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DESIGN AND ANALYSIS OF COOLINGFINS BY VARYING ITS GEOMETRY AND MATERIALS

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Abstract— The Engine cylinder automobile components, which is subjected to high temperature variations and thermal stresses. In order to cool the cylinder, fins are provided on the surface of the cylinder to increase the rate of heat transfer. The main purpose of using these cooling fins is to cool the engine cylinder by air. The cooling mechanism of the air cooled engine is mostly dependent on the fin design of the cylinder head and block. Cooling fins are used to increase the heat transfer rate of specified surface. Engine life and effectiveness can be improved with effective cooling.

The main aim of the project is to study and comparing different types of fins and analyze the thermal properties by varying geometry, material and thickness. We are analyzing the cylinder fins using Al 6061, Al 2014 and Mg AZ91D. The 3D modeling software used is creo 3.0. The analysis is done using PTC creo Simulate 3.0.

Keywords — Fin, Engine, Creo, Thermal Analysis

I. INTRODUCTION

In Internal engine, combustion of air fuel mixture takes place inside engine cylinder and hot gases are produced. The temperature of gases will be around 2300 – 500°C. The high temperature may result into burning of oil film between moving parts and may result into seizing or welding. Only approximately 30% of the energy released is converted into useful work. The remaining (70%) must be removed from the engine [1].

The heat generated during combustion in IC engine should be maintained at higher level to increase thermal efficiency, but to prevent the thermal damage some heat should remove from the engine.

In air-cooled engine, extended surfaces called fins are provided at the periphery of engine cylinder to increase heat transfer rate [2]. However, cooling beyond optimum limits is not desirable, because it decreases the overall efficiency due and also Thermal efficiency is decreased due to more loss of heat to the cylinder walls.

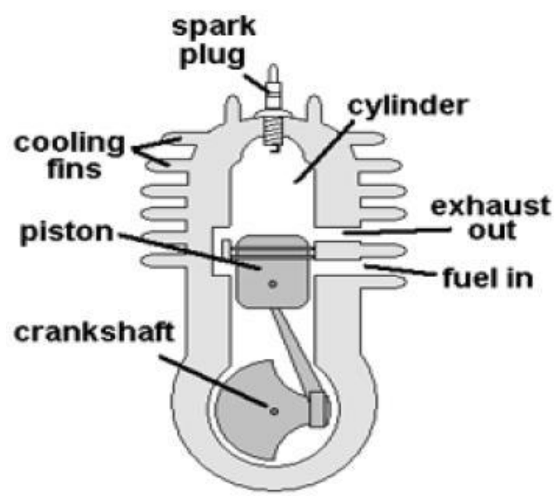

Fig.1 Layout of Air Cooled Engine with Fins

NEED FOR PROJECT

A necessity as cooling fins are part of IC engine the materials used for fins plays a very important role in heat transfer. In this project we mainly understood on how to effectively design the fins of the cylinder. Analysis is also done by varying the materials of fins. Materials considered are Aluminum 6061, Aluminum 2014 and Magnesium AZ91D. Finite element method is commonly used for thermal analysis. This process is done initially by modeling fins on CREO 3.0. As, the modeling is done, then it simulated. If they exceed the maximum stress of that the material can support, it will be necessary to add more materials or if it is not possible to work under the condition.

II. LITERATURE SURVEY

The material for the original model is changed by taking the consideration of their densities and thermal

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conductivity. Density is less for Aluminium alloy 6082 compared with other two materials so weight of fin body is less using Aluminium alloy 6082. By observing the thermal analysis results, thermal flux is more for Aluminium alloy than other two materials and also by using Aluminium alloy its weight is less, so using Aluminium alloy 6082 is better [3]. Heat releases from cylinder did not improved when the cylinder have the more fins and too narrow a fin pitch at lower wind velocities the air to flow into the narrower space between the fins, the temperature between them increased [4]. By reducing the thickness and also by changing the shape of the fin to circular shaped, the weight of the fin body reduces thereby increasing the heat transfer rate and efficiency of the fin. The material for the original model is changed by taking the consideration of their thermal conductivity and design of fins. And also by reducing the thickness of the fin, the heat transfer rate is increased. The materials are Aluminium alloy 7075, Magnesium Alloy and Beryllium. Thermal analysis is done for all the three materials. The material for the original model is changed by taking the consideration of their densities and thermal conductivity [4].

Air Cooled System

In this system fins or extended surfaces are provided on the cylinder walls, cylinder head, etc. Heat generated due to combustion in the engine cylinder will be conducted to the fins and when the air flows over the fins, heat will be dissipated to air [5].

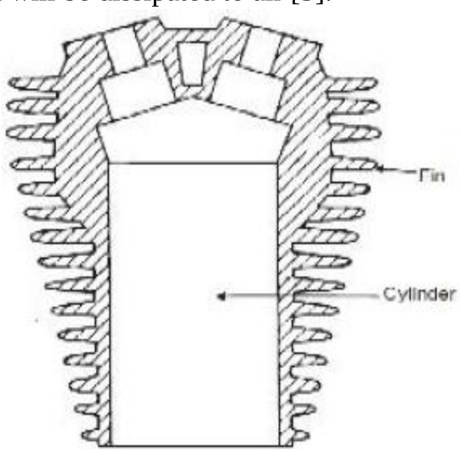

Fig.2 Air cooled engine cylinder with fins

III. TYPE OF FINS

The following are Different type of fins

1. Rectangular fins
2. Tapered fins
3. Radial plate fins
4. Pin fins
5. Disc or Annular fins

A. Rectangular Fins

The rectangular fin as shown in Fig. with L as the length of the fin, δ as thickness of the fin and W is width of fin and assuming the heat flow is unidirectional and it is along length and the heat transfer coefficient (h) on the surface of the fin is constant.

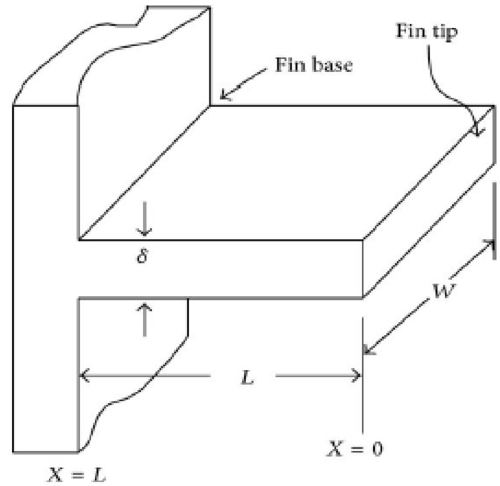

Fig.3 Rectangular fins

FINS SPECIFICATION

S.NO	Specification	Details	
1	Photographic View of Model		
2	Model Name	97.2	
3	CC	49.5	
4	Stroke (mm)	50	
5	Bore (mm)	11-8-11	
6	No. of Fins	9	
7	Fin Pitch (mm)	2	
8	Fin Thickness (mm)	Al Alloy	
9	Fin Material	Parallel	
10	Position of fins w.r.t. cylinder axis	Horizontal	
11	Position of fins w.r.t. cylinder axis	36	
12	Position of cylinder in vehicle	Min	8
		Max	36

Table 3.1: Fins Specification

B.Disc or Annular Fins

In thermal engineering, an annular fin is a specific type of fin used in heat transfer that varies, radially, in cross sectional area.

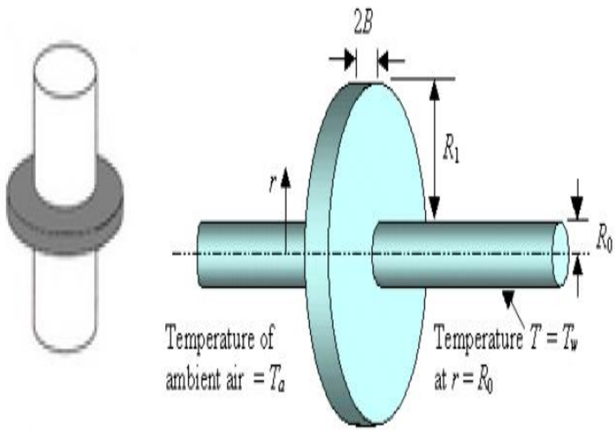

Fig.4 Disc or Annular Fins

IV. MATERIALS DESCRIPTION

The material description briefly explains the different types of materials and properties of IC engine cooling fins.

The following are generally used for casting process of IC engine cooling fins:

1. Aluminium Alloy 6061
2. Aluminium Alloy 2014
3. Magnesium Alloy AZ91D

S.No	NAME	PROPERTIES
1	Nominal composition (% by wt.)	Mg(90.753), Cu(0.002), Si(0.034), Fe(0.002),
2	Yield strength (MPa) (0.2%)	160
3	Tensile strength (MPa)	230
4	Elongation [%(in .500 inches)]	192
5	Thermal conductivity (W/m 26K.)	73.3
6	Co-efficient of Thermal expansion (0.00-100̊C) (μm/m̊C)	26

Table 4.1: Mg Alloy AZ91D Properties

S.NO	NAME	PROPERTIES
1)	Nominal composition (% by wt.)	Al(97.9),Cu(0.28), Mn(0.15),Mg(1.0) , Fe(0.70), Si(0.60), Zn(0.25), Cr(0.20)
2)	Yield strength (MPa)	48
3)	Tensile strength (MPa)	115
4)	Elongation [%(in 2 inches)]	16
5)	Thermal conductivity (W/m.K)	180
6)	Co-efficient of Thermal expansion(20□-100□C) (/□C)	23.5x10^-6

Table 4.2: Al 6061 Properties

S.No	Name	Properties
1	Nominal composition (% by wt.)	Al(93.50), Cu(4.40), Mg(0.50)
2	Yield strength (MPa)	95
3	Tensile strength (MPa)	185
4	Elongation [%(in .500 inches)]	27
5	Thermal conductivity (W/m. K)	192
6	Co-efficient of Thermal expansion(20̊-100̊C) (/̊C)	23x10^-6

Table 4.3: Al 2014 Properties

V. SOFTWARE DESCRIPTION

Here the dimensions of fins are taken from the Hero Honda 100cc engine. In this fin prototype is modeled using CREO 3.0 and analysis is carried out using CREO Simulate 3.0.

FIN PROTOTYPE MODELLING

The dimensions for the fin or tabulated in the previous chapter. According to the dimensions fin prototype for testing is modeled in CREO parametric 3.0, in which the dimensions of the cylinder along with fin where taken from commercially available bike data sheet.

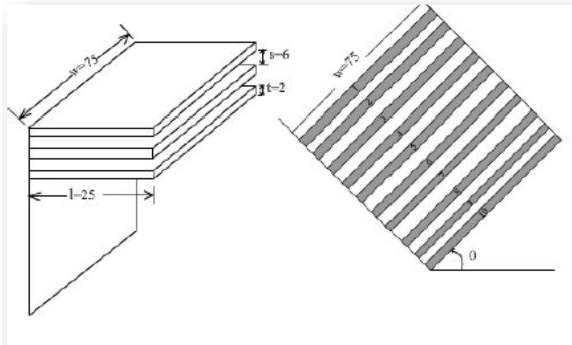

Fig.5: Fins for Prototype Modeling

VI. PROCEDURE FOR FIN PROTOTYPE MODELLING

The procedure for the various types of fin prototype modeling is listed below:

6.3.1 Rectangle Fins

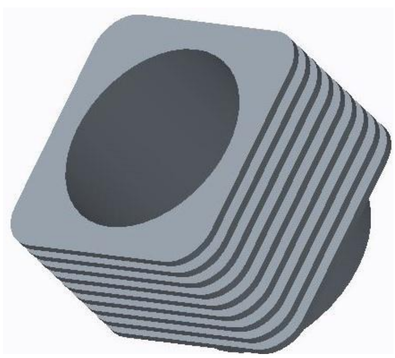

Fig.6:3D Modal Rectangle Fins

THERMAL ANALYSIS

Thermal analysis is a branch of materials science where the properties of materials are studied as they change with temperature. Thermal analysis is also often used as a term for the study of heat transfer through structures. Many of the basic engineering data for modelling such systems comes from measurements of heat capacity and thermal conductivity.

THERMAL ANALYSIS OF AL 6061

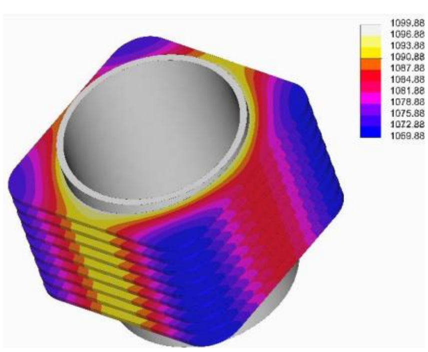

Fig.7: Nodal Temperature of Angular Fins 1.5mm

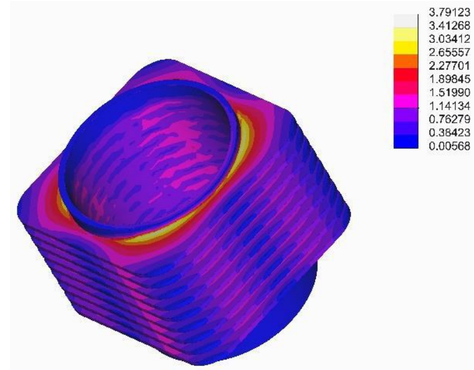

Fig.8: Temperature Gradient of Angular Fins 1.5mm

THERMAL ANALYSIS OF Mg AZ91D

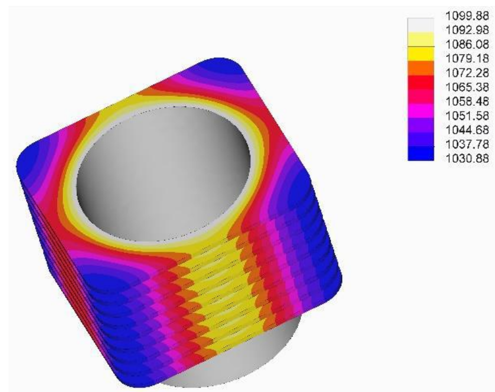

Fig.9: Nodal Temperature of Rectangular Fins 1.5mm

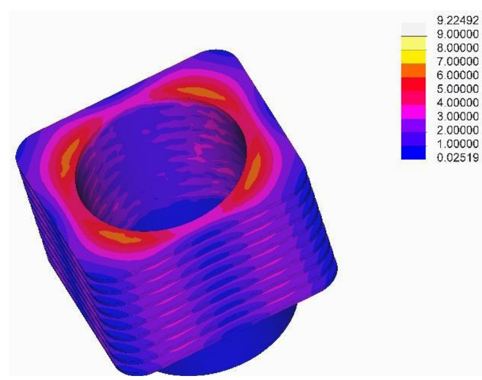

Fig.10: Temperature Gradient of Rectangular Fins 1.5mm

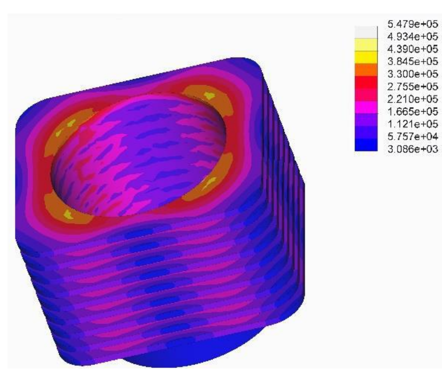

Fig.11: Flux of Rectangular Fins 2mm

VII. RESULT AND DISCUSSION

Heat flux or thermal flux is the rate of heat energy transfer through a given surface per unit time. To define the heat flux at a certain point in space, one takes the limiting case where the size of the surface becomes infinitesimally small. So the heat flux of the fins must be in maximum value. As on our project heat flux produced by the rectangular fins is more than the other fins types.

A temperature gradient is a physical quantity that describes in which direction and at what rate the temperature changes the most rapidly around a particular location. As well as the thermal flux of the fins the thermal gradient also had maximum value.

The contours are such that they give us the idea about at what place, the value of that parameter ranges, which is indicated by the color legend in the results.The variations of thermal gradient and thermal flux in different alloy materials on different fins type are tabulated.

SHAPE	THICKNESS (mm)	NODAL TEMPERATURE (°C)	THERMAL GRADIENT (C/mm)	THERMAL FLUX ×10^5(W/m²)
ANGULAR	1.5	1100	8.54997	6.669
	2	1100	6.68187	5.212
RECTANGULAR	1.5	1100	9.22492	7.195
	2	1100	7.02461	5.479
CIRCULAR	1.5	1100	7.18956	5.608
	2	1100	6.00618	4.685
VARIABLE		1100	3.88067	3.027

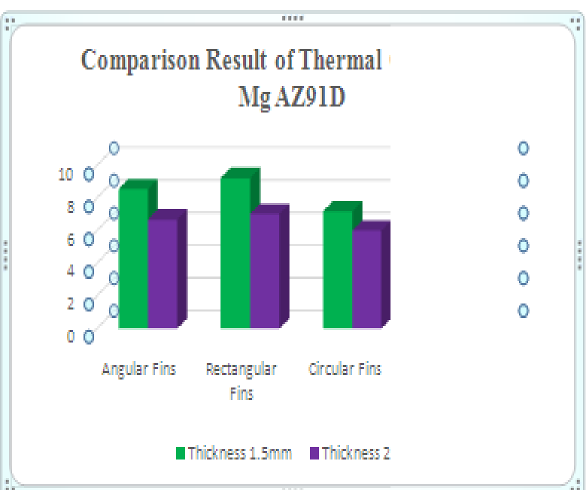

Chart 6.1: Comparison Result of Thermal Gradient in Mg AZ91D

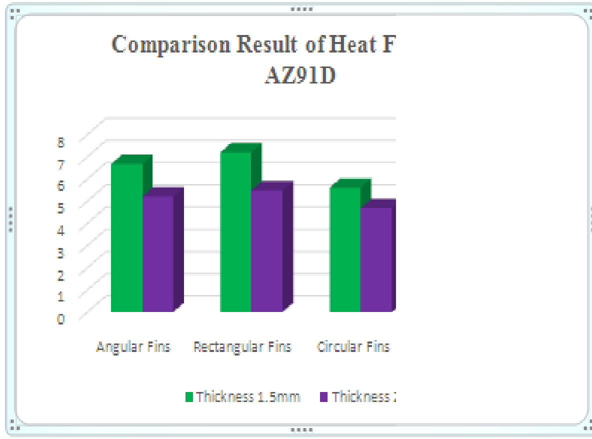

Chart 6.2: Comparison Result of Thermal Gradient in Mg AZ91D

It is observed from the steady state thermal analysis the rectangular fins showing good temperature distribution along the fin length. Figure 6.20 illustrates the temperature distribution of rectangular fins with different alloys. It is seen from the figure 6.19 the Magnesium Alloy 2014 showing more temperature distribution compared to that of Aluminium Alloy 2014 and Aluminium 6061. All the materials are showing linear distribution of temperature along the length of fins.

Result comparison of the above all chart shows that rectangular fins are more heat flu for magnesium alloy AZ91D.

VIII. CONCLUSION

In this project we modeled, a cylinder fin body for a 100cc motorcycle making use of using CREO 3.0 software. The thickness of the original model is 2 mm it has been reduced to 1.5 mm. By modifying shape of fins, the overall weight is reduced. Present used material for fin body is Aluminium alloy. In this project we considered Aluminum alloy 6061, Aluminum alloy 2014, Magnesium Alloy AZ91D as the fin materials. Thermal analysis is done on these materials. The material for the original model is changed by taking the consideration of their densities and thermal conductivity. By observing the thermal analysis results, we observed thermal flux is more for Magnesium and also by reducing the thickness of the fin to 1.5mm, heat transfer rate is increased. So by considering the above results, 1.5mm thickness rectangular fin made of Magnesium alloy AZ91D is good.

SCOPE FOR FUTURE WORK

The shape of the fin can be modified to improve the heat transfer rate and can be analyzed. So more experiments has to be done on curved fins. The use of Magnesium alloy as per the manufacturing aspect is to be considered. By changing the thickness of the fin, the total manufacturing cost is extra to prepare the new component.

Design of fin and type of materials plays the major role. As comparing various fin type design and materials will improve the stability.

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