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THE IMPROVED FORGEABILITY PROPERTIES OF MAGNESIUM AND SILICON OVER LM25 ALUMINUM ALLOY

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Abstract : Casting and powder metallurgy procedures are two of the most widely utilised manufacturing processes for metal matrix composites. While low alloy steels are common structural materials for systems like power plants, aerospace, and marine industries or bearing materials, the majority of automobile applications use ferrous structural elements.

Analyses and experiments are conducted on the mechanical characteristics of the LM25 (Aluminum 5005) Metal Matrix Composite (MMC) reinforced with Aluminum 5052. The LM25 alloy is mostly employed in castings of shapes or dimensions that call for upstanding mechanical qualities and outstanding castability in order to reach the acceptable standard of soundness. The alloy is also employed in situations where corrosion resistance is a crucial consideration, especially where strength quality is needed. The goal of the study project is to look at how forging conditions affect the mechanical characteristics of Al/Mg/Si composites made in open die at temperatures between 800 and 850 degrees Celsius using three different phases As a result, LM25 is added to Aluminum 5052, an Al-Mg alloy, to improve its forgeability. The Al 5052 particle distribution must be uniform if the characteristics of the composite are to be improved. Stir casting process is used to avoid particle clumping and uneven distribution. With the addition of 40 weight percent of Al5052, it is seen that the tensile property of the LM25 increases to 153.295 MPa. With the addition of 40 weight percent of reinforcement, the hardness of LM25 has increased to 95 BHN. So, LM25 High tensile strength and hardness are required in applications where (Al 5005) reinforced with Al 5052 composite can be used.

***IndexTerms* – Magnesium,Silicon,Aluminium Alloy,LM 25**

Introduction

Because of their desired mechanical characteristics, MMCs are currently widely used in numerous industrial applications. Engineering applications frequently use aluminium matrix composites. In comparison to unreinforced aluminium composites, reinforced aluminium composites have improved wear and friction properties. The tribological behaviour of traditionally made Aluminium Metal Matrix Composites reinforced with well-known ceramic elements, such as SiC, Al2O3, graphite, TiC, B4C, etc., has been documented by a number of studies. Due to its poorer strength, stiffness, and wear resistance as compared to ferrous alloys, employment of aluminium alloy in automotive applications have been particularly restricted. Aluminum alloys are combined with reinforcement, such as Al2O3 particles, to create aluminium matrix composites, which have improved characteristics (AMCs).

These qualities work well together, making them suitable for use in mining, military, and automotive engineering. In contrast, TiB2 has distinguished itself as a superior material for reinforcement in aluminium matrix composites thanks to its exceptional mechanical and physical characteristics, including its high elastic modulus, high hardness, high thermal conductivity, and high melting point.

According to reports, the traditional method of making metal matrix composites by stir casting causes a number of issues, including the agglomeration of ceramic particles due to their poor wetability, a weak bond between the matrix and the reinforcements, and interfacial reactions between the matrix and the reinforcements. In-situ processing of Al Metal Matrix Composites has various advantages over conventional processing methods, including the creation of tiny ceramic particles, great union between the matrix and reinforcement, strong thermal stability, etc. Due to its ability to quickly generate pieces with a close resemblance to net shapes, forging is a method that is commonly utilised in the industrial sector Incorporating particles into the liquid metal during casting is a cost-effective approach to create metal-matrix composites. Composites made from aluminium alloys are given a slight strength boost above unreinforced alloys during the casting process. On the other hand, when the addition of particle reinforcement to enhance Properties such as stiffness, strength, and microstructure are seen. In castings of a shape or size that necessitate an alloy with exceptional castability in order to reach the specified grade of soundness, LM25 alloy is typically utilised. The alloy is also employed in situations where corrosion resistance is a crucial factor, especially when high strength is also required. The availability of LM25 under four heat-treatment settings in both sand and chill castings expands the material's potential applications. In reality, it serves as the universal high strength casting alloy.

II. METHODOLOGY

A mechanical stirrer is used in the stir casting process to create a vortex that mixes the reinforcement with the matrix material. Due to its low cost, suitability for mass production, simplicity, nearly net shaping, and ease of composite structure control, it is an appropriate procedure for producing metal matrix composites. A furnace, reinforcement feeder, and mechanical stirrer make up a stir casting apparatus. The ingredients are heated and melted in the furnace. The bottom poring furnace is better suited for stir casting because instant poring is needed to prevent the solid particles from settling in the bottom of the crucible after stirring the combined slurry. The vortex created by the mechanical stirrer leads to the the blending of the reinforcing materials added to the melt. The impeller blade and the stirring rod make up a stirrer. The geometry and number of blades of the impeller blade might vary. As it leads to an axial flow pattern in the crucible with less power consumption, flat blades with three numbers are chosen. This stirrer is attached to motors with various speeds, and the regulator attached to the motor regulates the stirrer's rotational speed.

STIR CASTING SETUP

III. LM25 Alloy (Al 5005)

The LM25 alloy is mostly utilised in castings of shapes or dimensions that call for good mechanical qualities in order to attain the appropriate level of perfection. Additionally, the alloy is employed in situations where corrosion resistance is a crucial factor, especially when high strength is also required

LM25 Alloy

It can be welded well. According to reports, LM25 has uses in a variety of industries, including the food, chemical, maritime, electrical, and many others. In addition to these, LM25 is also used in road transport vehicles for castings such as wheels, cylinder blocks, and heads, as well as other engine and body parts. It is utilised for aircraft pump parts and nuclear energy systems. Castings that are challenging to produce to the requisite grade of quality, especially in chill moulds, may benefit from LM25.

Major alloying elements	Weight (%)
Silicon (Si)	8.21
Iron (Fe)	0.15
Copper (Cu)	0.007
Magnesium (Mg)	0.20
Zinc (Zn)	0.005

IV. AL 5052 ALLOY

Aluminum 5052 is an alloy of aluminium and magnesium that may be hardened through cold work but cannot be strengthened through heat treatment. The strength and alloying content of the series of aluminum-magnesium alloys are about halfway through. With an endurance limit of 115 MPa in the H32 temperate and 125 MPa in the H34 temperate, it possesses outstanding fatigue qualities. It is basically an alloy of aluminium with magnesium and chromium. Marine, aviation, architecture, general sheet metal work, heat exchangers, fuel lines, tanks, floors, streetlights, appliances, rivets, and wire are examples of typical applications. Large marine constructions that are vulnerable to failure, such as tanks for liquefied natural gas, are a prime contender for the 5052 alloy due to its remarkable corrosion resistance to seawater and salt spray. When compared to several other common alloys, this alloy is moderately strong, having a yield strength of 193 MPa (28,000 psi) and an ultimate tensile strength of 228 MPa (33,000 psi). The best material for sheet metal work is 5052-H32 since it can bend with a small radius. There is 2.5% magnesium in 5052-H32. It is one of the non-heat treatable grades' alloys with the maximum strength.

SAMPLE

V. EXPERIMENTAL PROCEDURE

Testing is done on LM25 aluminium alloy to determine its mechanical qualities, including hardness, tensile strength, and microstructure. The alloy is then heated in a stir casting furnace to 800 to 850 degrees Celsius with the intention of forging magnesium into the alloy. We choose Al-Mg alloy because magnesium powder is combustible, which prevents magnesium from being wasted during addition and serves as a safety precaution.

On the basis of weight percentage, varying amounts of the aluminium magnesium alloy (5052) are added, and it is then forged using LM25. There is no need to add more Si to the sample because both LM25 and the Al-Mg alloy already contain a certain proportion of Si. After stirring the mixture thoroughly for about 20 minutes, the molten metal is put into the die for various testing, including tensile and hardness tests. The resulting final product's chemical composition is also measured in order to compare it to the LM25 before the experiment. As it has greater overall qualities than the LM25 alloy, the resulting resultant composite can replace it in a variety of real-world applications.

The following procedure is done for three proportions:

LM 25	1200g	Al 5052 alloy 500g	(20 wt%)
LM 25	1000g	Al 5052 alloy 700g	(30 wt %)
LM 25	950g	Al 5052 alloy 900g	(40 wt%)

VI. Tensile Testing

One of the most fundamental and typical kinds of mechanical testing is the tensile test, sometimes referred to as the tension test. In a tensile test, a material is pulled with tensile force to determine how the specimen reacts to the stress. Tensile tests establish a material's strength and elongation limit in this way.

Tensile tests are commonly performed using electromechanical or universal testing equipment, are straightforward to carry out, and are completely standardised. Tensile testing can reveal a lot about a substance. We can get a complete profile of a material's tensile properties by measuring it as it is being tugged. This data produces a stress/strain curve when shown on a graph, demonstrating how the material responded to the applying forces. The point of failure or break is of great significance, but strain, yield strength, and elastic modulus are all significant characteristics.

VII. Hardness Testing

A material's properties, including strength, ductility, and wear resistance, can be assessed through the use of hardness testing, which allows you to decide whether a material or material treatment is appropriate for the purpose you need. A test to identify a substance's resistance to permanent deformation caused by the penetration of a harder material is known as a hardness test. Hardness is not a basic characteristic of a material, though. In order to test a material's hardness, you usually press an object (an "indenter") into its surface that has been specifically loaded and dimensioned. Measurements of the indenter's penetration depth or the size of the indenter's impression are used to measure the hardness.

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VIII.RESULTS AND DISCUSSION

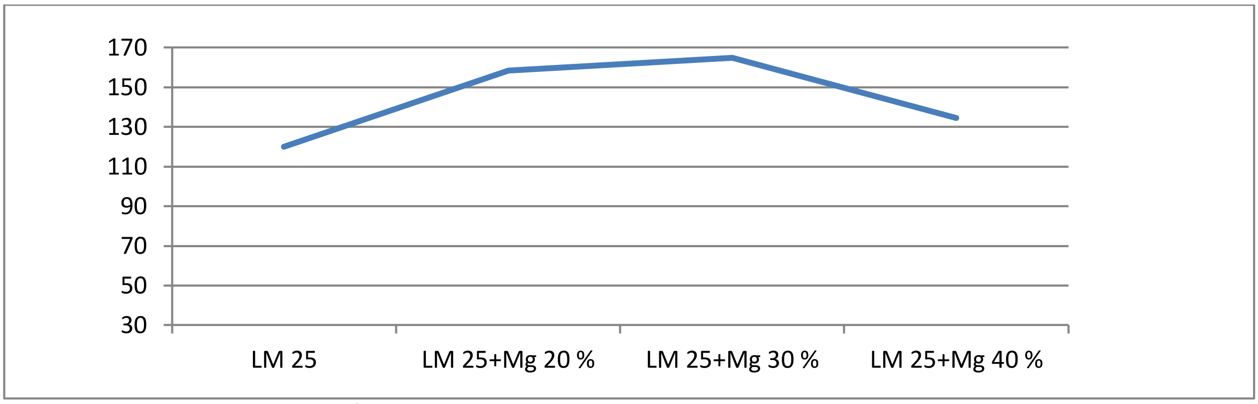
To compare the resulting test specimens' qualities to those of the control sample, we obtained specimen pieces reinforced with 20%, 30%, and 40% magnesium on LM25 material and put them through tensile and hardness testing. Additionally, we were able to determine the test specimen's makeup. One of the most fundamental and typical kinds of mechanical testing is the tensile test, sometimes referred to as the tension test. In a tensile test, a material is pulled with tensile force to determine how the specimen reacts to the stress. Tensile tests establish a material's strength and elongation limit in this way. You can assess a material's characteristics, such as strength, ductility, and wear, by using hardness testing.

1. Tensile Testing

We can learn a lot about a substance from tensile testing. By measuring the material while it is being pulled, we can obtain a complete profile of its tensile properties. When plotted on a graph, this data results in a stress/strain curve which shows how the material reacted to the forces being applied. The point of break or failure is of much interest, but other important properties include the modulus of elasticity, yield strength, and strain. The tensile strength of the specimen in which the reinforcement is 20 wt% is slightly improved than the control sample. The specimen with 30 wt% reinforcement shows a greater improvement in tensile strength. But the tensile strength of the specimen with 40 wt% is lesser than the control sample.

Results of Tensile Testing

Specimen	Reinforcement wt%	Tensile Strength in MPa	Elongation in %
1	20	158.54	2.57
2	30	164.76	8.74
3	40	134.43	5.32

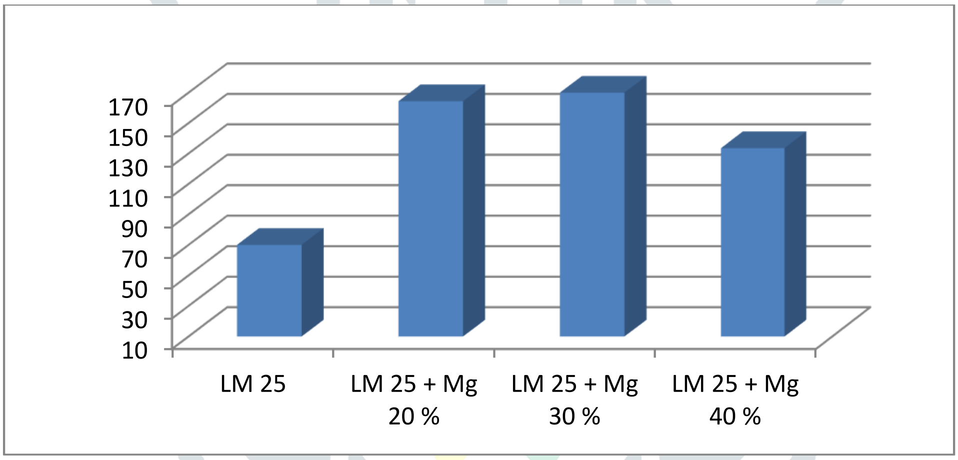


Reinforcement % vs Tensile Strength Graph

2.HARDNESS TESTING

The specimen with 30 wt% and 40 wt% reinforcement has a marginally higher Brinell hardness than the control sample. Additionally, they both share a comparable hardness. The specimen with 50% reinforcement has a slightly lower Brinell hardness than the reference sample.

Reinforcement % vs Hardness Graph



Results of Hardness Testing

Specimen	Reinforcement wt%	Brinell Hardness Number BHN
1	20	164.38
2	30	175.08
3	40	133.52

3.CONCLUSION

According to the results of the aforementioned experiment and analysis, magnesium and silicon can be employed as reinforcement in the form of an alloy to create MMC that is based on aluminium. Due to their superior mechanical qualities, these composites can be employed in place of LM25 in industrial components and a variety of real-time applications. When the reinforcement is between 20 and 30 weight percent, the tensile strength and the property variation then stabilises. This promotes strong forgeability. As soon as we reach 40% reinforcement, characteristics start to decline. Even if 20 and 30 weight percent reinforcements are preferred, tensile strength, for example, just slightly varies.

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