Feasibility Study on Aluminium 7075 Metal Matrix Composite Using Graphene Oxide

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Abstract: The automobile industry always explores the latest and advanced materials for the enhanced properties in today’s scenario. It’s all because raw material doesn’t show always required properties under all working proportions. Metal matrix composites are fabricated by metal as a matrix material and metal, organic compound, or ceramic as reinforcement. It is not possible for the metal to fulfill the requirement of each and every application every time, that’s why reinforcement of various materials has been done. Materials like Silicon carbide, Al2O3, Boron carbide, Zircon, Fly ash, etc. are used to reinforce in base alloy for enhancement of properties. This experimental focus on the change in mechanical properties of Al 7075 reinforced with graphene oxide fabricated by using the traditional casting method. For this purpose, Al 7075 with various weight percentages such as 5% of Graphene oxide (R1) and 10% of Graphene oxide (R2) reinforcements and its mechanical properties like compression, Impact resistance, hardness, corrosion behaviour, and microstructure analysis has to be analyzed in detail.

Keywords: Al7075 Metal Matrix Composite, Reinforced Graphene oxide, Impact resistance, Hardness, corrosion behaviour, and microstructure analysis.

1. Introduction

Aluminium metal matrix composites (AMC) has a wide range of applications in different sectors such as aerospace, automobile, and another useful sector. Stir casting method has been done to perform a high mechanical property, high corrosion resistance, and low density for good wear resistance [1].

And the production of Al composite material is done through various weight percentage of silicon nitrate were used for these microstructures, and some mechanical properties were verified in very good high tensile strength were improved by casting method [2].

In aluminium metal matrix composites tribological behaviour of gravity die stir cast is done and in these silicon nitride nanoparticles are investigated. And after that in the hybrid component is done of different weight percentage is taken in this Al–Gr–Si3N4 hybrid
composite, Al–Si3N4 nanocomposite and Al–Gr nanocomposites were separately fabricated and also and further it also improved their mechanical and microstructure properties [3]. The metal ceramic interpenetrating composites (IPCs) as AlSi11/ Si3N4 are fabricated by infiltrating technique. After that process they changed their phase while other mechanical processes the Reinforcements inhibit plastic flow and restrict the propagation of wear cracks. An increase in the volume fraction of reinforcement leads to improvement in the wear resistance has done through normal technique methods [4]. In aluminium metal matrix composites are to develop research work on aluminium composite is done Al–5%Cu alloy reinforced by silicon and boron nitride (Si3N4, BN). And in this novel MMCs Al5Cu–Si3N4/BN successfully completed by squeeze casting techniques and after that hardness curves of the MMCs exhibited the increasing trend till reaching a peak and when these processes are done then their mechanical as well as other properties are changing throughout the process [5].

In aluminium matrix composites were fabricated by powder metallurgy method technique and these processes is followed by common methods. In these experiments, microstructure and crystal structures were analysed. And when this analysis is done then some mechanical properties were changed according to a theoretical parameter which is hugely changed in the structure of possibility which is occurred [6]. In aluminium metal matrix composites the hybrid component is produced by the mixture of (silicon nitride (Si3N4) + graphite (Gr)) ceramic particulates by the conventional stir casting process. Si3N4 and Gr are ball milled to obtain a definite density of combined powder has been done and when the final process is completed then the last it shows that how the microstructures as well as mechanical properties of the fabricated hybrid composites are analyzed. The scanning electron micrograph reveals the uniform distribution of ball-milled (Si3N4 + Gr) ceramic particulates in the aluminium matrix have been done and once the process has been done, then in the systematic result is found in whole research work [7]. In the metal matrix aluminium alloys composites reinforced were done by Silicon Nitride and Aluminium Nitride through the process of powder metallurgy techniques is used. When the other phenomena are checked, the final properties such have medium strength, formability, weldability, corrosion resistance and low cost. Compared with a metal matrix material, significant improvements in mechanical and physical properties such as strength, toughness, and thermal conductivity can be achieved in metal matrix composites (MMCs) because when this work is analyzed then different types of mechanical behaviour was changed during phase changed of Al AA6061 and different percentage of silicon nitride is used for better surface obtained such as hardness, ductility properties and other mechanical properties [8].

In these metal matrix composites the Optimization of wear loss in silicon nitride (Si3N4)– hexagonal boron nitride (hBN) is done and in these, the different types of five samples of Si3N4–hBN are evaluated against alumina for its wear performance is done but in these again the optimum proportion of 8 % hBN in Si3N4 for minimization of wear loss against alumina counter-face and after they lose their some mechanical and their physical properties as the experiment are conducted during wear volume loss increase with an increase in load while sustained their physical changing is obtained in each process time [9].

In this process, it follows the rules of same data type AA6082 based aluminium matrix composites (AMC) were successfully fabricated by adding silicon nitride (Si3N4) particulates as reinforcement using a stir casting process and after the high quantity of silicon nitride were used to carry out the good mechanical, microhardness and ultimate tensile strength was found, to be increased with an increasing weight percentage of silicon nitride is finally carried out for all the valuable data through a high sustainability [10].

The main objective of this paper is Al7075 is mixed with graphene oxide in the respective ratio 5 wt% and 10 wt%. Once this mixture is done, the casting process will be done. Once done with the casting process, it will be processed to various testing such as compression, hardness resistances, impact, corrosion, and optical microscopy structure at standard laboratory conditions. And also, the graphene oxide is used as reinforcement because it has
less density, long durability as well as it’s very expensive, excellent mechanical properties and give mechanical strength to their inner and outer physical properties. Al 7075 having high strength properties and it does not have corrosion resistance or weldability than other common alloys. The resistance of stress and strain is highly useful in aerospace, automobile, and other domestic applications, where it allows for weight saving over steel and it is also used in composite materials for high mechanical properties.

2. Materials and methods:

2.1 Al 7075 Metal Matrix Composite Preparation:

The Al7075 metal matrix composite is prepared by aluminium powder is mixed with GO powder and when these two different powders are mixed then some properly fixed ratio is taken for the samples. And the graphene oxide is having a very high cost and also, Graphene has a very high melting point and its very strong because of its large regular arrangement of carbon atoms joined by covalent bonds. Like graphite, graphene conducts electricity well because it has delocalized electrons that are free to move through its structure and when it mixed with Al 7075, it has an excellent tendency for achieving very high mechanical as well as their physical properties and also it has very long life and for better use in any sector. As per our experiment, we collected Al7075 powder and graphene oxide powder 5 wt% and 10 wt% taken for the samples and we mixed in a proper ratio. And after mixing these samples we leave for sometimes so it will carry out a good result and also, we check the mixing ratio in a measuring device or calculating in a scale meter height. And when this process is completed then we gone for further process that is the traditional casting method and there is another parameter for doing the experiment as well. So, we choose one method that is liquid metallurgy, in these, we mixed the Al and graphene oxide powder in a liquid phase and after that, we have gone for further procedure. And also, there are other methods for casting such as powder metallurgy and squeeze casting. And after getting proper phase change, we have gone for the next process. The other process is casting method, in these, we pour the liquid samples in a die casting container and after few minutes we remove the material from the die casting container and again we put that samples in a certain furnace and throughout this we got a fine product. And in graphene oxide, while the experiment is performing time in each side's oxygen and hydrogen was carried out these signs that our experiment is going in the right direction mode. Once the process was completed then we have gone for various types of testing. And also, we got a very fine structure during manufacturing time. In this experiment, Aluminium metal matrix composite material melted coal fired crucible furnace mentioned ratio was melted very successfully.

Figure 1 Casting Process

Figure 1 shows the material was collected in a fixed ratio of GO and Al 7075 then casting was done by the traditional method. And after the casting specimen was taken to the laboratory and then the testing analysis has been done.
In Figure 2 it shows that when different types of shape and size were formed during casting time then the compression test has been done in a universal testing machine (UTM). And when these specimens are fixed in the universal machine then the Al7075 composite metal with 5 wt% graphene oxide (R1) and Al7075 composite metal with 10 wt% graphene oxide (R2) were conducted the test.

Figure 3 shows that after casting a specimen, the machining process has been done in all the specimen for the smooth surface as well for long life used. After that etching process has been done to avoid the formation of cracks.

In Figure 4 after collecting the entire specimen the testing process has been done in the laboratory. And finally, we got the Al7075 composite materials with 5 wt% graphene oxide (R1) and Al7075 composite materials with 10 wt% graphene oxide (R2) in a fixed ratio of GO.
Figure 5 Specimen 1 & 2 contains graphene oxide with 5% & 10%

In Figure 5 specimen 1 & 2 are the GO of 5 wt% and 10 wt% for achieving the good mechanical and physical properties, which has been analysed during the test period.

3. Results and Discussion:
3.1. Compression Test:
A compression test is a kind of test, in which any type of material experiences opposing forces push or pull to inward upon the specimen otherwise compressed 'squashed', crushed or flattened. And also, the compression test is more essential to the opposite of more common tension test in any type of material or other raw material of metallic or non-metallic parts have to be done.

Table 1 Compression Strength Values

| S.No | Composition        | Compression strength (CS) N/mm² |
|------|--------------------|---------------------------------|
| R1   | Al7075+5 wt%GO     | 76.06                           |
| R2   | Al7075+10 wt%GO    | 91.69                           |

In table 1 the GO contained 5 wt% and 10 wt% in Al7075 and different compression strength values are obtained such as Al7075 composite materials with 5 wt% graphene oxide (R1) 76.06 N/mm² and Al7075 composite materials with 10 wt% graphene oxide(R2)91.69 N/mm².

Figure 6 Al7075 with different GO ratio Vs Compression strength

In Figure 6 the compression strength graph clearly shows that the specimen Al7075 composite materials with 5 wt% graphene oxide (R1) and Al7075 composite materials with
10 wt% graphene oxide (R2) is obtained during the casting period. And also, it is indicated that R2 is stronger than R1 and its value are 76.06 N/mm² and 91.69 N/mm².

3.2. Hardness Test
A hardness test is thoroughly performed by pressing or applying an external force, specifically all sides of dimensioned and applied loaded specimen (indenter) into the surface of the material that we are testing the composite material of graphene oxide and aluminium 7075. And also, the hardness of graphene oxide composite material is determined by measuring the depth of loaded specimen penetration or by measuring the size of the impression left by a loaded specimen of the graphene oxide composite material in the laboratories. And finally, we determine the result of the testing and other values in a very systematic manner.

| S.No | Material          | HRB |
|------|-------------------|-----|
| R1   | Al7075 + 5 wt%GO  | 26  |
| R2   | Al7075 + 10 wt%GO | 30  |

In Table 2 GO contained with 5 wt% and 10 wt% in Al7075 and different hardness values have been carried out such as 26 HRB (R1) and 30 HRB (R2).

In Figure 7 the hardness test graph clearly shows that the specimens Al7075/5 wt%GO composite (R1) and Al7075/10 wt%GO composite (R2) has been carried out during the casting period. And also, it is indicated that R2 is stronger than R1 and its value is 26 HRB (R1) and 30 HRB (R2).

3.3 Impact Test
The impact test is determining the total amount of energy absorbed by a graphene oxide composite material during fracture time. And this absorbed energy is measured of a given graphene oxide composite material’s toughness and acts as a tool for study temperature-dependent brittle-ductile the transition during phase transformation. And finally, it determines whether the material is brittle or ductile in nature during phase changes of a graphene oxide composite material and other parameters. In table 3 the GO contained 5 wt% and 10 wt% in Al7075 and different impact strength values have been carried out such as 5 Joules and 7 Joules.
Table 3 Impact value

| S.No | Composition       | Impact Strength |
|------|-------------------|-----------------|
| R1   | Al7075+5 wt% GO   | 5               |
| R2   | Al7075+10 wt% GO  | 7               |

**Figure 8** Al 7075 with different GO ratio Vs Impact strength

In Figure 8 the impact test graph clearly shows that the specimens Al7075/5 wt% GO composite (R1) and Al7075/10 wt% GO composite (R2) has been formed during the casting period. And also, it is indicated that R2 is stronger than R1 and its value is R1 is 5 joules and R2 is 7 joules.

3.4. Corrosion Test

Corrosion testing determines whether the resistance of graphene oxide composite materials to corrosion under certain period of time during environmental conditions parameters such as temperature, humidity, and saltwater which is present in the atmospheric zone. And LTI trends to accelerated inter-crystalline corrosion testing of ‘Al’ 7075 metal matrix composite to defect corrosion susceptibility in a relatively short period of time in the laboratory. And in there we identify that in which certain level that the graphene oxide composite material is corroded in the physical or chemical status.

**Test Parameters:** Graphene oxide 5 wt%

- Chamber Temperature: 34.5 – 35.5 °C
- PH Value: 6.65 – 6.68
- The volume of Salt Solution Collected: 1.00 – 1.50 ml/hr
- The concentration of Solution: 4.80 – 5.30% of NaCl
- Air pressure: 14 – 18 psi
- Components Loading in the Chamber Position: 30 Degree Angel.

**Observation:**
White rust formation noticed at 24 Hrs.
Test Parameters: Graphene oxide 10 wt%
Chamber Temperature: 34.5 – 35.5 ºC
PH Value: 6.65 – 6.68
Volume of Salt Solution Collected: 1.00 – 1.50 ml/hr
Concentration of Solution: 4.80 – 5.30% of Nacl
Air pressure: 14 – 18 psi
Components Loading in the Chamber Position: 30 Degree Angel.

Observation:
Again, the white rust formation noticed at 24 Hrs.

3.5. Optical Microscopy Structure Test
The optical microscope is also known as light microscope, is one type of microscope that uses visible light and system of lenses to magnify the images of small or micro samples during the testing of graphene oxide composite material. And when the material is bringing nearby optical then the microscopes are used in the viewing of small specimens such as the cell of the composite material that how a fine surface is obtained and it also determines the life of the composite material or any material that will exist. And also, this type of microscope does not offer the highest magnification and so when viewing a cell has limited structures for determining the fine surfaces to obtaining the final product of any material during testing time.

In Given Figure 9 to Figure 12, Al7075 composite with 5 wt% graphene oxide and Al7075 composite with 10 wt% graphene oxide and finally formed micro structure.
In Figure 9 shown Al7075 composite with 5 wt% graphene oxide sample is used to be observed the microstructures. And the optical microscopy is used in 100x magnifications for seeing the grain particles which is occurred and some tiny holes are formed.

In Figure 10 shown Al7075 composite with 5 wt% graphene oxide sample is used to be observed the microstructures. And the optical microscopy is used in 200x magnification for seeing the grain particles which is occurred as well as some tiny holes and fewer cracks are formed.

In Figure 11 shown the optical microscopy is used in 500x magnification for seeing in a very high depth of grain particles to see the very high clarity, so that the places get damaged as well as tiny pores & cracks are formed, in order to avoid etching the process has been done in Al7075 composite with 5 wt% graphene oxide. After a few minutes, a proper polished process was carried out for good structure and fine surface.

In Figure 12 shown the optical microscopy is used in 1000x magnification for seeing in a very high depth of grain particles to see the very high clarity, so that the places get damaged as well as tiny pores & cracks are formed, in order to avoid etching process has been done in Al7075 composite with 5 wt% graphene oxide. After a few minutes a proper the polished process was carried out for good structure and fine surface. As compare to figure 11 in these polished has been done in very depth.

Given Figure 13 to Figure 16 shows that Al7075 composite with 10 wt% graphene oxide and its microstructure.
In Figure 13 shown Al7075 composite with 10 wt% graphene oxide sample is used to be observed the microstructures. And the optical microscopy is used in 100 x magnifications for seeing the grain particles which is occurred and some tiny holes are formed.

In Figure 14 shown Al7075 composite with 10 wt% graphene oxide sample is used to be observed the microstructures. And the optical microscopy is used in 200x magnification for seeing the grain particles which is occurred as well as some tiny holes and less cracks are formed.

In Figure 15 shown the optical microscopy is used in 500x magnification for seeing in a very high depth of grain particles to see the very high clarity, so that the places get damaged as well as tiny pores & cracks are formed, in order to avoid etching the process has been done in Al7075 composite with 10 wt% graphene oxide. After a few minutes, a proper polished process was carried out for good structure and fine surface.

In Figure 16 again the optical microscopy is used in 1000x magnification for seeing in a very high depth of grain particles to see the very high clarity, so that the places get damaged as well as tiny pores and cracks are formed, in order to avoid etching process has been done in Al7075 composite with 10 wt% graphene oxide. After a few minutes a proper the polished process was carried out for good structure and fine surface. As compare to figure 15 in these polished has been done in very depth.

4. Conclusion

In this paper, we focused on using the graphene oxide powder as reinforcement and Aluminium 7075 to mixed in a proper ratio, so that how much stress it can be applied to the graphene oxide MMCs. And also, we prepared our composite material by traditional casting method and there are various methods for fabrication but we choose these liquid powders for casting method. It is very easy and the casting process is good as compare to another parameter. But for machining graphene oxide MMCs takes much more time such as two to four days for good surface phase achievement and many more other things. The property of GO is low density, good wear resistance, good tensile strength and against corrosion resistant. Graphene oxide is one of the moderate expensive and low-density reinforcement. The Hardness strength will also be taken into consideration. For the achievement of the above, an experimental set up is prepared where all the necessary inputs will be made. In this work, a composite is developed by adding Graphene oxide in Aluminium metal by mass ratio with various percentages. The composite has to be prepared by a crucible casting technique and has to be analysed various mechanical properties such as compression test, hardness test, Impact test, corrosion test and Optical microscopy structure test and in these two composite Aluminium plate or bar plate has been taken and compared and as well we analysed all the five various testing values. And finally, we got to know that MMCs composite material is having high strength and also, Al7075 composite with 10 wt% graphene oxide (R2) has optimal mechanical properties can be achieved than Al7075 composite with 5 wt% graphene oxide (R1).as well as microstructures which have been analysed.

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