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Assessment of Axial Cramp Resistance of Graphene based Aluminum Nano Composites by Stir Casting Technique

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ABSTRACT

Determining the cramp resistance of structural member bears the potential naming for high durable metals and alloys like aluminum points the celestial asset to choose between the various elements which can perform the similar role as metal matrix composites implimnets. The Role of light weight materials in many industries and research fields is to accelerate the need of finding dynamic combinations to excel the most desirable commercial aspects owning to its light weight, high strength, higher hardness, wear resistance, durability. Graphene based materials offer better platform to innovate lighter and stiffer and tougher materials. Unlike other materials graphene weighs very lighter and stronger stimulate to use this as a major reinforcing material with most flexible matrix is aluminum. 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 objective, the present work involves the synthesis of graphene reinforced aluminum based metal matrix composites with the help of stir casting process. The aluminum powder used here is 7075 grade which is meant for aerospace structure to retain as better matrix material. Graphene is added to aluminum matrix with 0.5%, 1%, 1.5%, and 2.0% by weight of the matrix considered. Compression test has been performed for all the prepared samples with the help digital UTM. It is found that sample filled with 0.5% of graphene shows excellent resistance to compressive loading which records maximum strain of 0.60025 against applied break load of 222KN which are concluded to be better compared to the rest of the samples

Keywords: Light Weight Structures, Nano Composites, Cramp Resistance

I. INTRODUCTION

Graphene based composites now days projects as linear high end derivatives as light weight members to replace densified structures. 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 [1-5]. 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 [6-9]. 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 [10]. The structure of graphene is as shown in fig.1

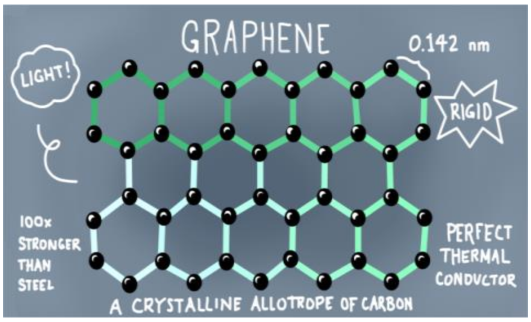


Fig.1 Structure of graphene

The alternatives plays dignified role in multidisciplinary sections of engineering. The performance of the composites can further be improved by adding fillers to them [11] 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 . . 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 [12]. 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.

II. 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:

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

Fig.2 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

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.4

Fig.4 Magnesium chips

Components used:

Die:

The die used (as shown in fig.5) for the stir casting process is hallow cylinder. Where the diameter of the die is 25mm and the length is 150mm

Fig.5 Die

Crucible:

The thickness of the crucible (shown in fig.6) used in the stir casting process is 15mm

Fig. 6 Crucible

Furnace:

The material used for the furnace (as shown in fig.7) is silicon carbide

Fig.7 Furnace

Pre-heater:

The pre-heater (fig.8), the pre-heating temperature of the mould is 400-500 deg Celsius. The material used for the mould is OHNS

Fig.8 Pre-heater

Specimen preparation:

The detailed methodology of preparing graphene based nano composites are discussed by employing stir casting technique. Aluminium reinforced MMC is prepared by stir cast process. In this study, Al-7075 is used as metal matrix composite with different % of graphene. 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.

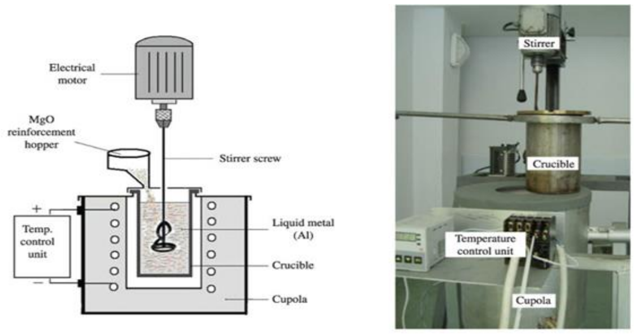


Fig.9 Specimen preparation

Table.1 Composition of aluminum and graphene

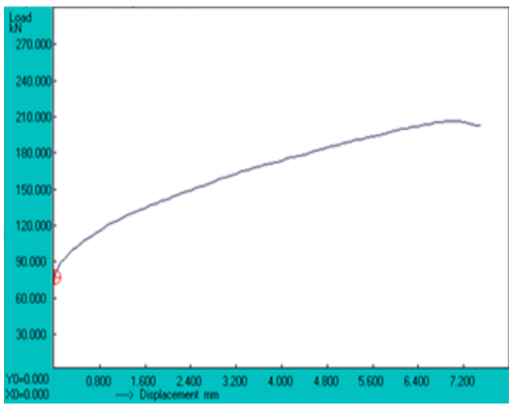
Specimen no	Graphene (%) By weight	Graphene (grams)	Aluminium (grams)
01	0	0	1030
02	0.5	5.5	1070
03	1	10.6	1061
04	1.5	15.6	1051
05	2	22	1099

III. EXPERIMENTATION & RESULTS

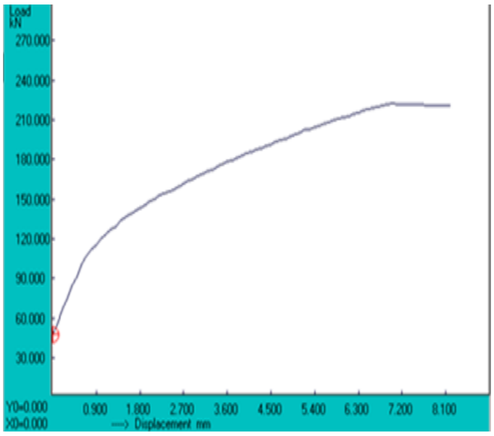
- **Compression test**

Fig.10 Digital UTM

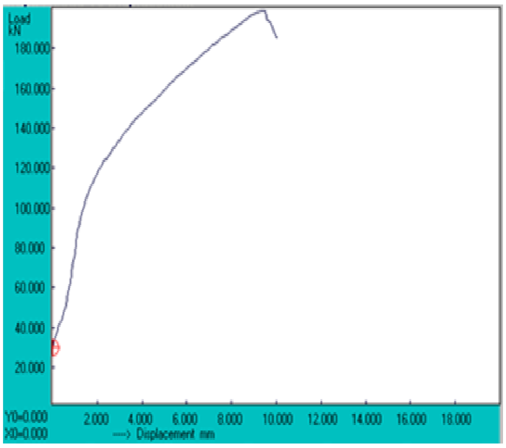
Cramp test is conducted to assess the material behavior against compressive loading so that maximum load taken by the sample with significant increase in area in terms of percentage increase in area and considerable reduction in length is strictly noticed before concluding the sample filled with what proportion of graphene yields better sustainability against external loading. Test is conducted according to ASTM standard and specimen is held tightly by jaw gripping at both the ends. When load is applied it is convenient to consider the strain on the sample in response to applied load. Different graphs are obtained for different samples indicating load against displacement which are discussed bellow.



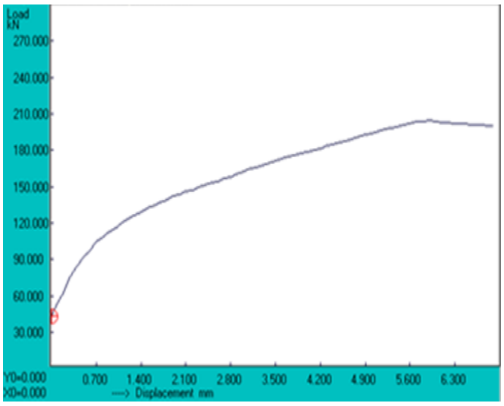
Graph.1 specimen 1 (load against displacement)



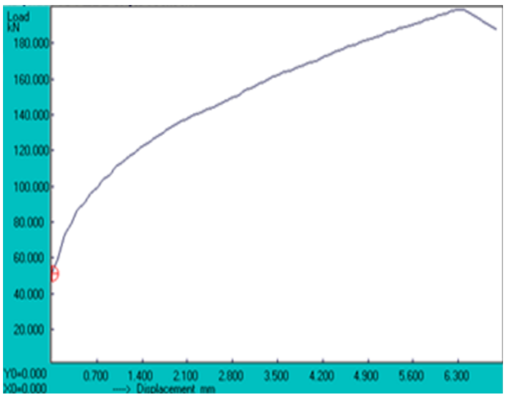
Graph.2 specimen.2 (load against displacement)



Graph.3 specimen.3 (load against displacement)



Graph.4 specimen.4 (load against displacement)



Graph.4 Specimen.4 (load against displacement)

Above graphs 1,2,3,4 & 5 depicts the experimental results of compression test for samples filled with 0%, 0.5%,1%,1.5%,2% graphene respectively. For the sample 1 which is pure aluminum results cleared that the breaking point of the specimen is at 206KN and the maximum displacement is 7.500mm.The cross section area of the specimen after the specimen compressed is 22.500mm². For the sample filled with 0.5% graphene shows the breaking point of the at 222KN and the maximum displacement is 8.200mm.The cross section area of the specimen after the specimen compressed is 22500mm². The breaking point of the specimen filled with 1% of graphene is at 199KN and the maximum displacement is 10.100mm.The cross section area of the specimen after the specimen compressed is 22500mm². The sample loaded with 1.5% breaking point of the specimen is at 203KN and the maximum displacement is 6.900mm.The cross section area of the specimen after the specimen compressed is 22500mm². Table.2 shows the results for different samples filled with different percentage of graphene material. The specimen numbers are designated with respect to the percentage of reinforcement that each sample is loaded with and corresponding changes in the intial and final dimensions in cross sectional are also recorded noticed with percentage of elongation.

Table.2 Compressive Test Results

Specimen no	**Initial Dia(mm)**	**Initial length(mm)**	**Final Dia(mm)**	**Final length (mm)**	**% elongation**
01	**19**	**30**	**25**	**26**	**-4**
02	**19**	**30**	**22**	**24**	**-6**
03	**19**	**30**	**24**	**27**	**-3**
04	**19**	**30**	**23**	**26**	**-4**
05	**19**	**30**	**21**	**28**	**-2**

IV. CONCLUSION

By employing strir casting technique preparation of graphene loaded with aluminum metal matrix composites has been successfully keeping the percentage of loading of graphene with 0.5%,1%,1.5%,2% by weight of the matrix considered. Compression testing was done for all the prepared samples using digital UTM. For the applied load corresponding strain and displacement was recorded and different plots for different samples have been documented. It is concluded that sample filled with 0.5% of graphene shows excellent resistance to compressive loading proves the saturation of graphene nano particles dispersed uniformly and maintain better bonding characteristics with aluminum matrix which enhance very good malleable properties for this particular proportion of metal matrix composites. Upon loading specimen with 0.5% of graphene records compression strain of 0.60025 with maximum break load of 222KN which are concluded to be better compare to the rest of the samples. This indicates the optimum percentage of graphene is found be 0.5 % which gives better cramp resistance for aluminium nano composites compare to the rest of the samples.

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