Evaluation of Tribological Properties of LM13 Alloy Hybrid Composites

Natarajan J¹, Naveen A¹, Praveen R¹, Rajeshkumar S¹, K. Kaviyarasan²

¹Assistant Professor, Department of Mechanical Engineering, Sri Krishna College of Technology
²Department of Mechanical Engineering, Sri Krishna College of Technology

ABSTRACT

In this work, Aluminium hybrid metal matrix composites are fabricated through stir casting methodology. The purpose of this project is to compare the tribological properties of the different pin specimens. Al-LM13 alloy was chosen as the matrix material owing to its inherent properties. Al-LM13 is reinforced with ceramic particle like Aluminium oxide (Al₂O₃) and Graphite in varying weight percentages of 100% LM13 alloy of specimen1, LM13 90% and Al₂O₃ 10% of specimen2, specimen3 LM13 90% Al₂O₃ 5% graphite 5% through stir casting technique. The properties of the composite specimens were compared with the parent metal (100% LM13). The casted specimens were subjected to brinell hardness test. Then the test the tribological properties were studied through pin on disc tribometer under different operating conditions. Under all conditions, the specimen of 90% Al-LM13+ 10% Al₂O₃ graphite exhibited superior properties when compared with the remaining two specimens. This is because the hard ceramic particulate Al₂O₃ have higher hardness when compared with soft matrix and the reinforcement particulate impart its property to the parent metal and hence the properties were improved.

Keywords: Aluminium Hybrid Metal Matrix, Tribological Properties, Reinforcement, Stir Casting.

1. INTRODUCTION

Aluminum and its alloys are mostly preferred for the matrix and also they showing great for the metal matrix composites (MMC). Most of the industries are moving towards hybrid aluminum metal matrix composites (HAMMs) because of its light weight in nature and also better strength comparing to other fabricating material. The major applications are in the field of automobiles, aerospace and also in industrial application. Aluminum are preferred because of its nature of low density, good strength and light in weight. They are good resistance over corrosion and also good thermal & electrical conductivity. The main purpose of this study is to manufacture and determine the tribological properties of MMC. Composite is defined as combination of two phases namely matrix phase and reinforcement phase, the combination of both will improve the mechanical properties. For Pure Al have very low mechanical properties in order to improve properties reinforcements are added. Aluminum alloys and aluminum-based metal matrix composites have found applications in the manufacture of various automotive engine components. When designed properly, the new combined material exhibits better strength than
would each individual material. The most primitive man-made composite materials are straw and mud combined to form bricks for building construction. Composites are classified in various ways by different authors, but in simplest and broadest sense this may be classified as Matrix material and Reinforcement material. Composites that occur in nature are called natural composites such as wood, human or animal body, sea shells and bones of elephants are examples of this type.

![Fig.1.1. CLASSIFICATION OF COMPOSITES](image)

A composite material is a material consisting of two or more physically and chemically distinct parts, suitably arranged, having different properties respect to those of the each constituent parts. In practice, most composites consist of a bulk material (the ‘matrix’) and a reinforcement of some kind, added primarily to increase the strength and stiffness of the matrix. The material, which uses as matrix must bind and hold firmly the reinforcing phase in position within. The matrix isolates the materials from one another in order to prevent abrasion and formation of new surface flaws and acts as a bridge to hold the materials in place. A good matrix should possess ability to deform easily under applied load, transfer the load onto the materials and evenly distribute stress concentration. Reinforcement can be made to perform all or one of these functions as per the requirements.

2. RELATED WORKS

Dheerendra Kumar et al. implemented Modification of LM13 using strontium refines the eutectic silicon crystals, and simultaneously, the addition of Al-5%Ti-1%B reduces the dendrite arm spacing of aluminium grains. This refinement of aluminium dendrites and eutectic silicon enhances tensile strength and ductility. Refinement of primary silicon particles using red phosphorous also enhances the mechanical properties. Modification does not change the mode of fracture appreciably. Heat treatment of both LM13 and LM28 causes the spheroidization of eutectic silicon crystals, which in turn enhances hardness, tensile strength, and ductility. The influence of heat treatment on mechanical properties (hardness, tensile strength, and ductility) has been found greater than that of the melt treatment.

H Akbulut et al. The wear behavior of the LM13 alloy reinforced with short aluminium, fibers from 10 to 30 vol% were studied under the loads from 5 to 60 N at a sliding speed of 1 m/s. Tests were run up to total sliding distance of 3600m and in all tests the volume-loss and coefficient of friction values monitored showed a short transient period and then reached a steady state in which while the volume-loss increased linearly with the sliding distance. Coefficient of friction values remained constant. The initial transient period was found to decrease with increasing fiber volume and applied load.

D.R. Kumar et al analysed that Aluminium hybrid composite has been fabricated by powder metallurgy (P/M) method with a combination of two reinforcements, namely, Glass and Silicon carbide particles. In P/M technique, cold pressing was used for compaction of the reinforced Glass–SiC Aluminium hybrid composites (Al + Glass + SiC). These green compacts were sintered and their workability behaviours were evaluated. The experimental results were analysed for workability.
under triaxial stress state condition during upsetting as a function of the relative density.

3. PROPOSED WORK FLOW

LM13 is an aluminum alloy, with magnesium and silicon as the alloying elements. It has generally good mechanical properties and is heat treatable and weldable. Al-LM13 is the most common alloy used for aluminum extrusion. It allows complex shapes to be formed with very smooth fit for anodizing.

Reinforcement increases the strength, stiffness and the temperature resistance capacity and lowers the density of MMC. In order to achieve these properties, the selection depends on the type of reinforcement, its method of production and chemical compatibility with the matrix and the following aspects must be considered while selecting the reinforcement material. Reinforcements are characterized by their chemical composition, shape, dimensions and properties as in gradient material and their volume fraction and spatial distribution in the matrix. There are several reinforcement materials such as Aluminium oxide, Titanium, Silicon Carbide, graphite. And we select graphite because it is emerged as an outstanding reinforcement and Al2O3 because of high hardness value among the others. Aluminum oxide is a chemical compound, a silicate of aluminum. It is usually colorless, but impurities induce various colorations. It is insoluble in water, acids, alkali and occurs in nature as mineral zircon.

Graphite is the only non-metal element that is a good conductor of electricity. Natural graphite is used mostly in what are called refractory applications. Graphite is a mineral that forms when carbon is subjected to heat and pressure in Earth’s crust and in the upper mantle. Pressures in the range of 75,000 pounds per square inch and temperatures in the range of 750 degrees Celsius are needed to produce graphite. These correspond to the granulites metamorphic faces.

4. STIR CASTING

Stir casting is a type of casting process in which a mechanical stirrer is introduced to form vortex to mix reinforcement in the matrix material. It is a suitable process for production of metal matrix composites due to its cost effectiveness, applicability to mass production, simplicity, almost net shaping and easier control of composite structure. The furnace is used to heating and melting of the materials. The bottom poring furnace is more suitable for the stir casting as after stirring of the mixed slurry instant poring is required to avoid the settling of the solid particles in the bottom the crucible. The mechanical stirrer is used to form the vortex which leads the mixing of the reinforcement material which are introduced in the melt. Stirrer consist of the stirring rod and the impeller blade. The impeller blade may be of, various geometry and
various number of blades. Flat blade with three number are the preferred as it leads to axial flow pattern in the crucible with less power consumption. This stirrer is connected to the variable speed motors, the rotation speed of the stirrer is controlled by the regulator attached with the motor. Further, the feeder is attached with the furnace and used to feed the reinforcement powder in the melt. A permanent mold, sand mold or a lost-wax mold can be used for pouring the mixed slurry.

Fig.5. stir casting

In this process, the matrix material are kept in the bottom pouring furnace for melting. Simultaneously, reinforcements are preheated in a different furnace at certain temperature to remove moisture, impurities etc. After melting the matrix material at certain temperature the mechanical stirring is started to form vortex for certain time period then reinforcements particles are poured by the feeder provided in the setup at constant feed rate at the center of the vortex, the stirring process is continued for certain time period after complete feeding of reinforcements particles. The molten mixture is then poured in preheated mold and kept for natural cooling and solidification. Further, post casting process such as heat treatment, machining, testing, inspection etc. has been done. There is various impeller blade geometry are available. Melting of the matrix material is very first step that has been done during this process.

5. **FRICTIONAL FORCE**

Friction force is the resistance offered by bodies under sliding condition. The results as in Fig. 5.0 and Fig. 5.1 show that, 90 % LM13, 10% Al₂O₃ casted specimen offer high friction force as compared Pure Al alloy and 5% Al₂O₃, 5% graphite friction force increase when applied load and sliding distance increases for all the three specimens. The main properties contributing to friction are adhesion and deformation. Adhesion refers to the shearing at local contact spots. The deformation part in tangential direction refers to the slippy over the asperities of the surfaces. For lower load conditions, the friction force is small when compared to higher load because of low adhesion between the surfaces and lower surface deformation. For higher load conditions, the friction force is high due to high adhesion between the surfaces and higher surface deformation. This can be attributed again to penetration of the tightly bonded particulates, to a greater depth in the counter surface of the stir casted specimen, resulting in friction force of the lower order. These 90% LM13, 10% Al₂O₃ casted specimen greatly offer resistance to sliding wear hence decrease in frictional force is observed as sliding distance increases at 500 and 1000m. Hence sliding distance and load were found to have highest influence on the frictional force of the casted specimens. The experiment unveils that sliding velocity for 2ms⁻¹ shows composition of 90% LM13 , 10% of Al₂O₃ for higher load (2N) and lower load (1.4N) casting experiences high friction force than the 5% Al₂O₃ , 5% graphite and pure LM13.
CONCLUSION

In this experimental study, AMCs of varying 90% LM13 Al₂O₃ content (10% wt) and were prepared using stir casting fabrication technique. Micro structural aspects such as wear characteristics of the prepared composites were studied. Based on experimental evaluation, following conclusions can be expressed. The experiment unveils that shows 90% LM13 and 10% of Al₂O₃ have better wear resistance than 5% Al₂O₃, 5% graphite and pure LM13. The experiment unveils that shows 90% LM13, 10% of Al₂O₃, high friction force than the 5% Al₂O₃, 5% graphite and pure LM13. The Hardness test for 90%LM13, 10%Al2O3 Composite is done using Vicker’s hardness test and it has higher strength than other composition with average of 129.4 is calculated.

REFERENCES

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