Analysis of Alsi10Mg-Quartz Composite Material for a Connecting Rod

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Abstract - *Connecting rod is one of the most important parts in engine assembly. In automobile engineering field, every vehicle runs on I.C. engine and uses at least one connecting rod. In this paper AlSi10Mg is used as matrix material and quartz is used as reinforcement. Stir casting method is used for preparation of AlSi10Mg-Quartz composite. The reinforcement size of 10, 20,30microns are taken and the composition is varied by 5, 10, 15% by weight. The Silica content in the composites have an effect in the mechanical properties of the composite. In modern automotive internal combustion engines, the connecting rods are mostly made of steel and aluminum. Aluminum is used for its lightness and the ability to absorb high impact. The AlSi10Mg-Quartz composite is used as a replacement for connecting rod. The increased Silica content in the quartz gives improved mechanical properties and microstructure.*

Key Words: Connecting Rod, Combustion engine, Quartz, Internal combustion.

1. INTRODUCTION

In the last two decades, research has shifted from monolithic materials to composite materials to meet the global demand for light weight, high performance, environmental friendly, wear and corrosion resistant materials. Metal Matrix Composites (MMCs) are suitable for applications requiring combined strength, thermal conductivity, damping properties and low coefficient of thermal expansion with lower density. These properties of MMCs enhance their usage in automotive and tribiological applications. In the field of automobile, MMCs are used for pistons, connecting rod, brake drum and cylinder block because of better corrosion resistance and wear resistance. Fabrication of MMCs has several challenges like porosity formation, poor wettability and improper distribution of reinforcement. Achieving uniform distribution of reinforcement is the foremost important work. A new technique of fabricating cast Aluminium matrix composite has been proposed to improve the wettability between alloy and reinforcement .In this, all the materials are placed in graphite crucible and heated in an inert atmosphere until the matrix alloy is melted and followed by two step stirring action to obtain uniform distribution of reinforcement. The fabrication techniques of MMCs play a major role in the improvement of mechanical and tribological properties.

1.1 Powder Metallurgy and Other Methods

The performance characteristics of Al alloy reinforced with 5% volume fraction of SiO_2 fabricated through stir casting and powder metallurgy have been analyzed and found that the stir casting specimen have higher strength compared to powder metallurgy specimen. The size and type of reinforcement also has a significant role in determining the mechanical and tribological properties of the composites. The effect of type of reinforcements such as SiC whisker, alumina fiber and SiC particle fabricated by Powder Metallurgy on the properties of MMCs has been investigated.

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1.2 Types of Reinforcements

Metal matrix composites use three types of reinforcements: particulate, fibrous, and continuous. Composites refer to a material consisting of two or more individual constituents. The reinforcing constituent is embedded in a matrix to form the composite. One form of composites is particulate reinforced composites with concrete being a good example. The aggregate of coarse rock or gravel is embedded in a matrix of cement. The aggregate provides stiffness and strength while the cement acts as the binder to hold the structure together. There are many different forms of particulate composites. The particulates can be very small particles (< 0.25 microns), chopped fibres (such as glass), platelets, hollow spheres, or new materials such as Bucky balls or carbon Nano-tubes. In each case, the particulates provide desirable material properties and the matrix acts as binding medium necessary for structural applications. Particulate composites offer several advantages. They provide reinforcement to the matrix material thereby strengthening the material. The combination of reinforcement and matrix can provide for very specific material properties. For example, the inclusion of conductive reinforcements in a plastic can produce plastics that are somewhat conductive. Particulate composites can often use more traditional manufacturing methods such as injection moulding which reduces cost.

2. MATERIALS FOR CONNECTING ROD

Fibrous-ceramic/aerogel composite tiles have been invented to afford combinations of thermal-insulation and mechanical properties superior to those attainable by making tiles of fibrous ceramics alone or aerogels alone. These lightweight tiles can be tailored to a variety of applications that range from insulating cryogenic tanks to protecting spacecraft against re-entry heating. Fibre-reinforced composites have certain distinct advantages over their particle- reinforced counterparts. Most of the high-strength, high- stiffness materials fail because of propagation of flaws. A fibre of such a material is inherently stronger than the bulk form because the size of the flaw is limited by the small diameter of the fibre. In addition, if equal volumes of fibrous and bulk materials are compared, it is found that even if a flaw does produce failure in a fibre, it will not propagate to fail the entire assemblage of fibres as would happen in bulk material.

Further, a preferred orientation may be used to increase the length-wise modulus and strength well above isotropic values. The high strength and moduli can be conveniently tailored to high load directions. Continuous reinforcement is reinforcement which occurs every time the desired behavior occurs. This is in contrast with a partial reinforcement schedule, in which reinforcement is provided sometimes, but not always, on a schedule which can vary in irregularity. Typically, continuous reinforcement is used at an early stage of operant conditioning, when the goal is to familiarize the organism being conditioned with the basic ground rules of the situation. Continuous reinforcement must be provided promptly and consistently in order to work.

Reinforcement is a technique which is designed to increase the probability of repeat behavior, in contrast with punishment, in which the goal is to decrease the probability of repeat behavior. In positive reinforcement, a pleasant stimulus is introduced to the situation as a reward, while in negative reinforcement, a negative stimulus is taken away as a reward. While negative reinforcement might sound strangely like punishment, it is important to note that rather than punishing behavior by introducing a negative stimulus, it is rewarding behavior by taking the unpleasant stimulus away.

Fig -1: Connecting rod analysis specimen

In the automobile industry, any reduction in the weight of the moving parts lowers the level of vibration and fuel consumption, leading eventually to a more efficient vehicle. Connecting rods are usually made of steel and are one of the moving parts that can increase the efficiency of the vehicle if they are lightened. When developing a material for connecting rod three major properties such as, the material should be economic friendly, environmental friendly and should be beneficial to the society.

When the auto mobile is running the connecting rod which is connected to the crank and the piston is subjected to continuous rotation and the motion of the part causes the wear to the connecting rod. So the connecting rod should have maximum wear resistance. The coefficient of friction between the bearing is a factor of great importance. when the vehicle is in running condition, the region at the bearing will subjected to maximum frictional force . So the connecting rod should be having a high friction coefficient. Weight reduction in an automobile plays a major role, the reduction of weight will leads to the less consumption of fuel leading to improved fuel economy. The weight of the vehicle can be reduced by choosing lightweight materials such as composites. The replacement of steel with aluminum MMCs in connecting rod enables a weight reduction of 5 to10%.Corrosion resistance should be considered when designing a connecting rod. This is due to the reason that the corrosion of the material will lead to concentration of stress from the reciprocating load represented by the piston, actually stretching and being compressed with every rotation and load increases to the third power with increasing engine speed thus leading to accidents. The material that has to be selected for the connecting rod application should have good corrosion resistance capacity.

List of components required for analysis of Alsi10mg is given in Table 1.

Table -1: Description of Components

Sl. No	Part Name	Material
1	Connecting rod	Composite material
2	silicon	Composite material
3	Aluminium	Composite material
4	Magnesium	Composite material

3. METHODOLOGY FOR THE ANALYSIS

Traditionally, connecting rod are manufactured by steel or aluminium alloy. But with the development of the metal matrix composites the automobile industry tend to show a curve due to its better material properties when compared with the conventional steel. The properties of the connecting rod such as thermal conductivity, wear resistance, hardness, coefficient of friction, thermal expansion etc. offered by the aluminium was outperformed by the metal matrix composites mainly by the aluminium metal matrix composites. One of the major reinforcement that was used for the preparation of the aluminium MMCs was SiC which provided better properties for the connecting rod. But the connecting rod with the aluminium-SiC was not an effective material due to the high cost of the SiC particles. The recent trend in the composites for the connecting rod is now AlSi10Mg-Quartz metal matrix composites which has been in the stage of research for its properties.

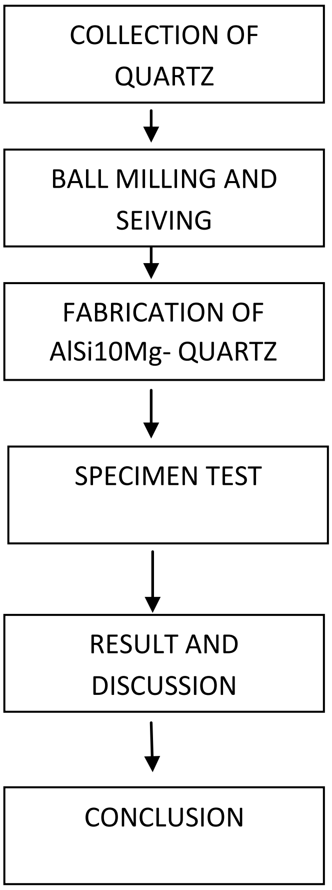

Chart -1: Methodology of Alsi10mg

Here the main objective is to develop a metal matrix composites which has its reinforcement abundantly available in the nature so that the cost of the composite material developed will be comparatively too low. It should also have good mechanical properties as compared with the conventional aluminium alloy and other composites. A tensile specimen is a standardized sample cross-section. It has two shoulders and a gage (section) in between. The shoulders of the test specimen can be manufactured in various ways to mate to various grips in the testing machine. Each system has advantages and disadvantages; for example, shoulders designed for serrated grips are easy and cheap to manufacture, but the alignment of the specimen is dependent on the skill of the technician. On the other hand, a pinned grip assures good alignment. Threaded shoulders and grips also assure good alignment, but must know to thread each shoulder into the grip at least one diameter's length, otherwise the threads can strip before the specimen fractures.

For this we first made a rough sketch and designed it in solid works. Later a static analysis was done using ANSYS to ensure its stability. The analysis done using ANSYS proved the design to be safe and was completed successfully.

4. CONCLUSIONS

The AlSi10Mg-Quartz metal matrix composite shows a considerable improvement in the mechanical properties. The addition of quartz in the composite decreases the weight there by improving the mechanical properties. Replacement of existing Aluminum alloy connecting rod material by SiC and other reinforcements cost high. Hence we are in the need of reinforcement with low cost and low density. Therefore the AlSi10Mg-Quartz MMC is best suitable material for connecting rod. Based on the test results and interpretation following conclusions were reached

1. Microstructure of the composite is found to be uniform and no inter metallic phase exist between the alloy and reinforcement.
2. Ultimate tensile stress, and hardness increases in sample no 5 (Reinforcement size is 20 micron and 10% weight fraction)
3. Yield strength of the composite is found to be high on sample no 5 (Reinforcement size is 20 micron and 10% weight fraction) as compared to other results.

A connecting rod is casted with the composition of AlSi10Mg-Quartz(20µm- 15%) and its weight is compared with the actual aluminium alloy and found to be reduced by 45g .

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BIOGRAPHIES

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