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# Ansys Analysis and Study of Mechanical Properties for Aluminum Based LM25 Metal Matrix Composite Fabricated with Conventional Method

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**Abstract.** Metal matrix composites with aluminum as base metal are extensively used in the important engineering industries, their properties can be improved for many important requirements. In current work it is tried to make the process cost effective. The efforts are made to make less expensive composites with improved properties. In this work a attempt is made to fabricate Aluminum LM25 based Metal Matrix Composite with the aim of developing a low cost conventional method for manufacturing of Metal Matrix Composites. The different combinations for LM25-$Fe_3O_4$ are made and their mechanical properties are tested and studied on alloy wheel with Ansys software. Experiments done for various combinations for LM25 and $Fe_3O_4$ as reinforce material (2.5%, 5% and 7.5%by weight) then examined for important mechanical properties. The present work also shows Ansys analysis on the alloy wheel of car with all new combinations of LM25 and $Fe_3O_4$ and to predict effect of loading. The effect of change in combination is also shown on alloy wheel of an automobile with Ansys software.

**Keywords.** Aluminum alloy (LM25), Hardness, Metal matrix composite (MMC), Tensile strength, Alloy wheel

## 1. Introduction

Composite is the combination of refractory particles with very good strength and the ductile matrix material. The savings on time and cost is the requirement for many important applications by using composite materials compare to the base metals [1]. LM25 based Metal Matrix composite which is established has created more interest in many important engineering areas. Aluminum Metal Matrix Composites created interest for many variety of important automobile components [2]. MMCs can be made with many fabrication technologies [3]. It is long-established and used extensively for automobile parts like heads of cylinder, alloy wheels, blocks of cylinder etc. It is widely used in other engineering industries [4]. There are many popular methods of fabrication of MMCs [5]. They have certain limitations which should be taken into account to get max possible benefits of composites. It is required to develop the better and more economical fabrication process for such MMCs and it should be used in particular application [6]. Composite materials are also used by various car wheel manufacturers to make them lighter in weight, for better performance and good in aesthetic looks.

Performance of the vehicle is enhanced because of reduced weight; increased fuel efficiency and spectacular look compared to that of normal wheels [7].

## 2. Experiment Details

### *2.1. Material*

In this experiment of the fabricating of aluminum based composite, aluminum alloy LM25 is the base metal, $Fe_3O_4$ powder is used as reinforcement particles.

**Table 1** Chemical analysis of LM25

| | |
|---|---|
| Cu | 0.12-0.15 |
| Fe | 0.6% max |
| Si | 6 to 7.5% |
| Ni | 0.5% max |
| Mn | 0.5% max |
| Ti | 0.2 % max |
| Sn | 0.2 % max |
| Pb | 0.3% max |

### *2.2. Moulding Process:*

The moulding system used for casting LM25 is green sand moulding. There is combination of silica sand, bentonite powder, dextrene, powder of coal and required quantity of water [8]. All are mixed in the sand Muller then water is added as required to this mixture for desired solidity of mould. Required moulds are prepared with the pattern.

### *2.3 Casting:*

For the casting of MMC a resistance muffle taken in use. The LM25 piece is then put in to furnace and the temperature is set at 750˚c. Here the $Fe_3O_4$ powder is first preheated and then mixed manually in the liquid metal inside furnace using the metal rod. Piece of LM25,5kg weight used every time and converted in liquid metal in furnace by mixing with 2.5%, 5%, and 7.5% by weight of $Fe_3O_4$ with spoon. As this process completes the liquid metal was then poured into green sand mould [9]. $Fe_3O_4$ powder was added with spoon and mixed for 3 to 4 minutes with metal rod in the liquid matrix material.

Figure 1 The furnace and mixing of the reinforcement powder

## 3. Testings

### *3.1. Spectrometer Analysis*

Spectrometer Analysis was carried out. A specific sized specimen is taken, grinded and kept in side of the spectrometer. Inert gas atmosphere is created. In the Spectrometer after 20 seconds complete chemical analysis can be seen on it's monitor [10].

**Table 2** Spectrometer Readings

| | Si | Fe | Cu | Mn | Mg | Cr | Ni | Zn | Al |
|---|---|---|---|---|---|---|---|---|---|
| **LM25 with 2.5% $Fe_3O_4$** | 7.06 | 1.80 | 0.12 | 0.26 | 0.54 | 0.26 | 0.048 | 0.081 | 89.77 |
| **LM25 with 5% $Fe_3O_4$** | 7.09 | 2.27 | 0.12 | 0.27 | 0.55 | 0.27 | 0.048 | 0.079 | 89.31 |
| **LM25 with 7.5% $Fe_3O_4$** | 7.08 | 2.57 | 0.12 | 0.28 | 0.54 | 0.28 | 0.048 | 0.080 | 88.98 |

### *3.2 Hardness Properties*

We have used the Vickers hardness testing machine for measurement 0f hardness. Specific range of loads with a small diamond indenter in line with standard shown in ASTM E-384 or IS:1501 is applied [11]. The results are shown in table. From this graph, it is observed that with the addition of $Fe_3O_4$ we get improved hardness.

**Table 3** Vickers Hardness test Results

| Materials | **HV** |
|---|---|
| LM25 | 65 |
| LM25-2.5% $Fe_3O_4$ | 75.33 |
| LM25-5% $Fe_3O_4$ | 79.66 |
| LM25-7.5% $Fe_3O_4$ | 83.33 |

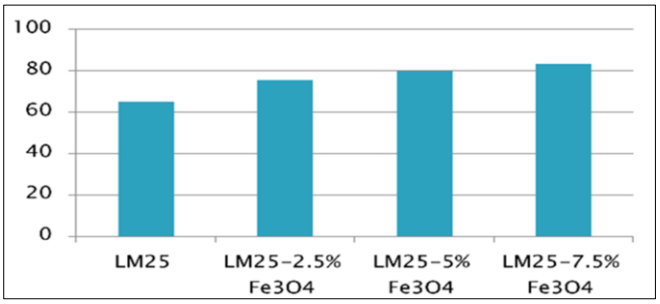


**Figure 2** Hardness values

### *3.3 Tensile Tests*

The tensile test is carried out for finding value of yield point strength, ultimate tensile strength and elongation for the tested material [12]. Tests carried at room temp. The dia. kept at 6mm and gauge length is 24 mm. The total length is of 80 mm. The required properties are checked on Universal Testing Machine (UTM).

**Table 4** Tensile test results

| Materials | UTS N/mm$^2$ | Yield strength N/mm$^2$ | %El |
|---|---|---|---|
| LM25-2.5% $Fe_3O_4$ | 116.56 | 75.52 | 13 |
| LM25-5% $Fe_3O_4$ | 121 | 79.11 | 14 |
| LM25-7.5% $Fe_3O_4$ | 129 | 83.52 | 13 |

It can be seen from graph that tensile strength of the composite improves as increase of weight percentage of reinforcement.

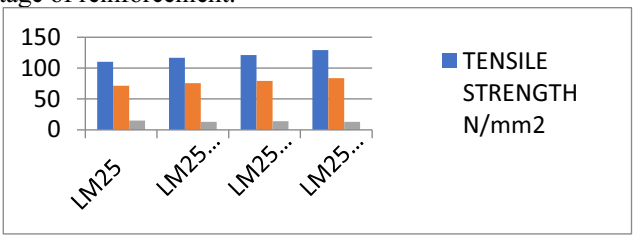


**Figure 3**Tensile strength Properties

## 4. Ansys work on the Alloy wheel of automobile

A rim model was prepared with Solid works software. Load analysis was performed based on the required input data with ANSYS 2019 R3 software. The model discretized for FEA analysis and meshing performed to generate elements for analysis.

**Figure 4** Alloy wheel mashing and applied force

The wheel analyzed in steady state condition. The hub of wheel kept fixed and downward force at the rim applied to simulate the dead loading on the wheel. The model solved for the same boundary condition and same meshing by changing the material property of respective material grade. At the end of solution, deformation and von-mises stress summary prepared for comparison.

The Ansys analysis for Equivalent elastic strain and Total deformation for LM25-2.5% $Fe_3O_4$ are as shown below.

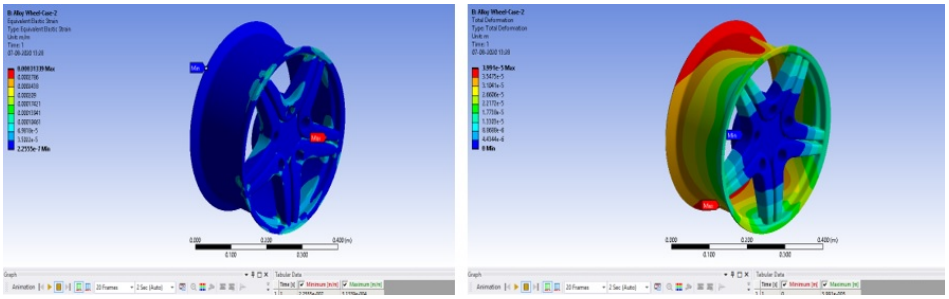

**Figure 5** Equivalent Elastic Strain and total deformation for LM25-2.5% $Fe_3O_4$

The Ansys analysis for Equivalent elastic strain and Total deformation for LM25-5% $Fe_3O_4$ are as shown below.

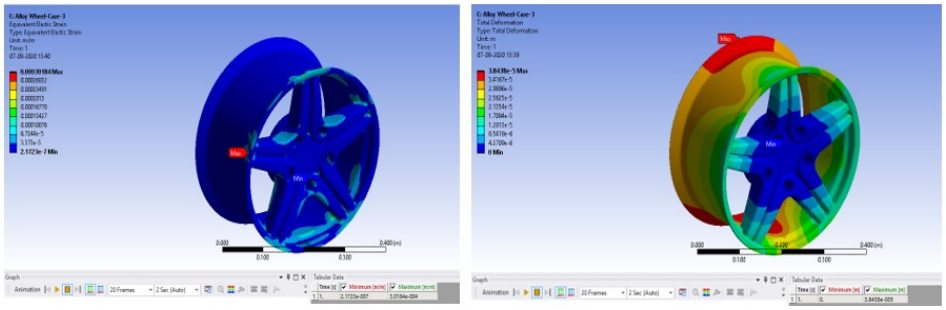

**Figure 6** Equivalent Elastic Strain and total deformation for LM25-5% $Fe_3O_4$

The Ansys analysis for Equivalent elastic strain and Total deformation for LM25-7.5% $Fe_3O_4$ are as shown below.

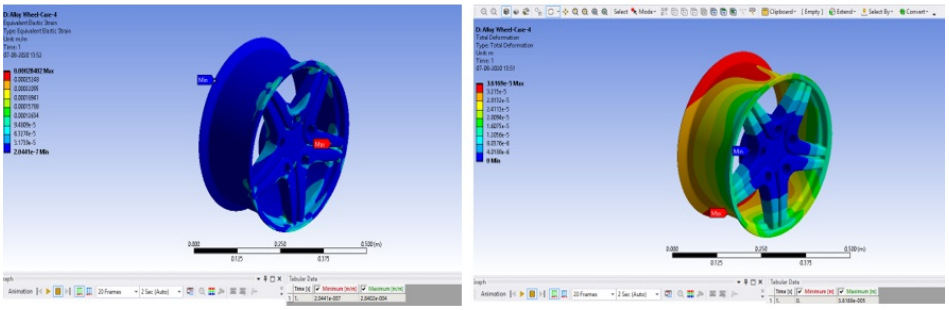

**Figure 7** Equivalent Elastic Strain and total deformation for LM25-7.5% $Fe_3O_4$

The results are as shown below.

**Table 5** Ansys results

| Sr No | Material | Applied Load N | Equivalent Stress MPa | Deformation mm | Equivalent Elastic Strain |
|---|---|---|---|---|---|
| 1 | LM-25 | 4000 | 233.54 | 0.4228 | 0.00033 |
| 2 | LM-25 2.5% $Fe_3O_4$ | 4000 | 233.54 | 0.3991 | 0.00031 |
| 3 | LM-25 5% $Fe_3O_4$ | 4000 | 233.54 | 0.3843 | 0.00030 |
| 4 | LM-25 7.5% $Fe_3O_4$ | 4000 | 233.54 | 0.3616 | 0.00028 |

## 5. Conclusion

In the present work mechanical tests carried out on different combinations of LM25 and $Fe_3O_4$.The analysis of stress, strain and deformation are studied on alloy wheel of car with Ansys software. It is seen from mechanical testing that there is good improvement in mechanical properties like Hardness, Ultimate Tensile strength and Yield strength with the increasing percentage of reinforcement particles and the results obtained after performing the Ansys analysis shows that there is decease in Equivalent elastic strain and deformation, as amount of $Fe_3O_4$ increases while Max. Principal stresses remain same in all cases. So it can be seen that changes in mechanical properties are good and decrease in strain and deformation is marginal. Hence, we can get better life of alloy wheel, as hardness and strength improvement is good in compare of decrease of strain and deformation. Hence from above study it can be seen that improvement mechanical properties can be seen even with low cost casting method with normal setup

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