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Determination of Scratch Resistance of Graphene based Nano Composites

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Abstract- *In modern day's composite materials play a vital role in many industries and research fields. To accelerate the need of finding dynamic combinations to excel the most desirable commercial aspects like light weight, high strength, higher hardness, wear resistance, durability, graphene based materials offer better platform to innovate more lighter and harder materials. Unlike other materials graphene weighs very lighter and stronger stimulate to use this as a major reinforcing material with most flexible matrix is aluminium. Significantly graphene is the only material available in two-dimensional structure which yields better mechanical properties like strength and hardness. To aid the easy preparation of metal matrix composites a well known technique called stir casting technique is normally employed. By keeping this in mind the present work involves the development of graphene reinforced aluminium based metal matrix composites with the help of stir casting process. The aluminium powder used here is 7075 grade which is meant for aerospace structure to retain as better matrix material. Graphene is added to alumiunm matrix with 0.5%, 1%, 1.5%, 2.0% by weight of the matrix considered. Hardness test has been done for all the prepared samples, it is found that maximum resistance to indentation was shown by the sample filled with 0.5% of graphene and least hardness number is noticed for the sample filled with 2% of graphene.*

Keywords: Graphene composites, Al-graphene, MMC's, Nano composites

1. INTRODUCTION

Metal matrix composites, at present though generating a wide interest in research fraternity, are not as widely in use as their plastic counterparts. High strength, fracture toughness and stiffness are offered by metal matrices than those offered by their polymer counterparts. They can withstand elevated temperature in corrosive environment than polymer composites. Only light metals are responsive, with their low density proving an advantage. Titanium, Aluminum and magnesium are the popular matrix metals currently in vogue, which are particularly useful for aircraft applications. The strength-to-weight ratios of resulting composites can be higher than most alloys. The melting point, physical and mechanical properties of the composite at various temperatures determine the service temperature of composites. It is more significant to introduce lighter metals as a part of structural aspects aiming that loading superficial material showing least density to impart desired qualities like strength and hardness by correlating with domain matrix, the new trend has been evolved to admin the light weight composites is graphene material. The graphene and aluminum are two metals so that these both come under metal matrix composites (MMC) these are fabricated by stir process, this is developed because lightweight material, cost is less, high strength, and it's a high thermal conductivity material. Graphene shows excellent thermal conductivity due to its excellent thermal conductivity, graphene is a good metal for the reinforcement of an aluminum matrix to enhance the thermal conductivity [1]. The Metal Matrix Composites (MMC) has been developed with powder metallurgy as we know that powder metallurgy is simple process that gives excellent finishing for micro structural materials because it has ability to distribute reinforcement uniformly [2]. The choice of Aluminum alloy is done because it's local availability and its lower cost for processing. There are many techniques are there to develop a reinforced MMC, mainly powder metallurgy and squeeze casting, the particular composite is preferred by the mixing of aluminum and graphene [3]. Aluminum powder was used as the matrix, it has the chemical composition of 0.2% Si, 0.15% Fe, 0.1% Cu, 0.1% Mg, 0.5% Mn and remainder is Al [4]. The alternatives plays dignified role in multidisciplinary sections of engineering. The performance of the composites can further be improved by adding fillers to them [5] . Support to this this one more work highlights the usage of Silicon carbide which has been added because it is well known for its hardness and its abrasive nature and graphite is a solid lubricant, result of its addition can change the surface roughness [6].in order to make possible the potential replacement for structural materials in aerospace structures like conductive and lighter parts we are more prevelaiged to synthesize graphene powder reinforced with aluminium matrix to fulfil the above objective by experimenting the synthesized samples to check the hardness of the lighter materials.

2. MATERIALS &METHODOLOGY

Following are the different kinds of devices which are successfully utilized to prepare graphene reinforced metal matrix composites. Description of each device is explained bellow.

Chemicals used;

Exo-chloro ethane:

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It is in tablet form. The exachloroethene is shown in fig.1 is used to degas the material

Fig.1 Exo-chloroethane

Coverall:
It is in powder form which is shown in fig.2 which is used to remove the impurities and slag and also to increase oxidation resistance. Coverall is significantly used to increase the wettability

Fig.2 Die arrangement

Magnesium chips:
It is in crystal form which is normally used to increase the wettability. If magnesium content increases more than 0.5% porosity will form, magnesium chips is as shown in fig.3

Fig.3 Magnesium chips

Components used:
Die:
The die used (as shown in fig.4) for the stir casting process is hallow cylinder. Where the diameter of the die is 25mm and the length is 150mm

Fig.4 Die

Crucible:
The thickness of the crucible (shown in fig.5) used in the stir casting process is 15mm

Fig.5 Crucible

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Furnace:
The material used for the furnace (as shown in fig.6) is silicon carbide

Fig.6 Furnace

Pre-heater:
The pre-heater (fig.7), the pre-heating temperature of the mould is 400-500 deg Celsius. The material used for the mould is OHNS

Fig.7 Pre-heater

Specimen preparation:
Aluminium reinforced MMC is prepared by stir cast process. In this study, Al-7075 is used as metal matrix composite with different % ofgraphene. The quantity of Al 7075 is 5291 grams and graphene particles required to produce composites are 0 %, 0.5 %, 1 %, 1.5 % and 2% by weight the composition of aluminium and graphene with specimen numbering is neatly recorded in the table.1 & sample preparation is as shown in fig.8. The process for fabrication of MMC remains same even though composition of MMC changes. First the metal matrix composite and graphene are weighed based on our requirement. Graphene is preheated up to 200^0 C for every sample. Then 1000 grams of aluminium 7075 is weighed for every sample and kept in the crucible until it melts. Later the chemicals like exachloro ethane, Cover all, Magnesium chips are added to the composition because to degas the material and increase wettability. After adding all chemicals, graphene is added to the aluminium and stirring the composition which allows the proper distribution of particles. After the mixture of aluminum and graphene is poured to die which is in liquid state and waited for 1hr to cool and then sample is removed from the die and specimen is obtained. Elongation at different intervals are recorded and tabulated.

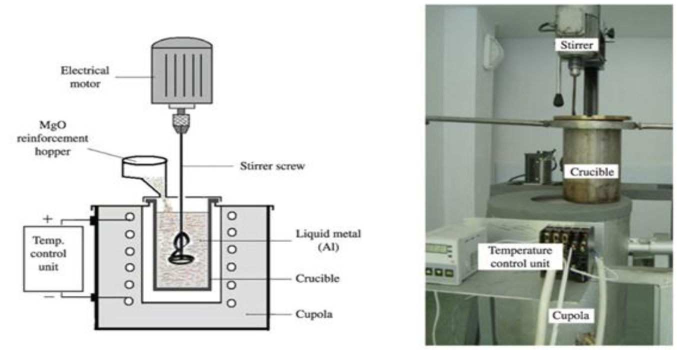

Fig.8 Specimen preparation

Table.1 Composition of aluminum and graphene

SPECIMEN NO	GRAPHENE (%) By weight	GRAPHENE (grams)	ALUMINIUM (grams)
01	0	0	1023
02	0.5	5.5	1074
03	1	10.6	1059
04	1.5	15.6	1041
05	2	22	1094

3. EXPERIMENTATION & RESULTS

- **Hardness test**

Fig.9 Rockwell Hardness tester

Rockwell hardness testing is a general method for measuring the bulk hardness of metallic and polymer materials. Although hardness testing does not give a direct measurement of any performance properties, hardness of a material correlates directly with its strength, wear resistance, and other properties. Hardness testing is widely used for material evaluation because of its simplicity and low cost relative to direct measurement of many properties. Specifically, conversion charts from Rockwell hardness to tensile strength are available for some structural alloys, including steel and aluminum.Rockwell hardness testing which is as shown in fig.9 is an indentation testing method. The indenter is either a conical diamond (brale) or a hard steel ball. Different indenter ball diameters from 1/16 to 1/2 in. are used depending on the test scale. To start the test, the indenter is “set” into the sample at a prescribed minor load. A major load is then applied and held for a set time period. The force on the indenter is then decreased back to the minor load. The Rockwell hardness number is calculated from the depth of permanent deformation of the indenter into the sample, i.e. the difference in indenter position before and after application of the major load. The minor and major loads can be applied using dead weights or springs. The indenter position is measured using an analog dial indicator or an electronic device with digital readout.

Table.2 Hardness test results

Specimen No.	Aluminium (grams)	Graphene (grams)	Trail	Load (Kg)	RHN
1	1023	0	01	100	70
	1023	0	02	100	70
	1023	0	03	100	71
			Avg		71
2	1074	5.5	01	100	74
	1074	5.5	02	100	73
	1074	5.5	03	100	78
			Avg		75
3	1059	10.6	01	100	73
	1059	10.6	02	100	71
	1059	10.6	03	100	74
			Avg		73
4	1041	15.1	01	100	69
	1041	15.1	02	100	70
	1041	15.1	03	100	71
			Avg		70
5	1094	22	01	100	70
	1094	22	02	100	73
	1094	22	03	100	76
			Avg		73

Table.2 shows the hardness test results for the samples filled with graphene in the range of 0.5%,1%,1.5%,2%. Results are tabulated when the samples prepared are tested by using Rockwell hardness testing machine to find the response of samples against indentation. It is noted that average values for each tested samples are documented. Higher value of hardness number is found clearly for the samples filled with 0.5% of graphene and least value of RHN is observed for the samples filled with 2% graphene.

4. CONCLUSION

Development of graphene reinforced with aluminium based metal matrix composites has been successfully done by employing stir casting technique keeping the proportion of loading of graphene with 0.5%,1%,1.5%,2% by weight of the matrix considered. Rock well hardness number is found by testing all the prepared samples. It is concluded that maximum resistance to indentation is displayed by the sample filled with 0.5% of graphene due to uniform dispersion of graphene particles in aluminium matrix. Graphene particles improves hardenabilty of soft matrix bearing more load and records 78RHN as compared to the parental composition, it is also noticed that minimum hardness number is found by the sample filled with 2% of graphene due to over loading of graphene particles as they are finding difficulty in replacing the parental atoms upon cooling and highlights the saturation limit of graphene particles filling aluminum matrix as a result the material is unable to bear more load applied in the way of finding its response to indentation.

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