINS WITH UNIFORM CROSS SECTION

$$\frac{d^2 T}{dx^2} - \left(\frac{1}{Ac} \frac{h}{K} \frac{dAs}{dx} \right) (T - T_\infty) = 0$$

$$\frac{dAc}{dx} = 0$$

$$A_s = Px$$

$$\frac{d^2 T}{dx^2} - \left(\frac{hP}{KAc} \right) (T - T_\infty) = 0$$

Excess temperature θ

$$\theta(x) = T(x) - T_\infty$$

$$\frac{d^2 \theta}{dx^2} - m^2 \theta = 0$$

$$m^2 = \frac{hP}{KAc}$$

$$\theta(x) = T(x) - T_\infty$$

The general Solution is of the form

$$\theta(x) = C_1 e^{mx} + C_2 e^{-mx}$$

Heat transfer from the fin surface

$$\dot{Q}_f = \dot{Q}_b = -KA_c \frac{dT}{dx} \Big|_{x=0} = -KA_c \frac{d\theta}{dx} \Big|_{x=0}$$

$$\dot{Q}_f = \sqrt{hPKAc} \theta_b \frac{\sin mL + (h/mK) \cos mL}{\cos mL + (h/mK) \sin mL}$$

Another way of finding Q

$$\dot{Q}_{fin} = \int A_{fin} h [T(x) - T_\infty] dA_{fin} = \int A_{fin} h \theta(x) dA_{fin}$$

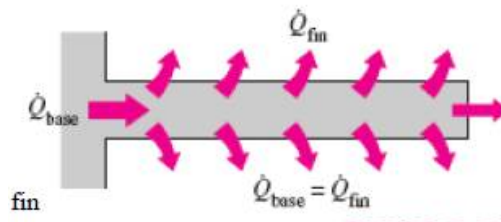


Figure 7: Heat transfer from fin

Under steady conditions, heat transfer from the exposed surfaces of the fin is equal to the heat conduction to the fin at the base.

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FIN EFFICIENCY

$$\eta_{fin} = \frac{Q_{fin}}{\dot{Q}_{finmax}}$$

Actual Heat Transfer From the fin
Ideal heat transfer from the fin is if the entire fin were at the base temperature. In the limiting case of zero thermal resistance or infinite thermal conductivity ($K \rightarrow \infty$), the temperature of the fin is uniform at the base value of T_b .

$$\dot{Q}_{fin} = \eta_{fin} \dot{Q}_{finmax} = \eta_{fin} h A_{fin} (T_b - T_\infty) = 0$$

$$\eta_{long\ fin} = \frac{Q_{fin}}{\dot{Q}_{finmax}} = \frac{\sqrt{hPKAc}(T_b - T_\infty)}{hA_{fin}(T_b - T_\infty)}$$

$$= \frac{1}{L} \sqrt{KAc/hP} = \frac{1}{mL}$$

$$\eta_{insulated\ tip} = \frac{Q_{fin}}{\dot{Q}_{finmax}} = \frac{\sqrt{hPKAc}(T_b - T_\infty) \tanh mL}{hA_{fin}(T_b - T_\infty)}$$

$$= \frac{\tanh mL}{mL}$$

$\epsilon_{fin} < 1$ Fin act as insulation (if low k material is used)

$\epsilon_{fin} > 1$ Enhancing heat transfer

$\epsilon_{fin} = 1$ Does not affect the heat transfer at all.

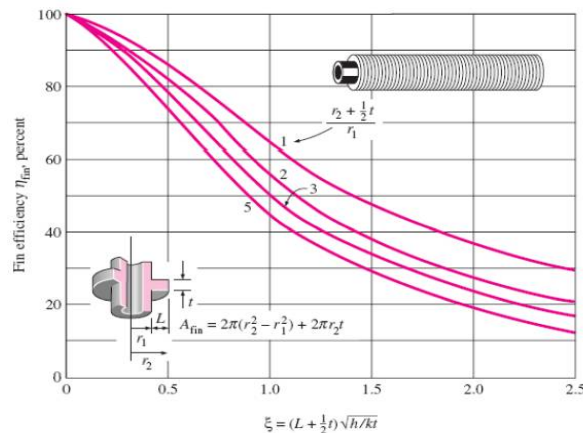


Figure 8: Efficiency of circular fins of length L and constant thickness

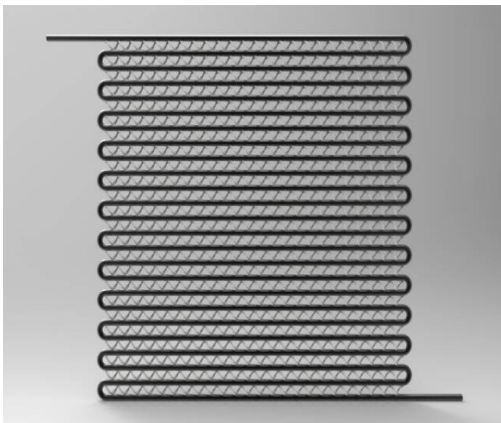


Figure 9: Coolant Tube with Fins

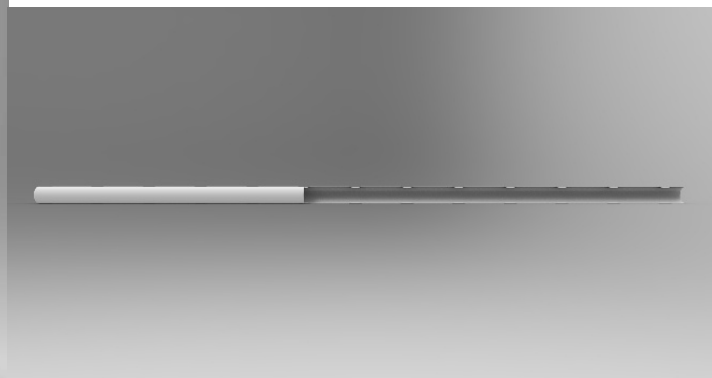


Figure 10: Cross Section of Tube

The design modification is done on a coolant tube and fin. In the previous design the fins revolved around the tube. Due to this, the area of contact is decreased. But in this design modification, the fins are placed in between the two tubes. The one face of the helical fin is dimpled in the tube. The air swirl is done when the helical fins are placed in between the tubes. The air swirl greatly increased the air contact area between the fins.

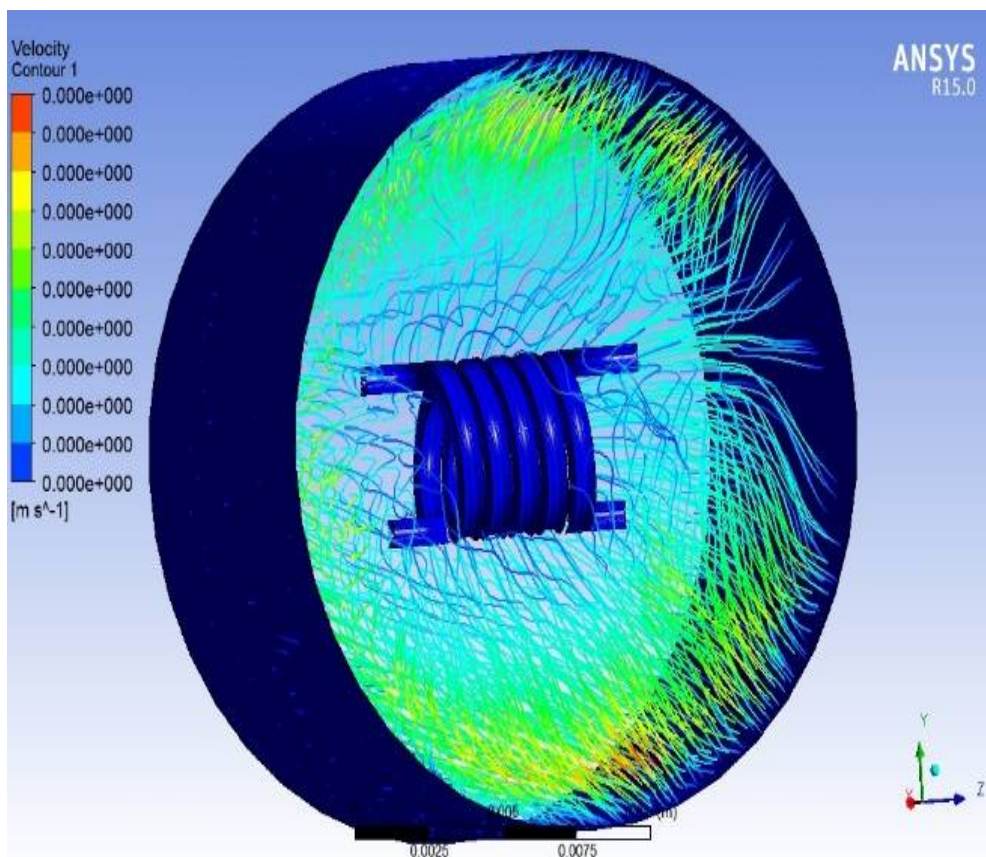


Figure 11: Air swirl in the helical spring shaped fin

This is the base concept of how to develop the efficiency of the engine. We are using the more coolant system in the locomotive engine to maintain the temperature of the water. This is due to the zigzag type fins have more contact area between them. By increasing air contact area, we can greatly increase cooling time or the optimized cooling rate to higher.

This modification greatly advantage to the engine system. It reduce the weight, cooling rate and space occupation by the cooling system in locomotive engine shown in the figure 2. From this results we can increase the overall efficiency of the engine.

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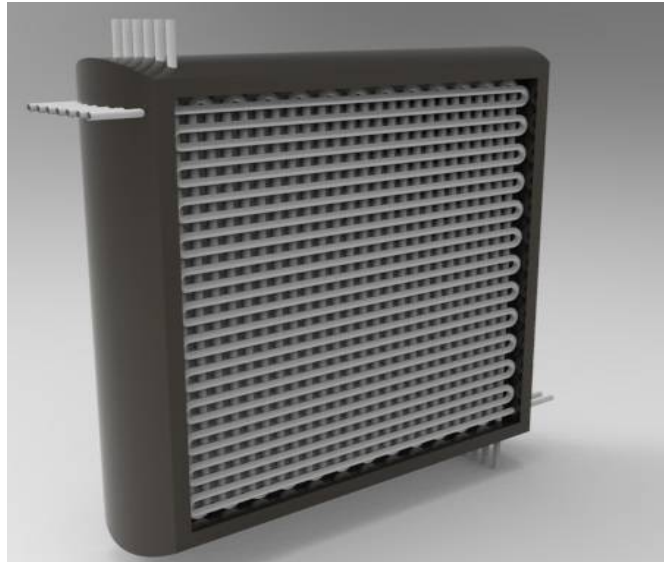


Figure 12: Modified radiator assembly

V. CONCLUSION

Engine cooling system is considered as one of the engine efficiency. Many researches are done to increase the cooling rate with minimum time. In this project, the concept is done on the fins to increase the cooling rate of the fluid. Due to this, helical spring shaped radiators are designed because to increase the air contact area by creating the air swirl in between the fins. The design is done on the standard parametric software and the air swirl is analyzed in the FEM solver Ansys Fluent. The theoretical concepts are applied to calculate the fin efficiency.

For the further enhancement, it would be developed for then realistic experiment to justify practically. This method can apply in all type of radiator cooling system because other than normal fins contact area of the area compared to the helical fins is multiplied by more. So, it should be possible to increase the efficiency of the cooling system.

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