Investigation on Mechanical Properties of Aluminium 7075 Hybrid composites

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Abstract: **The Purpose of this Research work is to investigate the Mechanical properties, of CNT and Zro_2 reinforced with Al 7075 hybrid Metal matrix composites and comparisons has been done. The alloys of Al 7075 reinforced with CNT and Zro_2 are prepared by using Stir casting. Al 7075 alloy of T6 grade is used as the base matrix which is reinforced with carbon nanotubes and zirconium dioxide (Zro2) having weight percentages of 0, 0.25, 0.5, 0.75 and 1. It is seen that as reinforcement content CNT & Zro2 increases the Ultimate tensile strength, compressive strength and Hardness of the hybrid composites ascompared with base alloy of Al 7075.**

Keywords: **Al 7075, Metal matrix, CNT, Zro2**

I. INTRODUCTION

The term “composite” broadly refers to a material system which is composed of a discrete constituent (the reinforcement) distributed in a continuous phase (the matrix), and which derives its distinguishing characteristics from the properties of its constituents, from the geometry and architecture of the constituents, and from the properties of the boundaries (interfaces) between different constituents. Composite materials are usually classified on the basis of the physical or chemical nature of the matrix phase, e.g., polymer matrix, metal-matrix and ceramic composites. In addition there are some reports to indicate the emergence of Inter metallic-matrix and carbon-matrix composites. This review is concerned with metal matrix composites and more specifically on the aluminum matrix composites (AMCs). In AMCs one of the constituent is aluminium/aluminium alloy, which forms percolating network and is termed as matrix phase. The other constituent is embedded in this aluminium/aluminium alloy matrix and serves as reinforcement, which is usually non-metallic such as CNT and Zro_2.

II. THEORY

Sneha H. Dhoria et.al: reported hybrid 6351 Al/Gr/SiC composites are produced via squeeze casting using 6351 aluminum alloy as the matrix, with graphite and silicon carbide particles as reinforcements. The mechanical properties, viz., hardness and tensile strength of Al 6351 hybrid metal matrix composites are studied by conducting Vicker’s hardness test and tensile test. It is observed from the results that the density of Al6351 alloy decreases by adding 10% graphite when compared to pure alloy, but the density increases by decreasing the graphite percentage and adding SiC particles gradually. The Al6351/0%Gr/10%SiC composite has got an increase in hardness value of 11.35% as compared to the pure Aluminium alloy (Al6351). There is an increase in tensile strength value for the Al6351/0% Gr/10%SiC composite by 22.39% as compared to the pure Aluminium alloy (Al6351). The percentage elongation of Al6351 alloy decreases with the addition of graphite and then increases by adding silicon carbide gradually. The reduction in ductility in the hybrid composite is due to the localized crack initiation and increased embrittlement effect on it.

B. Madhusudhana Reddy et.al: studied about the properties of Carbon Nano Tubes (CNTs) reinforced aluminum metal matrix Nano composites. These Nano composites are fabricated by using stir method by varying the CNT reinforcement weight percentage (0.4%, 0.7% and 1.1%) of size 30 nm in Al 5056 matrix. To study its properties, the fabricated specimens are tested for the properties such as tensile strength, hardness, toughness and density. The properties of the Nano composites are found to be greatly influenced with increasing of weight percentage of reinforcement. With mixing of different weight proportion reinforced particles by stir casting process, nearly 25% increase in tensile and hardness strength of composites. The experimental values obtained from tests more useful in the development of Nano composites for different applications.

Ana M. Dı´ez-Pascual et.al: Novel poly(ether ether ketone) (PEEK)/single-walled carbon nanotube (SWCNT)/glass fiber laminates incorporating polysulfone as a compatibilizing agent were fabricated by melt blending and hot-press processing. Their morphology, mechanical, thermal and electrical properties were investigated and compared with the behavior of similar non-compatibilized composites. Scanning electron micrographs demonstrated better SWCNT dispersion for samples with poly sulfone. Thermo gravimetric analysis indicated a remarkable improvement in the thermal stability of PEEK/glass fiber by the incorporation of SWCNTs wrapped in the compatibilizer, ascribed to a significant thermal conductivity enhancement. Differential scanning calorimetry showed a decrease in the crystallization temperatureandcrystallinity of the polymer with the addition of both wrapped and non-wrapped SWCNTs. The laminates exhibit anisotropic electrical behavior; their conductivity outof-plane is lower than that in-plane. Dynamic mechanical studies revealed an increase in the storage modulus and glass transition temperature in the presence of polysulfone. Mechanical tests demonstrated significant enhancements in stiffness, strength and toughness by the incorporation of wrapped nanofillers, whilst the mechanical properties of non compatibilized composites only improved marginally. Samples with laser-grown SWCNTs exhibit enhanced overall performance. This investigation confirms that SWCNT-reinforced PEEK/glass fiber compatibilized composites possess excellent potential to be used as multifunctional engineering materials in industrial applications.

PankajShrivastavaa et.al: The effect of addition of multiwalled carbon nanotubes-exfoliated graphite nanoplatelets (MWCNTxGnP) hybrid nanofiller on the mechanical properties of aluminium (Al) has been reported. MWCNTxGnP hybrids having MWCNT to xGnP weight ratios of 1:9, 3:7, 1:1, 7:3 and 9:1 were synthesized and 1, 2, 3, and 5 wt. % of all the hybrids were added to the Al powder to develop Al-MWCNT-xGnPnanocomposites. The highest hardness for the conventionally sintered nano composites was observed in the case of Al-2 wt. % MWCNT50xGnP50 nano composite (463 MPa) whereas for spark plasma sintered (SPSed) nano composites the hardness was found to increase with the increase in hybrid nanofiller content and the highest hardness was observed for Al-5 wt. % MWCNT50xGnP50 nanocomposite (645.2 MPa). For both conventionally sintered and SPSednanocomposites the best wear resistance was achieved in the case of Al-2 wt. % MWCNT50xGnP50 nano composite.

Abhishek Sharma and P.M. Mishra: Aluminium hybrid composites are most demanding composites in field of advanced lightweight materials because of their low density, good mechanical properties, better wear and corrosion resistance, low coefficient of thermal expansion as compared to conventional metals. Their low cost of production and excellent mechanical properties makes them the most potential materials for advanced aerospace and automotive applications. Among various grades of Aluminium alloy, 7075 grade is one of the most prominent and used for fabricating single and hybrid reinforced composites. Most of researchers reported the micro structural, physical, optical and mechanical characteristics of Aluminium 7075 hybrid composites. The reinforcements utilized for hybrid composites includes Al_2O_3, SiC, SiO_2, B_4C, TiC, TiO_2, Graphite WC, Ti, Cr, Cast Iron, Fly ash, Red Mud, Rice husk ash, Bagasse ash . This review article highlights about various combination of reinforcements used so far and their effects on mechanical characteristics of 7075 hybrid composites.

ChangjiangNie,et.al: In this study, a high-performance hybrid aluminum matrix composite (HAMC)reinforced with ceramic particles and carbon nanotubes (CNTs) is analyzed. A novel multi-step micromechanical approach, based on the Mori-Tanaka model and the generalized method of cell, is proposed in order to predict the effective elastic modulus and Poisson's ratio of the HAMCs. The influences of volume fraction, aspect ratio, waviness shape, alignment and agglomeration of CNTs, and ceramic particle volume fraction on the mechanical properties of CNT/ceramic particle-reinforced HAMCs are explored. Moreover, the role of aluminum carbide (Al_4C_3) which may be formed at the CNT/matrix interface in the mechanical behavior is micromechanically investigated. It is found that adding a small amount of CNTs into the microscale ceramic particle-reinforced aluminum matrix composites (AMCs) can significantly improve the effective mechanical properties of the resultant HAMCs. As compared to HAMCs, which contain the randomly dispersed CNTs, the alignment of CNTs into the HAMCs leads to a higher level of mechanical properties. However, the waviness and agglomeration of CNTs can decrease the HAMC elastic modulus. According to the obtained results, the CNT/matrix interfacial interaction may have significant effects on the effective properties of the particulate hybrid metal-based composites. The elastic properties estimated by the micromechanical model are compared to those measured by the experimental method. The outcomes of this research suggest that these hybrid metal-based composites, containing CNTs, have significant potential in diverse engineering applications as compared to the conventional metal-based composites.

Michael Oluwatosin Bodunrinaet.al: studied Aluminum hybrid composites are a new generation of metal matrix composites that have the potentials of satisfying the recent demands of advanced engineering applications. These demands are met due to improved mechanical properties, amenability to conventional processing technique and possibility of reducing production cost of aluminum hybrid composites. The performance of these materials is mostly dependent on selecting the right combination of reinforcing materials since some of the processing parameters are associated with the reinforcing particulates. A few combinations of reinforcing particulates have been conceptualized in the design of aluminum hybrid composites. This paper attempts to review the different combination of reinforcing materials used in the processing of hybrid aluminum matrix composites and how it affects the mechanical, corrosion and wear performance of the materials. The major techniques for fabricating these materials are briefly discussed and research areas for further improvement on aluminum hybrid composites are suggested.

III. Materials & Methods.

Al 7075 alloy

Aluminium 7075 was collected at Perfect metal works located at Bapujinagara, Bangalore.

7075 aluminum alloy (AA7075) is an aluminum alloy, with zinc as the primary alloying element. It has excellent mechanical properties, and exhibits good ductility, high strength, toughness and good resistance to fatigue. It is more susceptible to embrittlement than many other aluminum alloys because of micro segregation, but has significantly better corrosion resistance than the 2000 alloys.It is one of the most commonly used aluminum alloy for highly stressed structural applications, and has been extensively utilized in aircraft structural parts.

Carbon nanotubes

50 grams of CNT collected at Suntech fiber PVT. LTD, Ramnagara.

The Carbon nanotubes (CNT) are tubular structures made of carbon atoms, having diameter of nanometer order but length in micrometers. Carbon nanotubes are allotropes of carbon with a cylindrical structure. Their shape resembles a hollow tube, wit h a wall thickness of exactly one atom. It is mainly made up of hexagonal rings of carbon and this carbon nano tubes can have 1 layer or multiple layer of graphene sheet.SWCNTs consist of a single cylindrical carbon layer with a diameter in the range of 0.4-2 nm, depending on the temperature at which they have been synthesized. It was found that the higher the growth temperature larger is the diameter of CNTs.

MWCNTs consist of several coaxial cylinders, each made of a single grapheme sheet surrounding a hollow core. The outer diameter of MWCNTs ranges from 2-100 nm, while the inner diameter is in the range of 1-3 nm, and their length is one to several micrometers .

Zirconium dioxide

50grams of $Zro_2$was collected at Ramnagara. Karnataka.

Zirconium-dioxide (ZrO_2), sometimes known as zirconia (not to be confused with zircon), is a white crystalline oxide of zirconium with Its most naturally occurring form a monoclinic crystalline structure, is the mineral baddeleyite. A dopant stabilized cubic structured zirconia, cubic zirconia, is synthesized in various colours for use as a gemstone and a diamond simulantZirconia is produced by calcining zirconium compounds, exploiting its high thermal stability.

Fabrication (stir casting)

Sl no	Composition mix	Aluminum 7075	Carbon NanoTubes	Zirconium dioxide
	in %	in Kg	in grams	in grams
1	0	2	0	0
2	0.25	2	5	5
3	0.5	2	10	10
4	0.75	2	15	15
5	1	2	20	20

Mixing and Stirring

Graphite coated stainless steel impeller was used to stir the molten metal to create a vertex. The impeller was of centrifugal type with 3 blades welded at 450 inclination and1200 apart. The stirrer was rotated at a speed of 300 – 500 rpm and a vertex was created in the melt. The depth of immersion of the impeller was approximately one third of the height of the molten metal. From the bottom of the crucible. The particulates of CNT and$Zro_2$with varying percentages for every 2kg of AL7075 were introduced into the vertex. Stirring was continued until interface interactions between the particles and the matrix promoted wetting. The melt was degassed using Hexochloroethane tablets to reduce slag and was poured into the preheated die.

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Pouring of molten metal into dies

The dies are made up of cast iron with diameter 20*220mm length.The dies were pre heated and coated additives to ease the process of removing thecastings .Then after few minutes of mechanical stirring, the liquid metals with reinforcements are pouredinto the dies to get the required castings. The dies are cooled at room temperature for 2 hours, to obtain perfect cylindrical castings. The mould boxes are removed manually and the obtained castings are sent to machining.

IV Experiment

Ultimate Tensile strength

The tensile specimens prepared in accordance with ASTM E8 were subjected to homogenous and uniaxial tensile stresses in a Universal Testing Machine. The tensile specimens of diameter 16mm and gauge length 50mm were machined from the cast specimens with the gauge length of the specimens parallel to the longitudinal axis of the casting. The ultimate tensile strength of the composites specimens and of the base alloy, plotted against the flyash content and E-glass. It follows from the graph that the specimens show an increase in Ultimate Tensile Strength as the content of carbon nanotubes in the composite is increased in as cast conditions.

Specimen Configuration				
Sl no	Al 7075	CNT	Zro_2	Tensile Strength in N/mm^2
1	0%	0%	0%	103.5
2	0.25%	0.25%	0.25%	132
3	0.50%	0.50%	0.50%	155.5
4	0.75%	0.75%	0.75%	188.3
5	1%	1%	1%	218.968

Tensile Test Results of Al 7075 MMC

Comparison of tensile strength with Aluminium 7075

Composition	Tensile strength in N/mm^2	Tensile strength increased in %
0.25% of CNT and ZrO_2	132	27.53
0.5% of CNT and ZrO_2	155.5	50.24
0.75% of CNT and ZrO_2	188.3	81.93
1% of CNT and ZrO_2	218.968	111.56

Compression Strength

The table shows the effect of CNT and Zro_2 on compression strength of aluminium hybrid composites.

Specimen Configuration				
Sl no	Al 7075	CNT	Zro_2	Compression Strength in N/mm^2
1	0%	0%	0%	628.2
2	0.25%	0.25%	0.25%	639.895
3	0.50%	0.50%	0.50%	631.4
4	0.75%	0.75%	0.75%	680
5	1%	1%	1%	700.65

Table 6.3: Compression Test Results of Al 7075 MMC

Comparison of compressive strength with Aluminium 7075

Composition	Compressive strength in N/mm^2	Compressive strength Increased in %
0.25% of CNT and ZrO_2	639.895	1.766
0.5% of CNT and ZrO_2	651.4	3.693
0.75% of CNT and ZrO_2	680	8.245
1% of CNT and ZrO_2	700.634	11.53

Hardness strength

Hardness, which is the resistance of the specimens to deformation, is a measure of their resistance to plastic or permanent deformation. The static indentation test was the test used in the present study to examine the hardness of the specimens in which a ball indenter was forced into the specimens being tested. The hardness is a surface property measured by resistance to abrasion or wear, cutting, machining and crusting. Thus hardness is surface property measured by resistance to indentation or penetration by some hard body. The test results are tabulated for the as cast conditions.

Specimen Configuration				
Sl no	Al 7075	CNT	Zro_2	Rockwell Hardness No
1	0%	0%	0%	62.9
2	0.25%	0.25%	0.25%	65.33
3	0.50%	0.50%	0.50%	69.41
4	0.75%	0.75%	0.75%	72.6
5	1%	1%	1%	75.8

Table 6.4: Hardness Test Results of Al 7075 MMC

Comparison of hardness value with Aluminium 7075

Composition	Hardness number	Hardness in (%)
0.25% of CNT and ZrO_2	65.33	3.846
0.5% of CNT and ZrO_2	69.41	10.33
0.75% of CNT and ZrO_2	72.6	15.40
1% of CNT and ZrO_2	75.8	20.49

CONCLUSIONS

This chapter presents the overall conclusions of the research work undertaken to evaluate the different properties of Aluminium alloy 7075 Hybrid composites prepared by Mechanical stir casting method. From the experiments conducted to study the effect of adding various volumes fractions of CNT and Zro_2 on the different mechanical properties such as Tensile, Compression and hardness.

Mechanical Properties:

The summary of the effect of CNT and Zro_2 on the Mechanical Properties of Aluminium alloy 7075 Hybrid composite like Tensile strength, Compression strength, Hardness are as follows:

Aluminium 7075 Hybrid composites:

• Tests conducted to determine Ultimate tensile strength indicated no exact trends; however there has been an increase in UTS due to presence of CNT and Zro_2 as compared to base metal.
• Tests conducted to determine the compressive strength revealed very encouraging results as the reinforced composite was able to take more compressive load due to presence of CNT and Zro_2, the compressive strength increased.
• The hardness increased as the % of CNT and Zro_2 particulates increases up to 1% of reinforcement.
• Metal matrix composites of Al 7075 reinforced with CNT and Zro_2 particulates is found to have improved tensile strength when compared to Al 7075 alloy alone.

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