International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 08 Issue: 05 | May 2021 www.irjet.net p-ISSN: 2395-0072

Experimental Investigation on Mechanical Properties of Aluminium Alloy LM25 with Dual Reinforcement Nano Particles

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Abstract - *Aluminium alloy LM25 is used to attain good mechanical properties, corrosion resistance and high strength. The mechanical properties of aluminium alloy LM25 with dual reinforcement nano particles were studied. Dual reinforcement of nano particles were used to strengthen the mechanical properties of aluminium alloy. Silicon carbide and waste ceramic material were used as reinforcements. Wash basin material is used as waste ceramic material. Aluminium alloy LM25 was enriched with various amounts of nano silicon carbide (0.5%,1% & 1.5%) and nano waste ceramic material (1%) were produced by stir casting process. The tensile and Hardness properties were investigated to determine their ultimate tensile strength and hardness. Optimized results were obtained from sample where silicon carbide is 1% and waste ceramic material is 1%.*

Key Words: Aluminium alloy LM25, Dual reinforcement of nano particles, Silicon carbide and waste ceramic material, Stir casting, Tensile strength and hardness.

1. INTRODUCTION

Metal matrix composites (MMCs) is composite materials it involves two main constituents one being a metal certainly and other being a ceramic material or organic compound. Metal matrix composites are used in many fields because of its low cost and low weight, good mechanical properties. Composite materials are reinforced with particulate, fibers to improve the mechanical properties. Light metal based MMCs has shown increased interest in engineering fields like aircraft industry, automobile, electronics engineering and electrical appliances industry etc. Aluminium based composites are the leaders in this type of engineering area. The requirement of aluminium based composites gets momentum because of improved properties. They can be fabricated by many methods [1].

LM25 is a high purity aluminium alloy combined with 6–7.5% silicon and other materials. It's mechanical properties can be varied by heat treatment it has good castability [2]. AA LM25 is broadly used in industries for high specification castings where better shape and complex items are required and casting soundness may be also important. It is used in the automobile industries for cylinder heads, alloy wheels and cylinder blocks it is also used in many other industries like marine, chemical, electrical aerospace etc. [3].

LM25 can be anodized to get better corrosion resistance. It also has excellent resistance to seawater attack, better machining characteristics and can be welded when required [4]. There are many methods for fabrication of LM25 based metal matrix composites. The most popular are stir casting, powder metallurgy etc. [5].

Fabrication methods of composite materials are normally slow and expensive. There are many limitations which must be considered to exploit max possible potential of composite materials [6]. It is important that the best and most economical process for manufacturing to be developed and implemented. The discontinuous section is generally tougher and more potent than the non-stop section and is referred to as the reinforcement or reinforcing material, while the non-stop section is called because the Properties of composites are strongly depending on the residences in their constituent materials, their distribution and the interplay amongst them. The composite residences can be the quantity fraction sum of the residences of the Constituents or the elements may also engage in a synergistic manner ensuing in advanced or higher residences.

2. SELECTION OF MATERIALS

Aluminium alloy LM25 to be enriched with Nano size particles of silicon carbide (SiC) and waste ceramic material. Aluminium alloy LM25 used as matrix material and silicon carbide and waste ceramic materials are used as reinforcement materials. The reinforcements are used in stir casting process to upgrade the mechanical properties of the Aluminium LM25. The properties are tested by various mechanical properties testing methods using ASTM standards. The aluminium alloy LM25 as shown in Fig. 1.

Matrix material is Aluminium alloy LM25 because of its good mechanical properties and resistance to corrosion and high strength that can be accomplished in the heat treated condition but heat treated materials cannot be used in high pressure die casting. So that AA LM25 is mostly used in gravity casting or sand casting.

The aluminium alloy LM25 follows the BS 1490:1988. It is available in different four conditions which is given below.

A. M - Cast condition.

B. TE - The precipitation treated condition.

C. TB7 - The solution treated and stabilised condition.

D. TF - The fully heat treated condition.

Fig-1 : Aluminium alloy LM25

Silicon carbide and waste ceramic material in nano size particles are used as reinforcements. Silicon carbide and waste ceramic material is shown in Fig.2. & Fig.3.

Fig-2 : Silicon carbide

Fig-3 : Waste ceramic material

2.1 Reinforcement mixing ratio

Reinforcements are added with LM25 aluminium alloy with different proportions to improve the properties of material. The different proportions of reinforcements used are shown in the table 1. Reinforcements are used to strengthen the mechanical properties of base material.

The nano size silicon carbide and Waste ceramic material is produced by ball milling process. Planetary ball milling is used to produce the nano size particle of reinforcements.

Table -1: Reinforcement mixing ratio

Sl.No	Reinforced Mixing Ratio
1	AA LM25 + Nano SiC (0.5%) + Nano waste ceramic material (1%)
2	AA LM25 + Nano SiC (1%) + Nano waste ceramic material (1%)
3	AA LM25 + Nano SiC (1.5%) + Nano waste ceramic material (1%)

3. PROCESS METHODOLOGY

Casting method is most preferred method for production of aluminium MMCs. Stir casting is used to fabricate the aluminium metal matrix composites. It is a liquid state technique for the fabrication of metal matrix composites.

The aluminium alloy LM25 were cut in power hacksaw machine to the small pieces to feed the materials in to the crucible. The power hacksaw machine is used to cut the metals into the small pieces.

The powdered (Nano size particle) Silicon carbide and Waste ceramic material of required amount is mixed with Aluminium LM25.

The samples are fabricated with different proportions of reinforcement weights are added with aluminium alloy LM25. First the mould is preheated to prevent the porosity. The reinforcements are preheated upto 500^0 C for 40 minutes. It removes moisture as well as gas presented in the reinforcements. The LM25 aluminium material is cut into small pieces to feed into the crucible. After the metals melts the reinforcements are added at the same time stirrer mixes the matrix material and reinforcement materials. Then the liquid metal is poured into the molud. Then the mould is allowed to cooling of casting. By this way samples are fabricated.

4. EXPERIMENTAL SETUP

4.1 Stir casting setup

The experimental setup of stir casting essentially consists of an electric furnace and a mechanical stirrer. The electric furnace carries a crucible of capacity 2kg. The furnace works with maximum temperature of 1000^0 C and it uses current range of 200 V AC single phase and frequency is 50Hz. The stir casting setup as shown in Fig. 4.

Fig- 4: Stir casting setup

The LM25 aluminium alloy is introduced to the melt furnace and it is melted. After melting of actual, the liquid metal is made to pour on the cylindrical die. After solidification of cast, then die end is removed. Then the casted sample are collected. The sample were fabricated by varying the process parameters (reinforcement weight percentage). The fabricated samples are shown in Fig.5.

Fig-5: Fabricated Samples

After the fabrication of samples machining of samples is required to conduct the test. So that the fabricated samples are machined as per ASTM standard by using lathe. The samples are prepared to the conduct the tensile test. The machining of samples are shown in the Fig.6.

Fig-6: Machining of samples

The samples are machined for tensile testing as per ASTM E8 standard which is shown in the Fig.7.

Fig-7: Tensile test specimen

The hardness specimen is to determine the Vicker's hardness value as shown in Fig.8.

5. RESULTS AND DISCUSSION

The obtained metal matrix of Aluminium LM25 enriched with nano silicon carbide and nano waste ceramic material is tested for the mechanical properties for various mechanical testing's using ASTM standards.

5.1 Tensile test

The ability of a material to withstand a static load can be determined by testing the material in tension or compression. Mechanical testing plays an important role in evaluating the fundamental properties of engineering materials as well as in developing new materials and to control the quality of materials used in design and construction. Tensile test is conducted to determine the ultimate tensile strength and stress strain curve for the material and to find out the mechanical behaviour of engineering material such as elongation percentage, yield strength and breaking strength. The tensile test was conducted on the samples as per standard of ASTM E-8 using a universal testing machine. The tensile test results are shown in Table 2.

5.2 Hardness test

Hardness is the mechanical property for any material that helps to check the plastic deformation with penetration. Harness is mechanical property of material by virtue of which it can resist plastic deformation under the effect of penetration.

The following types of hardness tests are used in metal industries

- Brinell hardness test
- Rockwell hardness test
- Vicker's hardness test

. In this work we considered only vicker's hardness test. The vicker's hardness test method, also referred to as a microhardness test method, is mostly used for small parts, thin sections, or case depth work. The results of vicker's hardness are shown in Table 3.

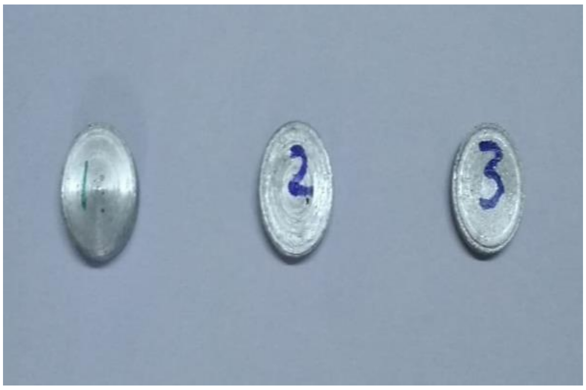


Fig-8: Hardness specimen

Table -2 : Tensile test results

Sample. No	Yield strength (N/mm^2)	Tensile strength (N/mm^2)	Breaking strength (N/mm^2)
1	114.78	130.168	76.199
2	112.965	142.952	134.430
3	69.214	86.566	76.440

Through the tensile test results the maximum tensile is obtained from sample 2 as compared to other samples.

Table -3 : Vicker's hardness results

Sample. No	Vicker's hardness value (HV)	
Sample 1	294	308.26
	260.5	
	370.3	
Sample 2	377.9	349.56
	345	
	325.8	
Sample 3	363	591.53
	783	
	628.6	

Fig 8. Shows the three samples with their yield strength, tensile strength and % of elongation. Tensile properties are important properties for engineering materials.

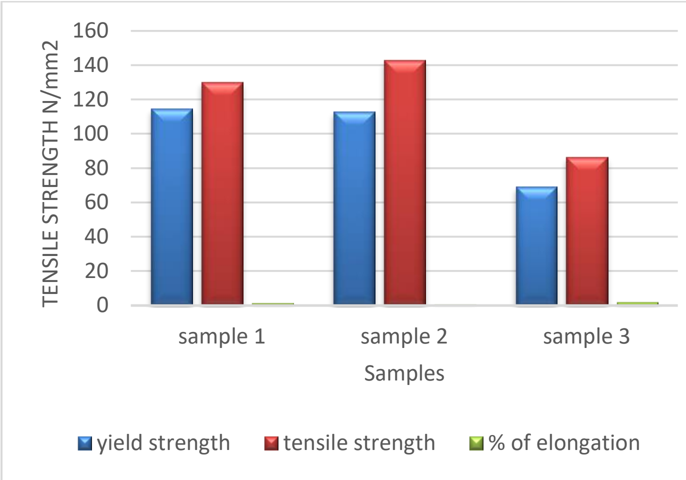


Fig-9: Tensile properties

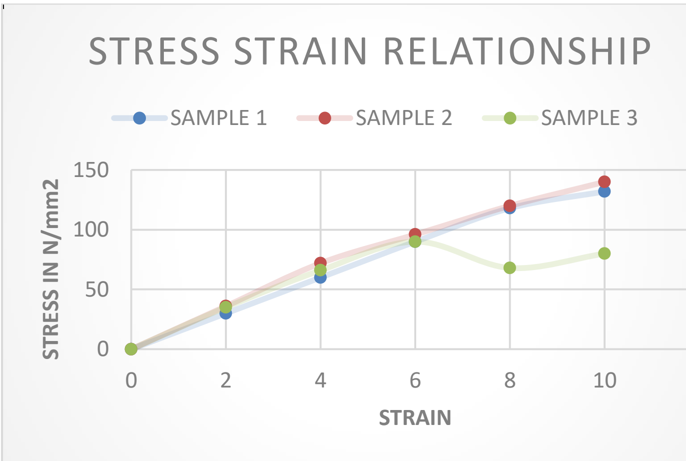


Fig-10: Stress Vs Strain

Fig.10 shows the stress strain relationship for the samples. The stress strain graph gives the value for the stress and strain under different loads. It clearly indicates that the maximum tensile strength obtained was 142.952 N/mm^2 from sample 2. **Fig.11,12** shows the relationship between Stress vs CHT and Load vs Strain.

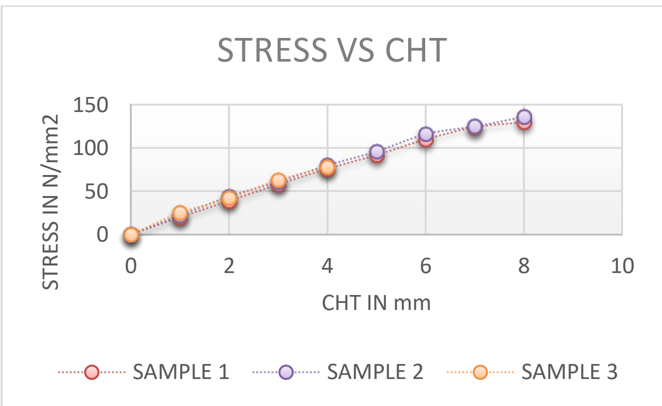


Fig-11: Stress vs CHT

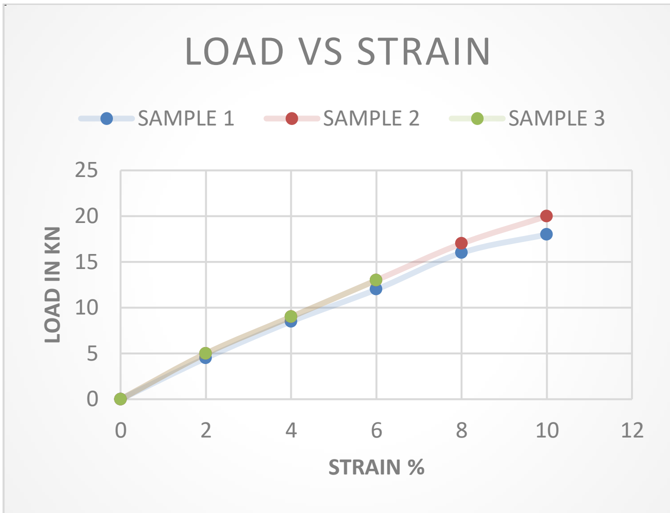


Fig-12: Load Vs Strain

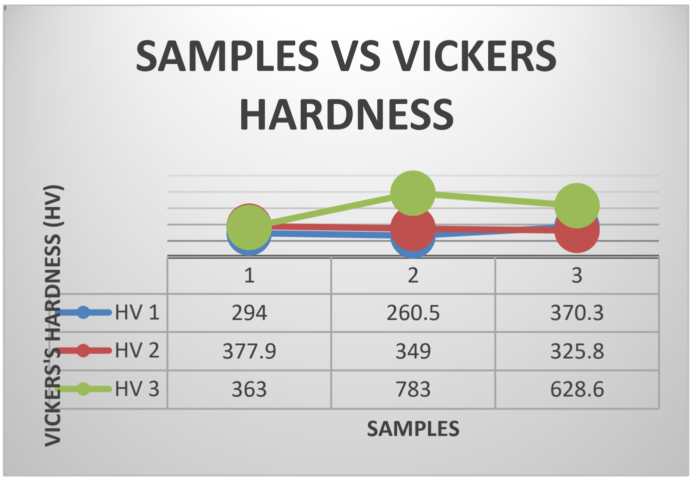
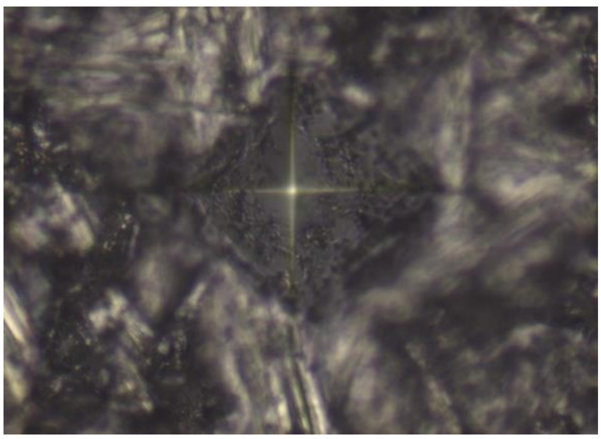
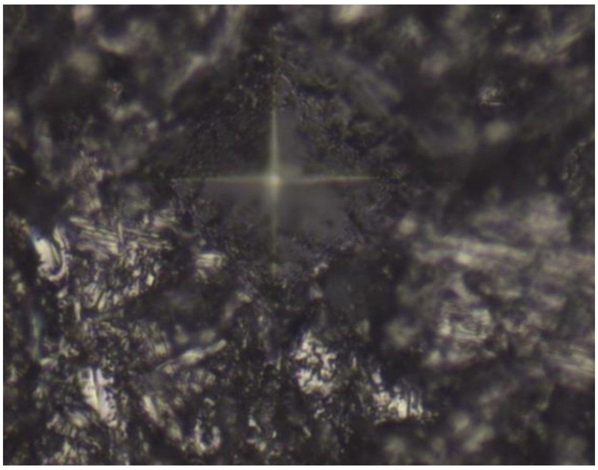


Fig-13: Samples Vs Hardness

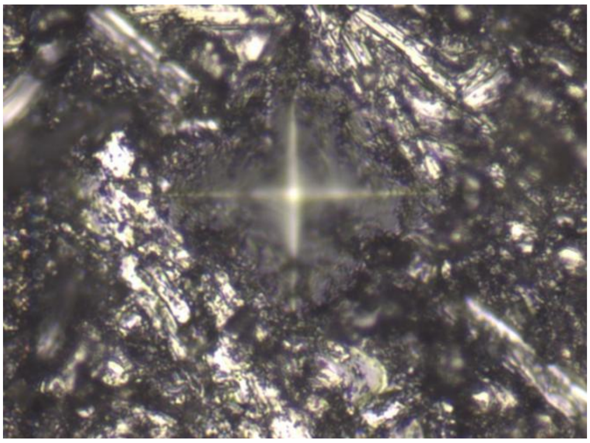
Fig.12. shows the vicker's hardness (HV) for three samples. The maximum hardness value was obtained from sample 3. Fig.14 indicates that the micro diamond indentation for three samples.



a)



b)



c)

Fig-14: Diamond indentation of samples

{a) sample 1, b) sample 2 & c) sample 3}

6. CONCLUSIONS

The aluminium alloy LM25 was reinforced with nano silicon carbide and Nano waste ceramic material with use of stir casting. The mechanical properties such as tensile strength and hardness were investigated from the fabricated samples.

The following results were obtained in this work on stir casting of aluminium LM25 alloy:

- Optimized process parameters for higher tensile strength were Nano silicon carbide (1%) and nano waste ceramic material (1%) .
- Optimized process parameter for hardness strength were Nano silicon carbide (1%) and nano waste ceramic material (1%) .
- Increasing the reinforcements weights (SiC & waste ceramic) results in decreases the tensile strength and increases the hardness.

ACKNOWLEDGEMENT

The authors thank the Department of Mechanical Engineering, Government College of Technology for providing partial support for carrying out this research work.

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