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Design and Analysis of Fin using Al-Si Alloys with Mg for improving Heat Transfer Efficiency

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Abstract : The Engine cylinder is one of the major automobile components, which is subjected to high temperature variations and thermal stresses. In order to cool the cylinder, fins are provided on the cylinder to increase the rate of heat transfer. By doing thermal analysis on the engine cylinder fins, it is helpful to know the heat dissipation inside the cylinder. The principle implemented in this project is to increase the heat dissipation rate by using the invisible working fluid, nothing but air. We know that, by increasing the surface area we can increase the heat dissipation rate, so designing such a large complex engine is very difficult. The main purpose of using these cooling fins is to cool the engine cylinder by air. Presently Material used for manufacturing cylinder fin body is Cast Iron. In this thesis, using materials Al-Si Alloys with Mg are analyzed. Thermal analysis is done in combination or two alloy materials by changing geometries.

Index words – Engine cylinder, Heat dissipation, Fins, Al-Si alloys with Mg, Thermal analysis.

I. INTRODUCTION

The internal combustion engine is an engine in which the combustion of a fuel occurs with an oxidizer (usually air) in a combustion chamber. In an internal combustion engine, the expansion of the high-temperature and -pressure gases produced by combustion applies direct force to some component of the engine, such as pistons, turbine blades, or a nozzle. This force moves the component over a distance, generating useful mechanical energy. Most modern internal combustion engines are cooled by a closed circuit carrying liquid coolant through channels in the engine block, where the coolant absorbs heat, to a heat exchanger or radiator where the coolant releases heat into the air. Thus, while they are ultimately cooled by air, because of the liquid-coolant circuit they are known as water-cooled. In contrast, heat generated by an air-cooled engine is released directly into the air. Typically this is facilitated with metal fins covering the outside of the cylinders which increase the surface area that air can act on. In all combustion engines, a great percentage of the heat generated (around 44%) escapes through the exhaust, not through either a liquid cooling system or through the metal fins of an air-cooled engine (12%). About 8% of the heat energy finds its way into the oil, which although primarily meant for lubrication, also plays a role in heat dissipation via a cooler.

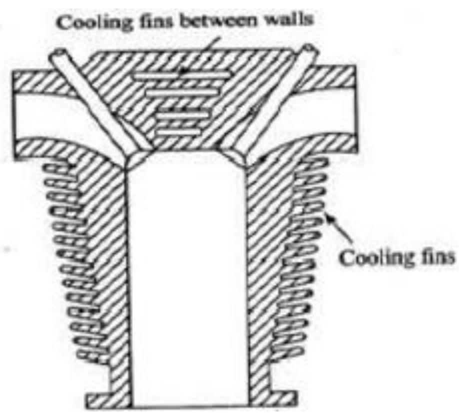

Fig. 1 2-Dimensional vie of fins

Heat transfer is classified into three types. The first is conduction, which is defined as transfer of heat occurring through intervening matter without bulk motion of the matter. A solid has one surface at a high temperature and one at a lower temperature. This type of heat conduction can occur, for example, through a turbine blade in a jet engine. The outside surface, which is exposed to gases from the combustor, is at a higher temperature than the inside surface, which has cooling air next to it. The second heat transfer process is convection, or heat transfer due to a flowing fluid. The fluid can be a gas or a liquid; both have applications in aerospace technology. In convection heat transfer, the heat is moved through bulk transfer of a non-uniform temperature fluid. The third process is radiation or transmission of energy through space without the necessary presence of matter. Radiation is the only method for heat transfer in space. Radiation can be important even in situations in which there is an intervening medium; a familiar example is the heat transfer from a glowing piece of metal or from a fire. Convective heat transfer is between the surfaces and surrounding fluid can be increased by providing the thin strips of metal called fins. Fins are also referred as extended surfaces. Whenever the available surfaces are inadequate to transfer the required quantity of heat, fins will be used. Fins are manufactured with different sizes and shape depends on the type of application. Air cooling for an IC Engine is well known example for Air cooling system in which air acting as a medium. Heat generated in the cylinder will be dissipated in to the atmosphere by conduction mode through the fins or extended surfaces are used in this system, which are incorporated around cylinder.

II. LITERATURE SURVEY

Pulkit Agarwal etc. simulated the heat transfer in motor cycle engine fan using CFD analysis. It is observed that ambient temperature reduces to the very low value; it results in over cooling and poor efficiency of the engine. They have concluded that over cooling also affects the engine efficiency.

Magarajan U et.al. have studied heat release of engine cylinder cooling fins with six numbers of fins having pitch of 10 mm and 20 mm, and are calculated numerically using commercially available CFD tool Ansys Fluent. The engine was at 150 C and the heat release from the cylinder was analyzed at a wind velocity of 0 km/h. Their CFD results were mostly same as that of the experimental results. So, they concluded that, it is possible to modify the fin geometry and predict those results, changes like tapered fins, providing slits and holes in fins geometry can be made and the optimization of fins can be done.

A.K. Mishra et.al. carried out transient numerical analysis with wall cylinder temperature of 423 K initially and the heat release from the cylinder is analyzed for zero wind velocity. The heat release from the cylinder which is calculated numerically is validated with the experimental results. To increase the cylinder cooling, the cylinder should have a greater number of fins. However, the cylinder cooling may decrease with an increased number of fins and too narrow a fin pitch.

G. Babu and M. Lavakumar analyzed the thermal properties by varying geometry, material and thickness of cylinder fins. The models were created by varying the geometry, rectangular, circular and curved shaped fins and also by varying thickness of the fins. Material used for manufacturing cylinder fin body was Aluminum Alloy 204 which has thermal conductivity of 110-150W/mk and also using Aluminum alloy 6061 and Magnesium alloy which have higher thermal conductivities. They concluded that by reducing the thickness and also by changing the shape of the fin to curve shaped, the weight of the fin body reduces thereby increasing the efficiency. The weight of the fin body is reduced when Magnesium alloy is used and using circular fin, material Aluminum alloy 6061 and thickness of 2.5mm is better since heat transfer rate is more and using circular fins the heat lost is more, efficiency and effectiveness is also more.

S.S. Chandrakant et.al. conducted experiments for rectangular and triangular fin profiles for air velocities ranging from 0 to 11 m/s. Experimental and CFD simulated result proves that annular fins with rectangular fin profiles are more suitable for heat transfer enhancement as compared to triangular fin profiles. Surface temperature of triangular fin profile is higher than rectangular fin profile at different air velocity. Heat transfer coefficient increase with increases with increases in velocity in both profiles. In comparison of both profile rectangular fin profile have higher heat transfer coefficient than triangular fin profile.

III. BASIC PRINCIPLES

There are many demands on a cooling system. One key requirement is that an engine fails if just one part overheats. Therefore, it is vital that the cooling system keep all parts at suitably low temperatures. Liquid-cooled engines are able to vary the size of their passageways through the engine block so that coolant flow may be tailored to the needs of each area.

Locations with either high peak temperatures (narrow islands around the combustion chamber) or high heat flow (around exhaust ports) may require generous cooling. This reduces the occurrence of hot spots, which are more difficult to avoid with air cooling. Air cooled engines may also vary their cooling capacity by using more closely-spaced cooling fins in that area, but this can make their manufacture difficult and expensive. Conductive heat transfer is proportional to the temperature difference between materials. If engine metal is at 250 °C and the air is at 20°C, then there is a 230°C temperature difference for cooling. An air-cooled engine uses all of this difference.Fins are manufactured with different sizes and shape depends on the type of application.

IV. ENGINE FINS

The heat transferring fins plays a vital role as heat sink in various equipment and machines. Fins increases surface area for increased heat dissipation to system or surrounding. It has a particular shape of geometry. Fins experience thermal loads from source and even some time static loads from external sources at time of cleaning or during finishing. The design and development of fins has always been a challenging task for weight, shape and design consideration. These improvements result in lighter parts with better heat transferring rate.

Fig. 2 Aluminium fin

This comparison was conducted on a rectangular pin fin with one side as a source of heat and also fixed onto that side of fin. Two different materials are analysed in same model and their results are compared. The heat transferring fins are modelled.

Scientists are continuously trying to improve various properties of engineering materials. This led to new category of materials called composite materials. They are composed of a combination of distinctly different two or more micro or macro constituents that differ in the form of composition and it is insoluble in each other. Composite materials have a continuous, phase called the matrix and a dispersed, non-continuous, phase called the reinforcement. The reinforcing phase material may be in the form of fibers, particles, or flakes. The matrix phase materials are generally continuous. In a composite, each material retains its original properties but when composited it yields superior properties which cannot be obtained separately. Heat transfer inside flow passages can be enhanced by using passive surface modifications such as rib tabulators, protrusions, pin fins, and dimples. These heat transfer enhancement techniques have practical. Application for internal cooling of turbine airfoils, combustion chamber liners and electronics cooling devices, biomedical devices and heat exchangers.

V. SELECTION OF MATERIALS

This chapter describes the details of processing of the composites and the experimental procedures followed for their mechanical characterization. The materials used in this work are

1. Aluminium alloy
2. Silicon carbide
3. magnesium

1. ALUMINIUM:-

Aluminium is a light metal (ρ = 2.7 g/cc); is easily machinable has wide variety of surface finishes; good electrical and thermal conductivities; highly reflective to heat and light.

- Versatile metal - can be cast, rolled, stamped, drawn, spun, roll-formed, hammered, extruded and forged into many shapes. Aluminium can be riveted, welded, brazed, or resin bonded.
- Corrosion resistant - no protective coating needed, however it is often anodized to improve surface finish, appearance.
- Al and its alloys - high strength-to-weight ratio (high specific strength) owing to low density.
- Such materials are widely used in aerospace and automotive applications where weight savings are needed for better fuel efficiency and performance.
- Al-Li alloys are lightest among all Al alloys and find wide applications in the aerospace industry.

Properties	Value
Poisson's Ratio	0.17
Coefficient of Thermal Expansion	-0.5 (K)
Young's Modulus	150 GPa
Density	2330 kg/m^3

Table. 1 Properties of aluminium alloys

The history of the light metal industry, as that ofmany other industries in this century, is one of notable and ever accelerating expansion and development.There are few people today who are not familiar with at least some modern application of aluminium and its alloys. The part it plays in our everyday life is such that it is difficult to realise that a century ago the metal was still a comparative.The chief alloying constituents added to aluminium are copper, Magnesium, silicon, manganese, nickel and zinc.

A good example of its structural use was the aluminum bridge. (Gilbert Kaufman, 2000). The alloy has versatile application as given below

- Pressure vessels
- Pipelines
- Cryogenic tanks
- Door beams, seat tracks, racks, rails
- Electrical cable towers
- Petroleum and Chemical Industry Components

2. SILICON:-

The formation of SiC from the reaction between silicon and carbon can take place at temperatures below the melting point of silicon. The phase diagram of the Si-C system. It can be seen that SiC is the only compound of silicon and carbon to occur in the condensed state in addition to elemental silicon and carbon. A eutectic point between silicon and SiC exists at 1402˚C and 0.75 atom % carbon. The liquid us curve between Si and SiC is shown up to 2600˚C and 27 atom % C. A peritectic point is located at 2540˚C and 27 atom % C under normal conditions. There are numerous (~200) poly types for SiC, but only a few are common. All of the structures may be visualized as being made up of a single basic unit, a layer of tetrahedra, in which each silicon atom is tetrahedrally bonded to four carbon atoms and each carbon atom is tetrahedrally bonded to four silicon atoms. The differences among the existing polytypes are the orientational sequences by which such layers of tetrahedra are stacked. Successive layers of tetrahedra may be stacked in only one of two ways or orientations but with many possible sequential combinations, each of which represent a different crystal poly type.

Properties	value
Elastic Modulus	69000 N/mm2
Poisson's Ratio	0.33
Thermal Expansions Co-efficient	2.4x10-5 /K
Thermal Conductivity	170 w/mk
Specific Heat	1300 J/kg k

Table. 2 Properties of silicon alloys

SiC powders are produced predominantly via the traditional Acheson method where a reaction mixture of green petroleum coke and sand is heated to 2500°C using two large graphite electrodes. Due to the high temperatures, the Acheson process yields the alpha form of SiC, i.e. hexagonal or rhombohedral (α-SiC).

3. MAGNESIUM:-

In the past, magnesium was used extensively in World War I and again in World War II but apart from use in niche applications in the nuclear industry, metal and military aircraft, interest subsequently waned. The most significant application was its use in the VW beetle but even this petered out when higher performance was required. The requirement to reduce the weight of car components as a result in part of the introduction of legislation limiting emission has triggered renewed interest in magnesium. In 1944 the consumption had reached 228 000 t but slumped after the war to 10 000 t per annum. In 1998 with renewed interest it has climbed to 360 000 t per annum at a price of US$3.6 per kg. The growth rate over the next 10 years has been forecast to be 7% per annum.

Structure of magnesium is hexagonal which limits its inherent ductility. The only alloying element, which causes a useful phase change to bcc, in this respect, is lithium. The lack of large-scale applications of magnesium alloys in the past has resulted in limited research and development. Consequently, there are few optimised casting alloys available and even fewer wrought alloys. The production techniques have been adapted from those for other low melting point alloys aluminium. No experience is available on new production and working techniques and the know-how accumulated in the past has largely disappeared. The renewed demand has recently started to change this. The number of primary producers has increased and it is hoped that, when demand increases further, magnesium will be available the magnesium apportioned to metallurgical applications. Magnesium alloys are in use around the world in a variety of different applications. It is a preferred material when looking for weight reduction without compromising overall strength. The vibration damping capacity is also beneficial in applications in which the internal forces of high-speed components must be reduced.The mechanical properties, especially of die cast alloys, depend strongly on the actual fabrication route and the fabrication variables involved. Properties of die cast alloys are based on separately die cast test bars, if not otherwise stated. The given property values must be understood, as examples, of what might be expected when casting parts with cross-sections, structure and quality comparable to those used bars.The property profiles demanded by automobile and other large-scale potential users of magnesium have revealed the need for alloy development.

VI. REUSLTS AND CONCLUSION

Micron-sized SiC particles were incorporated into a melt of aluminium with magnesium the aid of addition as a wetting agent to fabricate aluminium matrix composite. Two casting temperatures and stirring time were applied to focus on the ceramic particle incorporation, porosity formation, agglomeration of ceramic particles, and interfacial reactions between Composite materials especially aluminum and silicon composites having good mechanical properties compared with the conventional materials. It is used in various industrial application these materials having light weight along with high hardness. It with stand high load compare with the existing materials are most applicable in the engineering products instead of existing materials. Finally it was concluded that the percentage of al-si-mg increases automatically the hardness strength and heat transfer rate increased.

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