Characterization of AMCs Produced by Stir Casting Technique

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Abstract. Stir casting is the simplest and cheapest method to manufacture composite materials. The objective of the research work is to produce Aluminum Matrix Composites with LM5 as matrix material and Fly Ash as reinforcement material at 0, 5, 10 % by weight, using stir casting technique and to study the mechanical properties such as tensile test, impact test, hardness test. The wettability between all these materials is assured by stir casting process. The microstructure of the composite show that the reinforcement material is homogeneously distributed in the matrix materials. Tensile Strength decreases with increase in weight percentage of Fly Ash. The weight percentage of Fly Ash has no effect on the impact strength of the composite. The hardness increases with the increase in weight percentage of fly ash and hence the fly ash can be used for increasing the wear resistance of the composites, where hardness plays a major role in industries which can turn industrial waste into industrial wealth. Key words: AMCs, Stir Casting, Microstructure, characterization.

1.Introduction

From past many years need for advanced materials in engineering is increasing tremendously day by day. Conventional materials has limitations in fulfilling our needs for stiffness, toughness, lightness and density. For satisfying our need of better material with more advantages metal matrix composites are best for industries. Constituents for making MMCs are taken such that it should give better results according to our need. MMCs are widely used in many manufacturing companies such as medical, aerospace, automotive, civil, marine and electronics industries for their superior properties like high module, low thermal expansions, high strength, low weight and low ductility.

There are many method available for fabrication of composites materials but stir casting method seems to be best among all because it gives better result as compared to others and it is simple also. For mass production of materials such as MMCs stir casting method seems to be more useful. In Aluminium metal matrix composites Aluminium is taken as matrix phase and the component or material which is enclosed in it is taken as reinforcement phase. The materials taken in matrix phase have a continuous character and is more ductile from the reinforcement phase component while component or material taken in reinforcement phase have a discontinuous character and is usually stronger than the matrix phase.
Fly ash is widely used as a reinforcement phase in thermal power plants because of its low density and inexpensiveness. Normally Fly ash includes some amount of calcium oxide (CaO), aluminium oxide (Al₂O₃) as well as Silicon dioxide (SiO₂). It has very low density so when it is mixed with molten metal overall weight and density of the material is reduced. Apart from MMCs it has many more applications in different area such as in bricks, Asphalt concrete, Geopolymers and can also be used as catalyst for converting polyethylene to crude oil.

In this research work Aluminium (LM5) is reinforced with fly ash to give a strong, light weight and high stiffness material. For effortless and economical method, stir casting method has been used. Many tests were also conducted to the new material in the lab and many results were found out.

2. MATERIAL SELECTION
LM5 has been used as a matrix phase and fly ash has been taken as reinforced phase. For satisfying the need of strong and better material many procedure has to be done for selecting the material. Because of good corrosion resistance and high strength LM5 is being used in many manufacturing industries. For knowing better constituent of material number of constituents have been taken which is shown in table1.

| Sl.No | Aluminium (%) | Fly ash (%) |
|-------|---------------|-------------|
| 1     | 95            | 5           |
| 2     | 90            | 10          |
| 3     | 85            | 15          |
| 4     | 80            | 20          |
| 5     | 75            | 25          |

3. TESTING and RESULTS:
After Reinforcing Aluminium and Fly ash a new material has been formed which has been tested with different methods to know about its strength as well as its hardness value. Five types of specimens was created with different proportion of Aluminium and Fly ash and was tested. Figure 1 and 2 shows front view and top view of two samples created from stir casting technique.

![Fig 1. Front view of samples created from stir casting techniques](image1)

![Fig 2. Top view of samples created from stir casting techniques](image2)
Figure 3 shows Rockwell hardness testing machine in which samples has been tested. Many more testing also has been done in Tensile as well as charpy test.

![Rockwell hardness testing machine](image)

**Fig 3.** Rockwell hardness testing machine

Many tabulation has been formed from the results taken from different types of testing. Table 2 shows ultimate strength values for all the different specimens. All the specimens have been tested in the testing machine present in our laboratory.

**Table 2.** Ultimate strength values for specimen

| S.N | Aluminium % | Fly ash% | Ultimate strength(Mpa) |
|-----|-------------|----------|-----------------------|
| 1   | 95          | 5        | 678                   |
| 2   | 90          | 10       | 698                   |
| 3   | 85          | 15       | 725                   |
| 4   | 80          | 20       | 744                   |
| 5   | 75          | 25       | 756                   |

![Graph of fly ash percentage vs ultimate strength](image)

**Fig 4.** Graph of fly ash percentage vs ultimate strength

Figure 4 shows the graph plotted between Ultimate strength and Fly ash Weight percentage. From the graph it has been found that as increasing the fly ash weight percentage in our material ultimate strength is also increasing. From this we can conclude that Fly ash weight percentage is directly proportional to Ultimate strength. Table 3 shows the value of hardness which has been calculated from hardness testing machine.
Table 3. Value of hardness from hardness testing machine

| S.NO. | Aluminium% | Fly ash % | Hardness(HRA) |
|-------|------------|-----------|---------------|
| 1     | 95         | 5         | 78            |
| 2     | 90         | 10        | 84            |
| 3     | 85         | 15        | 87            |
| 4     | 80         | 20        | 92            |
| 5     | 75         | 25        | 94.4          |

Fig 5. Graph of Hardness vs Fly ash weight percentage

Figure 5 shows the graph plotted between Fly ash weight percentage and Hardness. Similarly, like previous one in this also we have seen that while increasing Fly ash weight percentage Hardness of the material is also increasing. After hardness test toughness test has also been done to the material. Charpy test has been done on the material to determine its toughness. Table 4 shows the value of toughness that has been calculated by charpy test to each specimen.

Table 4. value of toughness for individual element from charpy test

| S.NO. | Aluminium % | Fly ash % | Toughness/(m)³ |
|-------|-------------|-----------|----------------|
| 1     | 95          | 5         | 71.2           |
|       |             |           | 74             |
|       |             |           | 78             |
|       |             |           | 71             |
|       |             |           | 81             |
| 2     | 90          | 10        | 130            |
|       |             |           | 127            |
|       |             |           | 122            |
|       |             |           | 118            |
|       |             |           | 116            |
From all the above results we have found that as we increase the amount of Fly ash in Aluminium metal matrix composites, Ultimate strength, Hardness as well as Toughness of the material also increases. So we can say that increasing of percentage of fly ash leads to improve the material quality. Different graphs have also been plotted to show the variation of values of our results.

4. Conclusion
The concern research work is done for the production of aluminium matrix composites with LM5 as matrix material and fly ash as reinforcement material at 0,5,10% by weight using stir casting materials. Here we have selected the materials and analyse uts constituents and reinforced them. The materials formed by reinforcement of different materials constituent was tested and strength and hardness are analysed. Rockwell hardness testing machines are used for the testings and ultimate strength values are determined for individual materials. Some more hardness testing and strength testing are done by charpy test. From all the reinforcements , testings and determined and nanalysed data of hardness , toughness and strength we came to the conclusion that increasing amount of fly ash in aluminium metal matrix composites lead to improve the material quality.

5. References
[1] Ranjan T.P, Pillai M R, Pal B C, Satyanarayana K G and Rohtagi P K 2001 Proc. of national conf. on Recent Advances in materials processing (RAMP- 2001) India pp 327-324
[2] Sudipta kumar and Ananda Theertan 2008 Production and characterization of aluminium -fly ash composite using stir casting method, NIT , Rourkela
[3] Suman kanta n d  Ajay Singh Verma stir casting process in particulate aluminium metal matrix composite : A review, Int. J. of Mechanics and solids
[4] Surappa M K 2003 Aluminium matrix composites challenges and opportunities Sadhana 28(1-2),319-334.
[5] Jims G, John Wessley, Saidu Srinivas and Azgar Ali M D 2019 Preparation and characterization of an aluminium 6061 alloy based metal matrix composite
[6] Sachin Mohal Microstructural investigation of aluminium silicon carbide particulate metal matrix composite Fabricated by stir casting
[7] https://www.sciencedirect.com/science/article/pii/S2214785315005271
[8] Rajsekhar Gangaram Bhandare and Parshuram M. sonawane 2014 Preparation of aluminium matrix composite by using stir casting method & its characterization.