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Design and Analysis of Various Material Two -Wheeler Engine Cooling Fins

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Abstract--- *In order to conserve natural resources and economize energy, weight reduction has been the main focus of automobile manufacturers in the present scenario. Weight reduction can be achieved primarily by the introduction of better material, design optimization and better manufacturing processes. The suspension cooling fins is one of the potential items for weight reduction in automobiles as it accounts for 10% - 20% of the unspring weight. This achieves the vehicle with more fuel efficiency and improved riding qualities. The introduction of metal alloys was made it possible to reduce the weight of cooling fins without any reduction on load carrying capacity and stiffness. Since, the aluminium alloy has more elastic strain energy storage capacity and high strength to weight ratio as compared with those of steel, it can used as the cooling fins for automobiles. Modelling and analysis of the aluminium alloy cooling fins will be done in this project.*

Keywords--- *Engine Cooling Fins, Various Material, Design and Analysis.*

I. INTRODUCTION

1.1 Cooling Fins

In the study of heat transfer, a fin is a surface that extends from an object to increase the rate of heat transfer to or from the environment by increasing convection. The amount of conduction, convection, or radiation of an object determines the amount of heat it transfers. Increasing the temperature difference between the object and the environment, increasing the convection heat transfer coefficient, or increasing the surface area of the object increases the heat transfer. Sometimes it is not economical or it is not feasible to change the first two options. Adding a fin to an object, however, increases the surface area and can sometimes be an economical solution to heat transfer problems.

Because fins are used to improve heat transfer, it is important to allow open spaces toward optimization. In other words, the shape of fins must be optimized such that the heat transfer density is maximized when the space and the materials used for the finned surfaces are constraints.

1.1.1 Inverted Fins

Open cavities are defined as the regions formed between adjacent fins and stand for the essential promoters of nucleate boiling or condensation. These cavities are usually utilized to extract heat from a variety of heat generating bodies. From 2004 until now, many researchers have been motivated to seek for the optimal design of cavities.

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1.1.2 Uses

Fins are most commonly used in heat exchanging devices such as radiators in cars, computer CPU heatsinks, and heat exchangers in power plants. They are also used in newer technology such as hydrogen fuel cells.[6] Nature has also taken advantage of the phenomena of fins. The ears of jackrabbits and Fennec Foxes act as fins to release heat from the blood that flows through them.

Fig.1.1: Two Wheeler Engine Cooling Fins

1.2 Aluminium Alloys

Aluminium alloys are alloys in which aluminium (Al) is the predominant metal. The typical alloying elements are copper, magnesium, manganese, silicon, tin and zinc. There are two principal classifications, namely casting alloys and wrought alloys, both of which are further subdivided into the categories heat-treatable and non-heat-treatable. About 85% of aluminium is used for wrought products, for example rolled plate, foils and extrusions.

Cast aluminium alloys yield cost-effective products due to the low melting point, although they generally have lower tensile strengths than wrought alloys. The most important cast aluminium alloy system is Al–Si, where the high levels of silicon (4.0–13%) contribute to give good casting characteristics. Aluminium alloys are widely used in engineering structures and components where light weight or corrosion resistance is required.

Alloys composed mostly of aluminium have been very important in aerospace manufacturing since the introduction of metal skinned aircraft. Aluminium-magnesium alloys are both lighter than other aluminium alloys and much less flammable than alloys that contain a very high percentage of magnesium.

Aluminium alloy surfaces will formulate a white, protective layer of corrosion aluminium oxide if left unprotected by anodizing correct painting procedures. In a wet environment, galvanic corrosion can occur when an aluminium alloy is placed in electrical contact with other metals with more negative corrosion potentials than aluminium, and an electrolyte is present that allows ion exchange.

Referred to as dissimilar metal corrosion this process can occur as exfoliation or intergranular corrosion. Aluminium alloys can be improperly heat treated. This causes internal element separation and the metal corrodes from the inside out. Aircraft mechanics deal daily with aluminium alloy corrosion.

1.2.1 Composition

Weight	**Al**	**Zn**	**Fe**	**Mn**	**Mg**
2219	70	29	0.30 max	0.20 – 0.40	0.02 max

1.2.2 Engineering Use and Aluminium Alloys Properties

Aluminium alloys with a wide range of properties are used in engineering structures. Alloy systems are classified by a number system (ANSI) or by names indicating their main alloying constituents (DIN and ISO).

Selecting the right alloy for a given application entails considerations of its tensile strength, density, ductility, formability, workability, Weldability, and corrosion resistance, to name a few. Aluminium alloys are used extensively in aircraft due to their high strength-to-weight ratio. On the other hand, pure aluminium metal is much too soft for such uses, and it does not have the high tensile strength that is needed for airplanes and helicopters.

1.3 Aluminium Alloys Versus Types Of Steel

Aluminium alloys typically have an elastic modulus of about 70 GPa, which is about one-third of the elastic modulus of most kinds of steel and steel alloys. Therefore, for a given load, a component or unit made of an aluminium alloy will experience a greater elastic deformation than a steel part of the identical size and shape.

With completely new metal products, the design choices are often governed by the choice of manufacturing technology. Extrusions are particularly important in this regard, owing to the ease with which aluminium alloys, particularly the Al–Mg–Si series, can be extruded to form complex profiles.

In general, stiffer and lighter designs can be achieved with aluminium alloys than is feasible with steels. For instance, consider the bending of a thin-walled tube: the second moment of area is inversely related to the stress in the tube wall, i.e. stresses are lower for larger values. The second moment of area is proportional to the cube of the radius times the wall thickness, thus increasing the radius (and weight) by 26% will lead to a halving of the wall stress.

For this reason, bicycle frames made of aluminium alloys make use of larger tube diameters than steel or titanium in order to yield the desired stiffness and strength. In automotive engineering, cars made of aluminium alloys employ space frames made of extruded profiles to ensure rigidity.

This represents a radical change from the common approach for current steel car design, which depend on the body shells for stiffness, known as unibody design. Aluminium alloys are widely used in automotive engines, particularly in cylinder and crankcases due to the weight savings that are possible.

Since aluminium alloys are susceptible to warping at elevated temperatures, the cooling system of such engines is critical. Manufacturing techniques and metallurgical advancements have also been instrumental for the successful application in automotive engines. In the 1960s, the aluminium cylinder heads of the Corvair earned a reputation for failure and stripping of threads, which is not seen in current aluminium cylinder heads.

An important structural limitation of aluminium alloys is their lower fatigue strength compared to steel. In controlled laboratory conditions, steels display a fatigue limit, which is the stress amplitude below which no failures occur – the metal does not continue to weaken with extended stress cycles.

Aluminium alloys do not have this lower fatigue limit and will continue to weaken with continued stress cycles. Aluminium alloys are therefore sparsely used in parts that require high fatigue strength in the high cycle regime (more than 10^7stress cycles).

Table 1.1: Properties of Cooling Fins

Physical Properties	**Unit**
Density	2.84 g/cc
Hardness, Brinell	130
Hardness, Knoop	163
Hardness, Rockwell A	49.5
Hardness, Rockwell B	80
Hardness, Vickers	149
Ultimate Tensile Strength	455 MPa
Tensile Yield Strength	352 MPa
Elongation at Break	10 %
Modulus of Elasticity	73.1 GPa
Ultimate Bearing Strength	896 MPa
Bearing Yield Strength	696 MPa
Poisson's Ratio	0.33
Fatigue Strength	103 MPa
Fracture Toughness	36 MPa-m½
Machinability	30 %
Shear Modulus	27 GPa
Electrical Resistivity	5.82e-006 ohm-cm
CTE, linear 68°F	22.3 µm/m-°C
CTE, linear 250°C	24.1 µm/m-°C
Specific Heat Capacity	0.864 J/g-°C
Thermal Conductivity	121 W/m-K
Melting Point	543 - 643 °C
Solidus	543 °C
Liquidus	643 °C
Annealing Temperature	413 °C
Solution Temperature	535 °C
Aging Temperature	163 - 191 °C

Aluminium's intolerance to high temperatures has not precluded its use in rocketry; even for use in constructing combustion chambers where gases can reach 3500 K.

The Agena upper stage engine used a regenerative cooled aluminium design for some parts of the nozzle, including the thermally critical throat region; in fact the extremely high thermal conductivity of aluminium prevented the throat from reaching the melting point even under massive heat flux, resulting in a reliable lightweight component.

1.4 Machinability

In the annealed condition this alloy is readily machined. It is more difficult to machine in any of the heat treated conditions, which is the condition in which most machining is actually done. Use of oil base lubrication is advised for all machining operations.

1.5 Advantages of Alloy Based Cooling Fins

- Less weight
- Acceptable mechanical properties.
- Good surface finish
- High machinability
- More flexible than steel
- More heat transfer.
- Simple manufacturing process
- Less manufacturing time
- No heat treatment

1.6 Modeling and Design

For the analysis purpose existing Model is taken and same model is modified with different geometry of fins and comparison is plotted in results.

The Design of different geometrical shape of Fins was in Pro E and Analysis done by the ANSYS FLUENT software and for mashing purpose Hyper Mesh was used. The computational domain consists of a rectangular volume of large dimensions containing the finned body at its Centre. It was focused on the fins and appropriate boundary conditions were applied at the domain ends to maintain continuity. A fine mesh has been created near the fins to resolve the thermal boundary layer which is surrounded by a coarse external mesh for better results and fast solution.

II. MATERIALS AND METHODS

2.1 Comparison with Steel Material

The objective of this study is to evaluate the applicability of an aluminium alloy material in automobiles by considering cost-effectiveness and strength. The comparison between multi-material and mono-leaf aluminium alloy spring is made for the same requirements and loading conditions. The comparison is based on four major aspects such as weight, riding comfort, cost and strength.

2.1.1 Methodology

The cooling fins behaves like a simply supported beam and the flexural analysis is done considering it as a simply supported beam.

2.1.2 Assumptions

- All non-linear effects are excluded. The stress-strain relationship for composite material is linear and elastic; hence Hooke’s law is applicable for Alloy materials
- The load is distributed uniformly at the middle of the cooling fins.The cooling fins has a uniform, rectangular cross section and check where you went wrong.

III. MODELING OF COOLING FINS

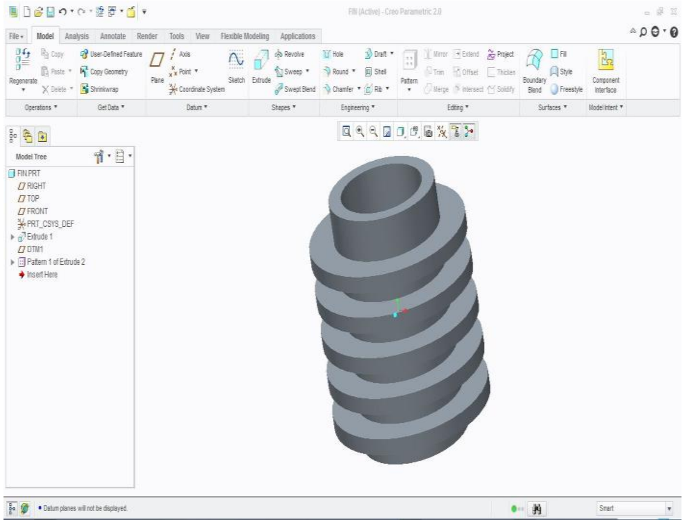

Fig 3.1: Modeling of Cooling Fins

3.1 Meshing

Meshing involves division of the entire of model into small pieces called elements. It is convenient to select the free mesh because the cooling fins has sharp curves, so that shape of the object will not alter. To mesh the cooling fins the element type must be decided first. Here, the element type is solid 45. The element edge length is taken as 5 mm. The numbers of elements are taken 2225 and the total numbers of nodes are 8099.

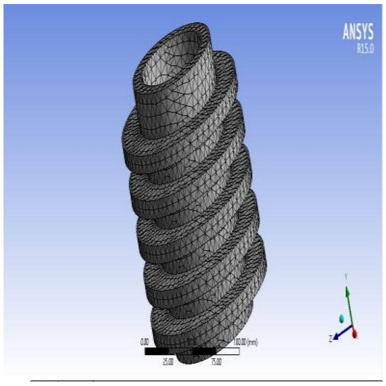

Fig 3.2: Mesh of Cooling Fins

3.2 boundary Conditions

The front eye of the cooling fins is coupled directly with a pin to the frame so that the eye can rotate freely about the pin but no translation is occurred. The rear eye of the spring is connected to the shackle which is a flexible link the other end of the shackle is connected to the frame of the vehicle.

The cooling fins is totally fixed at the centre with the help of bottom plate to the axel of vehicle. The force applied at both the eye end of cooling fins. The both eyes of the cooling fins have the flexibility to slide along the X-direction when load applied on the spring and also it can rotate about the pin in Z- direction. The link oscillates during load applied and removed. So the displacement at the both eye is constrained along the X and Z directions.

IV. RESULTS AND DISCUSSION

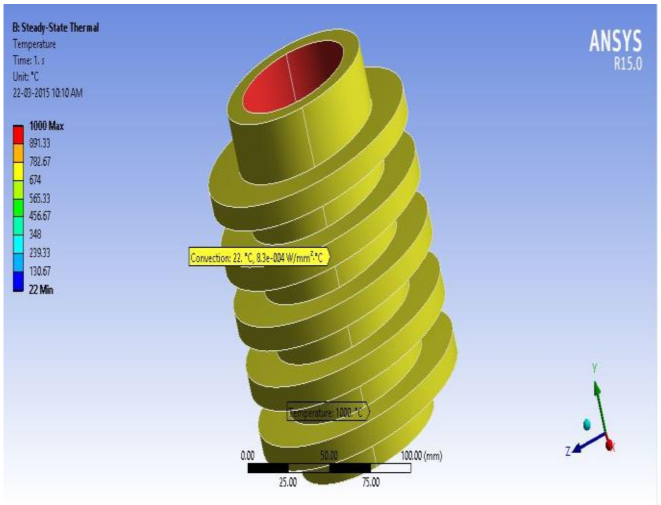

Fig 4.1: Temperature on Cooling Fins

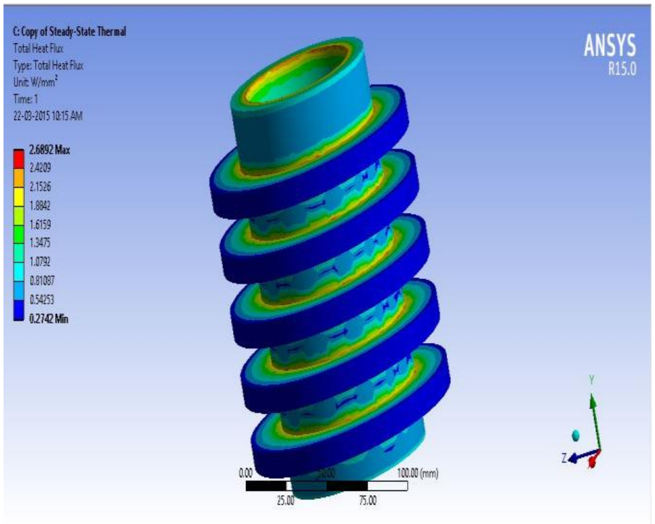

Fig 4.2: Total Heat Flux

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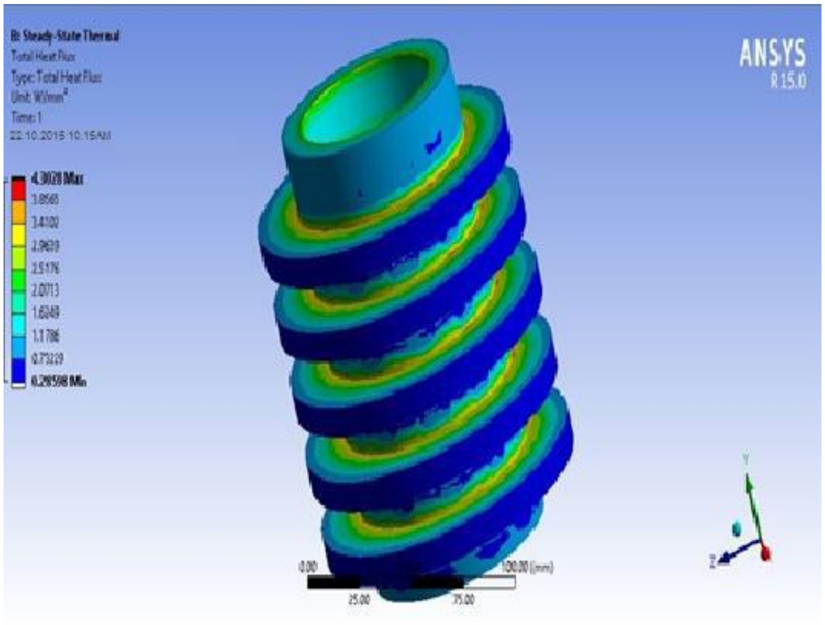

Fig 4.3: Heat Flux on Aluminium - Copper Material

4.2 Comparison based on Rigidity Qualities

The weight reduction of dead mass of an automobile will improve the riding quality. The suspension leaf contributes 10% - 20% of the unsprung mass. The weight of the aluminium alloy material is 4 times less than steel material. Hence the riding comfort of an automobile is increased due to the replacement of the steel material by aluminium alloy material. No one to the best of knowledge has worked but qualitatively on how much improvement in mileage/lit of passenger vehicle occurs and how much riding comfort improves. Only qualitative information is available on riding comfort of vehicle with respect to its unsprung mass. Steel spring is a multi-material and its inter-leaf fabrication reduces its riding quality.

4.3 Applications

Commercial and industrial applications of aluminium alloys are so varied that it is impossible to list them all. The major structural application areas, which include aircraft, space, automotive, sporting goods, and marine engineering. A potential for weight saving with aluminium alloy s exists in many engineering field.

- More suitable for light and medium duty vehicles
- These alloys were targeted for applications which included conductive springs.
- These alloy can also be used for making machine elements, contacts and terminals for electronic, electric and automotive connectors and other electromechanical components.

4.4 Discussion

This study explains the various characteristics and properties of the aluminium alloy. By means the literature survey it is well clear that the aluminium alloy is best suitable for its properties.

This project describes the latest and strongest alloy automobile cooling fins. The new alloy, containing 90% aluminium & 7% zinc is an inexpensive substitute for steel. This work will show that successful analysis of an aluminium alloy with 4 times weight reduction than steel.

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