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Influence of Reinforcement Materials on Mechanical, Metallurgical and Tribological Behavior of Aluminum Composites-Review

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Abstract: Aluminum alloys and aluminium based composites are used presently in engineering applications. Aluminium matrix composites are imparting such superior properties which are very difficult to achieve by any existing monolithic material. These composites (MMCs) pursued over other conventional materials in the field of aerospace, automotive and marine applications due to their outstanding improved properties. These materials are of much interest to the researchers from few decades. These composites primarily replaced ferrous based such as cast iron and alloyed high temperature nonferrous based materials such as brass or bronze alloys but because of their poor wear and seizure resistance, they were subjected to many experiments and the wear behavior of these composites were explored to a maximum extent and were reported by number of research scholars for the past couple of years. Properties of aluminum matrix composites are highly influenced by the type and geometry of reinforcement such as particle size, continues or discontinues fiber form. It also depends on the processing techniques adopted for the fabrication of aluminum matrix composites which also depends on many factors including type of matrix and reinforcement the extent of microstructural integrity desired and their structural, mechanical and thermal properties. Present paper reports an overview on synthesis routes or processing methods as solid or liquid state techniques used to produce specimens with different reinforcements including carbon nanotubes. Mechanical and tribological behavior and its challenges of aluminum matrix composites are discussed.

Keywords: Carbon Nanotube, Metal Matrix Composites, Mechanical Properties, Stiffness, Strength, Wear behavior

Introduction

The unique combinations of properties provided by aluminum and its alloys make aluminum one of the most versatile, economical, and attractive metallic materials for a broad range of uses from soft, highly ductile wrapping foil to the most demanding engineering applications. Aluminum alloys are second only to steels in use as structural metals.

Developing new structural materials with higher strength to weight ratios is one of the biggest challenges for many engineering applications such as transportation, aerospace and marine sectors. Properties like high specific strength and stiffness, better wear characteristics and retaining properties at elevated temperature compared to the conventional metals and alloys are the key reasons for the increasing attention towards new materials called Composites. Composite materials consist of two or more materials that differ in chemical and physical properties and are not soluble in one another. The primary constituent in a composite material is the matrix phase that offers load transfer and structural integrity, while the reinforcement to improve mechanical properties. The matrix and reinforcement materials can either be polymers, ceramic (or glass) or metallic materials (aluminium, titanium, etc.). The most common forms of reinforcement materials are fibers (long and short), or particulates. Aluminium and its alloys have attracted most attention as base metal in metal matrix composites. Composite materials have superior specific properties (high strength to weight ratio) compared to metals, high stiffness and good damage resistance over a wide range of operating conditions, making them an attractive option in replacing conventional materials for many engineering applications. Important properties of composite materials are: improved strength & stiffness, excellent fatigue resistance, high heat resistant, high wear resistant, high corrosion resistant, low weight etc. By suitable arrangement of metal matrix and reinforcement addition, it is possible to tailor the desired properties to suit for a particular application. Matrix materials in Metal Matrix Composites (MMC) are aluminium, magnesium and titanium alloys. Reinforcing materials in MMC are silicon carbide, boron carbide, alumina and graphite in the form of particles, short fibers (whiskers) or long fibers. In Aluminium Metal Matrix Composites (AMMC), matrix material is aluminium and reinforcement materials are silicon carbide, aluminum oxide, boron carbide, graphite etc. in the form of fibers, whiskers & particles.

Aluminium based metal matrix composites reinforced with one or more of the ceramic materials provides enhanced properties. These composites are becoming more popular because of their low density, low melting and high specific stiffness and are attracted by many fields of engineering applications such as automobiles, aerospace, electronic devices, etc.

Aluminium-based metal matrix composites with an ideal reinforcement as carbon nanotubes (CNT's) possesses an awfully high strength, exceptional stiffness and excellent wear resistance. This paper reports about the discussions made by many investigators during their research studies on aluminium metal matrix composites with different reinforcements. Highlighted the mechanical and tribological properties observed after the investigation done by various researchers.

Experimental Details and Discussions

S.T. Selvamani et al. [1] In their research work, three different reinforcements of Carbon Nano Tubes (in weight%) such as 2%, 3% and 4% were added to the magnesium AZ91D grade magnesium alloy to fabricate the Nanocomposites through stir casting method. The effects of volume percentage on the mechanical, metallurgical and wear behavior were analyzed. The composites with 4% reinforcement show high hardness while the composites with 3% reinforcement show better tensile and yield strength and also an improved wear resistance compared to other.

Harun Mindivan et al. [2] conducted the experiment on dry sliding and corrosion wear resistances and cavitation erosion-corrosion behavior of T6 and "Retrogression and Reaging" treated 7039 alloys were compared. Dry sliding wear performance of the alloy was examined in normal atmospheric conditions. Cavitation erosion- corrosion and corrosion wear tests were conducted in a NaCl plus HCl solution of suitable proportion. The experimental results showed that the Retrogression and Reaging treatment considerably improved the resistance of 7039 aluminium alloy to cavitation erosion -corrosion and dry sliding wear. The Retrogression and Reaging treated alloy exhibit lower corrosive wear resistance than the T6 treated alloy.

Nadeem Faisal et al. [3] investigator clarified that the distribution of CNTs in the forged CNT/6061Al composites with the CN T contents of 1.5 and 3 vol%. Clusters of CNTs with an average size of about 10 μm were observed, indicating that homogenous dispersion of CNTs cannot be achieved by simple mechanical mixing and hot forging. However, no clusters of CNTs could be fo und after Friction Stir Processing which was witnessed by SEM images, which indicated that the severe plastic deformation du ring Friction Stir Processing dispersed CNTs into the aluminum matrix.

Researcher chosen solid state method to develop the specimens. Carbon nanotube (CNT)-reinforced 6061Al (CNT/6061Al) co mposites and were fabricated via powder metallurgy combined with friction stir processing (FSP). CNTs were dispersed after FSP and accelerated the precipitation process of the CNT/6061Al composites. However, the strengthening effect of CNTs on th e T6-treated materials was unimportant, while the composites under the FSP and solution treatment conditions showed increa sed strength compared to the matrix. Precipitate-free zones (PFZs) were detected around CNTs in the T6-treated CNT/6061Al composites, and a model was proposed to describe the effect of PFZs on strength. The calculations indicated that the strength o f PFZs was similar to that of the T6-treated 6061Al. As a result, the strengthening effect of CNTs on the T6-treated CNT/6061Al composites was trivial.

AbouBakr Elshal akany et al. [4] investigator adopted rheocasting and squeeze casting methods to develop A356 hypoeutectic aluminum silicon alloys matrix composites reinforced by different contents of multiwalled carbon nanotubes (MWCNTs). A innovative approach by adding MWCNTs into A356 aluminum alloy matrix with CNTs has been performed. This method is momentous in debundling and preventing flotation of the CNTs within the molten alloy. The microstructures of nanocomposites and the interface between the aluminum alloy matrix and the MWCNs were observed by using an optical microscopy (OM) and scanning electron microscopy (SEM) equipped with an energy dispersive X-ray analysis (EDX). This method curiously facilitated a uniform dispersion of nanotubes within A356 aluminum alloy matrix as well as a refinement of grain size.

Author reveals that addition of CNT increases ultimate tensile strength and elongation percentage. Evaluated mechanical properties with weight fraction (0.5,1.0,1.5,2.0, and 2.5wt%) of the CNT-blended to matrix. Noticed that 1.5wt%MWCNTs which signifies an increase in their values by a ratio of about 50% and 280%, respectively, and shown that a significant improvement in ultimate tensile strength and elongation percentage with an addition of 1.5wt%MWCNTs compared to their corresponding values of base alloy. Hardness of the samples was also increased considerably by the addition of CNTs.

Eduardo Uriza-Vegaa et al. [6] researcher studied on Al7075 aluminum with multiwalled carbon nanotubes were developed by spray pyrolysis. Aluminum matrix in different concentrations up to 3.0 wt% prepared. The dispersion in the aluminum matrix was carried out by ultrasonic/methanol method followed by high-energy mechanical milling process. homogeneous dispersion of CNTs was observed in this process. The mechanical behavior of the composites shows a noticeable improvement for MWCNTs concentrations above 2.0 wt%. Report reveals that ductility observed was reflects the same recorded in literature for the Al7075 alloy. Base metal mixed with MWCNTs at different concentrations from 0.0% upto 3.0 wt% in steps of 0.5%.

later, the uniform mixture achieved by subjecting them to sonicated in isopropyl alcohol for 30 minutes and lastly dried by using heat gun. Then the mixtures were subjected to mechanical milling in a high energy horizontal attritor mill (ZOZ CM01 Simoloyer); A ball to powder ratio of 20:1 was used in all runs. Hardened steel balls are used in the container. Methanol was added to the milling runs to control welding of powders. Milling atmosphere maintained by argon gas with 5 hours milling time. The morphology and size of the as-milled powders, as well as the dispersion of the reinforcement into the matrix were analyzed by SEM images. Tensile strength of the composite increases to 533Mpa for 2.5wt% of MWCNTs, in comparison to base alloy of 28Mpa.

The improvement in tensile performance is because of the synergic contribution of the milling process and the MWCNTs presence in the composite. In addition, an increment of 37% is observed in the 2.5-MWCNTs/Al7075 composite when comparing with the milled 0.0-MWCNTs/Al7075 composite. This increment in the tensile strength can be attributed to the individual effect produced by the MWCNTs in the composite. the yield strength of the composites is seen, compared to the milled and the reference Al7075-O alloys. The σy increases up to 25% for the sample with 2.0 wt% of MWCNTs, in comparison with the 0.0-MWCNTs/ Al7075 sample.

Pothamsetty Kasi V Rao1 et al. [7] investigated the effect of CNT size in Al-CNT metal matrix composite. Composites developed using using solid state process called powder metallurgy process. Influence of reinforcement size and content of multi walled carbon nanotube in matrix on thermal properties (CTE) were experimentally investigated. Observed microstructure through SEM of fabricated metal matrix and to inspect the uniform dispersion of CNT without any clusters or agglomerations in the matrix. The results of thermal test showed that if the CNT particle content increases considerably the Coefficient of thermal expansion decreases evidently upon the increase in CNT content and Type 1 Al-CNT matrix shows a maximum decrement of 15.36% in CTE when compared to Type 2 and Type 3 Al-CNT matrix.

Hashim Hanizam et al [8] Developed the composites through stir casting followed by thixo-forming and modified by T6 heat treatment. Optimization and effect of variables such as amount of CNT, amount of wettability agent of magnesium and mechanical stirring duration were investigated using Taguchi method. With two factorial levels. Composite fabricated using LM processing considering the homogeneous distribution and pullout of MWCNT across the grain boundaries observed in SEM images. The highest hardness and Tensile Strength values 106 VHN and 277 MPa respectively were observed and much higher than the values obtained for as cast A356 alloy. Magnesium content contributes to the enhancement of wettability. Thixo-forming and heat treatment further helps to enhance the properties of the composites.

S. García-Villarreal et al [9] investigators prepared the samples by powder metallurgy and stir casting techniques. Material characterization studied such as hardness, tensile test and compression test. The experimental results reveal that increasing in cooling rate during solidification of Al-Zn-Si alloys yields refinement of microstructure. Increase in silicon witnesses the microhardness and tensile strength of the based Al-Zn-Si alloys increased up to 1.5wt%, above which they decreased as the silicon content increased further.

Hardness test, tensile strength and compressive strength of various compositions of wt.% of MWCNTs under different heat treatment and age hardening have been obtained and compared with the mechanical properties of base alloy matrix. Comparative studies of mechanical properties revealed a decrease in compressive strength due to the hollow structure, high aspect ratio of MWCNT and the tendency to undergo buckling with good improvement in the hardness and tensile strength of the specimens prepared by the stir casting method under different quenching and age hardening conditions. The percentage increase and decrease of the strength were found to be more predominant in the specimens obtained by the stir casting technique due to less porous and fine grains in the microstructure compared to the powder metallurgy technique. Novel processing techniques are to be applied to enhance the mechanical properties especially the compression strength to improve the particle distribution and elimination of porosity

L. H. Manjunatha et al [10] Specimen samples developed by powder metallurgy and Stir casting routes. Aluminum 6061 material and multi-wall CNT (MWCNT) in different concentrations as the reinforcing material. Properties such as compression, Tensile and Hardness tests were conducted. Compare to pure Aluminum samples, the effects of addition of MWCNT, improves the properties significantly while compression strength was decreased in case of stir casting technique subjected to heat treatment and age hardening compared to the powder metallurgy technique.

Addition of reinforcement by 0.5, 1.0, 2.0 and 3.0 wt.% of CNTs weight percentage was mixed with Al6061 powder in ethanol solution. The mixing was carried out for the duration of 10 minutes at 200 rpm to obtain uniform mixing using the ball mill. The mixture of a required proportion of weight percentage of MWCNT and Al6061 was compacted in the die assembly using a hydraulic press at gradually applied a standard load of 200 KN.

In the present study, the addition of MWCNT has been limited to 3 wt.% as beyond this value the specimen showed cracked surfaces rendering the sample unusable. Al powder of 20 grams was filled into a compacting steel die and pressed hydraulically at a pressure 180 kN with initial dimensions of 20 mm diameter and 40 mm length were compacted to a final size of 20 mm diameter 20 mm length. A low-cost sintering furnace was designed and fabricated for the current research work to impart strength and integrity. The compacted samples were sintered in the vacuum furnace at 600°C for 45 minutes followed by air-cooling in the nitrogen atmosphere. Samples were sintered in a tube furnace under the flowing nitrogen which passes over warm steel wool. Sintered billets were hot extruded by a hot extrusion process at 560°C to obtain a 25% reduction in diameter. Upon sintering, the metallic bonding between the powder particles is formed mainly by diffusion.

Stir casting techniques are preferred for higher tensile strength achievement between 1 to 3 wt. % of MWCNT because these particles can act as obstacles to the movement of dislocation and provide protection to the softer matrix in the matrix alloy. Thus, it limits deformation and resists the penetration and cutting of slides on the surface of the composites. Ultimate tensile strength of all the composites was significantly greater than the base alloy characterized by the hard nature of the MWCNT particles

The present study has highlighted the need for developing Al-MWCNT metal matrix composites with heat treatment and age hardening to explore the possibility of using different fabrication techniques in enhancing the mechanical characteristics. The MMCs have been prepared successfully using powder metallurgy and stir casting methods. Hardness test, tensile strength and compressive strength of various compositions of wt.% of MWCNTs under different heat treatment and age hardening have been obtained and compared with the mechanical properties of base alloy matrix.

Pothamsetty Kasi V Rao et al [11] In their study Aluminum Alloy 7075 was selected as the matrix and carbon nanotubes was selected as reinforcing element to explore the percentage improvement of flexural strength and impact strength of metal matrix composite. Stir casting process was selected to produce the specimens. The multi walled carbon nanotubes with different percentages by weight (0.5, 1.0, 2.0, 5.0 wt %) were selected to prepare the AA7075-CNT metal matrix composite samples. Microstructure and dispersion of CNT was examined using Scanning Electron Microscope (SEM) with EDX. The experimental results of mechanical tests showed that if the MWCNTs particle content increases considerably flexural strength and impact strength increases about 125% and 90% respectively. Thus the AA7075-CNT metal matrix can be used in automobile and aerospace applications under high load conditions.

The specimens were fabricated by stir casting process as this process is the best method to achieve high strength to the specimens. The stir casting setup consists of an electric furnace, stirrer motor with stirrer, stirrer holding attachment and temperature indicating panel with thermocouples. The maximum range of temperature achieved in the furnace is 1200 0C with 250 kW high frequency Induction furnace and 5 kg capacity steel crucible. The melting temperature is maintained around 660 to 700 0C with speed of 350 to 400 rpm and vibration based high frequency stirrer was used for uniform mixing of reinforcing particles in the base metal. Electric furnace was used for the melting of the aluminum alloy. The melting point of the alloy is 650 and it was superheated by 100, so the temperature was set at 750 0C. CNT powder (0.5% by weight) was added in another crucible and was preheated to temperature of 1000 0C in second furnace. The preheating was done in the presence of air so that it assists in removing surface impurities, desorption of gases and formation of oxide layer around each particle which will act as protective layer and inhibit the reaction between the CNT powder and molten aluminum alloy. The melt was stirred continuously by electrically operated stirrer running at 200 rpm, in the crucible. Due to the stirrer action there will be formation of vortex in the molten metal and this vortex produces a pressure difference along the depth and radius.

The process of introducing CNT into the molten matrix was done in two consecutive steps with 0.25% by weight each time. This was done to get more uniform mixing and to reduce the formation of clusters of CNT into the molten matrix. The preheated CNT 0.25% by wt.in above mentioned percentage by weight were then added to the side of the vortex formed. The pressure difference induced by vortex, forces the CNT deep into the molten aluminum and across the radius of vortex. This phenomenon helps in uniform mixing of CNT into the molten matrix. The stirring was continued for 5 min while the temperature of the furnace was set at 900°C. After completion of the first mixing step, again 0.25% CNT (0.25% of initial AA7075) was added to the molten aluminum that already contains 0.25% CNT, to complete the final stage of mixing with overall 0.5% by weight CNT in molten metal and the specimen was removed after solidification. The same procedure repeated for remaining samples of with 1.0 wt%, 2.0 wt% and 5.0wt% of CNT respectively in AA7075. Charpy impact test was conducted. The impact strength of the composite found to be increasing gradually with the increase in carbon nanotubes (MWCNTs) weight percentage (0.5wt%, 1wt%, 2wt%, 5wt %) in AA7075 matrix when compared to pure AA7075. The maximum of 90 % increment was found in AA7075- 5wt% CNT matrix. The Flexural strength of pure AA7075 was found to be 71.52 N/mm^2. The trend shows that flexural strength increases gradually with increase in carbon nanotubes (MWCNTs) weight percentage (0.5wt%, 1wt%, 2wt%, 5wt %) in AA7075 matrix. The maximum of 125 % increment was found in AA7075- 5wt% CNT matrix.

Balamurugan Adhithan et al. [12] Main challenge faced by the investigators is the obstacle to obtain a uniform dispersion of the reinforcement materials in the desired matrix. The researcher made an attempt to reinforce light Aluminum with CNT by melt stirring method. Experiment conducted to observe the mechanical properties including physical and thermal properties. Improvement in all properties found. In this work, a two-step process was applied. In first stage, a block copolymer was used as a dispersion agent to pre-disperse multiwall carbon nanotubes (MWNTs) on Mg alloy chip. Then the chip with the well dispersed MWNTs on their surface were melted and at the same time vigorously stirred.

The crucible was placed into an oven and heated up to 650 c under an inert gas atmosphere to avoid oxidation. When the Al chips get melted up, the liquid was mechanically stirred at 370rpm for 30min to further disperse MWCNTs. After stirring, the prepared molten metal composite was poured into a mould. The cooled sample was machined to dimensions of the specimens.

Rockwell Hardness Test conducted by varying weight fraction of CNT (2% and 4%). Test has been conducted on each specimen using a load of 100Kgf and a steel ball of diameter 1.588mm as indenter. The results of increasing trend of hardness with increase in Weight percentage of CNT up to 3%. Beyond this hardness decreases because of formation of cluster occurred. Highest value of hardness found was 57HRB for 3% CNT. By adding 3%wt of CNT with Al the hardness increases up to 22% when compared to pure Al. The Ultimate tensile strength increases (UTS) up to 27% while adding 4% of CNT with Al at a peak load 8.672 kN and with increasing amount of CNT, the ductility gradually increases when compared to pure Al. Study also reveals that the Co-efficient of thermal expansion of the composite are thermally more stable than pure Aluminum base metal.

Mingyang Zhou et al [13]

Prepared the samples using powder metallurgy method followed by hot extrusion process. CNT reinforced AZ31 material developed. Investigator stated that the addition of CNTs could weaken basal plane texture. However, the yield strength and ultimate tensile strength of the composites were enhanced as the amount of CNTs increased up to 2.0 wt. %, reaching maximum values of 241 MPa (+28.2%) and 297 MPa (+6.1%), respectively. The effect of CNT content on the friction coefficient and weight loss of the nanocomposites was also studied. Metal powders are used to prepare the magnesium alloy, here metal powders of Mg, Al and Zn used to prepare raw material. Samples with different reinforcements of 0.5 wt. %, 1.0 wt. %, 2.0 wt.

%, and 4.0 wt. % CNTs, prepared with 99 wt. % metal powders (AZ31) were added into a stainless-steel container and mixed under the protection of argon atmosphere to minimize the oxidation.

Researcher stated that the grain refinement was responsible for increase in hardness further clarified that the presence of agglomeration leads to decrease in its value at 4%CNTs. It can be observed that the addition of CNTs significantly increases the Yield Strength and marginal increase in the Tensile Strength of the AZ31 matrix, which reached a maximum value of 241MPa (+28.2%) and 297MPa (+6.1%), respectively, with the addition of 2.0 wt. % CNTs. Formation of CNT clusters in the matrix causes the decrease in YS and UTS as reported. Researcher also observed that the addition of CNTs could weaken the basal plane texture of the AZ31 fabricated via powder metallurgy method followed by hot extrusion, which might counteract the strengthening effect of CNTs to some extent.

C. Parswajinan et al [14] investigator chosen silicon carbide and CNT reinforced aluminium matrix composites were developed by stir casting process. Samples were subjected to Impact and hardness test. Sufficient care was taken to remove gases and impurities in the melt. Reinforcement preheated to ~400°C. Rigorous stirring of 550 rpm involved to ensure uniform dispersion, finally prepared melt poured into the preheated die. Researcher expressed that the composition Al+3%SiC+0.2%CNT bears more impact load compared to rest of the compositions but at the same time there is a massive drop in the hardness of that material which may be, due to its plasticity. There is a stable increase in hardness upon addition of silicon carbide but if the same is added more, hardness decreases gradually after attaining a peak value. Discussing the load withstanding capability, it's also starts to decrease after attaining a limiting value. Thus, we infer with optimum addition of silicon carbide and carbon nanotubes in their corresponding ratios to the base metal aluminum yields a metal matrix composite that have a superior balance between high hardness and prevail against excellent impact load

Li Si, Wang Chao et al [15] investigator attempted the ultrasonic dispersion and mechanical milling of CNTs in the liquid phase to tackle the agglomeration. Furthermore, acid calcination and strong oxidation methods can add –OH and –COOH and other active groups on the sides and open ends of CNTs, and improve the dispersing of CNTs. Expressed that the majority of researches are adding CNTs without surface treatment to metal matrix directly, and the combine of CNTs and matrix is slight. To solve this trouble, surface treatment can be adopted. The usual method is coating metal matrix on the surface of CNTs. Coating Cu, Ni, Ag and Co、 Mg on the surface of CNTs have been reported. After surface treatment, the boundaries of CNTs and matrix become stronger and the dispersing of CNTs was promoted. Therefore, author reported that the surface treatment of CNTs during the development of CNTs reinforced metal matrix composite is necessary to achieve stronger bonds.

Song Jeng Huanga et al [16] investigator's experimental results reveal that addition of CNT content in AZ61 magnesium alloy causes the decrease in mass wear loss and COF, improves grain refinement and compressive strength. Three wear mechanisms such as abrasive, oxidation and delamination had been studied. The compression strength of the composite increases with increase in CNTs contents for both aged and as cast composites. Aging has remarkable effects to increase fracture strain which increases upto 0.5wt% CNTs/AZ61 and then decreases for 1wt% CNTs/AZ61.Result analysis indicated that aged CNTs/AZ61 composites exhibit enhanced wear and mechanical properties with load bearing capacity, grain refinement and modification at grain boundaries than as cast composites.

J. Stein1 et al [17] Composites developed by CVD techniques. These CNTs are delivered as dense agglomerates which makes their dispersion very difficult. The atomic structure of these MWNT has been characterized using Raman spectroscopy. The matrix was an aluminium alloy powder from the AA5XXX series (Al Mg - N2 atomized) with an average particle size of about 25 µm. Planetary ball milling used for dispersion and processing steps with high milling kinetics in order to disentangle CNT-agglomerates and disperse CNT homogeneously. The milled powder mixture was degassed under vacuum down to a pressure of 10-2 mbar at a temperature between 300°C and 400°C in a stainless-steel capsule to avoid humidity and oxidation. After this step, the mixed powders were hot isostatic pressed under high pressure at 350°C before being extruded through a 6 mm diameter die. Finally, tensile specimens were machined from the extruded rods in order to investigate the mechanical properties of the composite.

Dense CNT-reinforced high-performance aluminum alloy composites were prepared by a repeatable powder metallurgical process. Homogeneous dispersion of CNT in metallic matrix has been achieved and optimized. The corresponding composite material containing 2.0 wt.-% CNT shows Young's modulus, yield strength and tensile strength increased by 5%, 9% and 15%, respectively, with respect to base metal pure aluminum alloy processed in the same conditions

C. Kannan et al [18] Stir casting technique was adopted to produce single reinforced nanocomposite and hybrid composite. Nano alumina particles of average size 30-50nm used as reinforcement of 2wt% in the molten aluminum alloy of grade AA7075. In this research work hybrid reinforced nanocomposites also developed with 4wt% silicon carbide particles of average size of 5 to 10μm along with 2wt%, 4wt% alumina particles were used as reinforcing materials for aluminum-based matrix. Single reinforced nanocomposite was also developed by squeeze casting with a pressure of 101Mpa.

Enhanced charecteristics observed by these developed samples were tensile strength, impact strength and hardness. 63.7% and 81.1% in BHN improvement was noticed for single and hybrid nanocomposites respectively compared to base metal. Arround 16% higher tensile strength observed with the squeeze cast single reinforced nanocomposite over the stir cast of single reinforced nanocomposite. Microstructural observation also carried out using optical and SEM.

Uniform dispersion of the nanopartcles beyond 2wt% was an issue and agglomeration of the nanoparticles in the base matrix metal was difficult to control consequently materail charecteristics deteriorates in hybrid composites.

Conclusions

Aluminum play a major role in engineering applications because of its moldability, low density, corrosion resistance, low melting point, better machinability and deformable properties etc. But at the same time has certain limitations such as low hardness, low strength and low wear resistance etc. if these limitations are overcome by tailoring them by suitable fabrication processes, then these tailor-made materials find wider applications in various fields. So, it is necessary to develop the Aluminum based materials that could have all combinational properties satisfying all our engineering requirements. Carbon nanotubes can be considered as ideal reinforcements, due to their high strength, high aspect ratio and thermo-mechanic properties.

Most of the researchers found that the uniform dispersion of the reinforcement during the development of the composites was a key issue and need to be addressed by further investigation to tackle the problem. Investigator made an attempt to debundling and preventing flotation of the CNTs within the molten alloy to improve dispersion of reinforcement.

Researcher made an effort to reduce clustering of reinforcements of CNTs during the development of the samples. Researcher used the ball milling, Molecular level mixing and colloidal mixing as mixing methods and incorporated the cold pressed sintering followed by hot uniaxial pressing. Friction stir processing, hot isostatic pressing as processing methods. CNTs agglomeration is observed, being the size and amount of those agglomerates strongly related to the chosen dispersion method. Specifically, in those reports where ball milling is used, a significant clustering is noticed. Effort on surface coating of CNTs to build stronger interface between matrix and reinforcement.

Researcher made an attempt in fabricating the samples that the formation of vortex in the molten metal produces a pressure difference along the depth and radius which helps in uniform mixing of reinforcement. In addition, introducing CNT into molten metal done at two steps to achieve better dispersion of the CNTs into the matrix metal. This was done to get more uniform mixing and to reduce the formation of clusters of CNT into the molten matrix. Many researchers expressed that the composite characteristics could be improved by incorporating nanosized reinforcement materials. But at the same time difficult to avoid agglomeration of the reinforcement particles as its content increases.

Although a large amount of efforts was directed towards the development of CNT-MMCs systems, there is still a significant room for improvement. This statement is supported by the fact that, dissimilar results have been obtained by even using the same processing methods as well as the same type and amount of CNTs. This is generated by a scarcity of proper knowledge of each particular system or there is a necessity for further studies to overcome the flaws by acquiring adequate amount of knowledge. As an example, there is still an ongoing discussion in the community about the most suitable dispersion and blending methods for a certain application. Furthermore, it can be noticed that the impact of interphases on the physical properties of the composites is still not well understood. Thus, we foresee a very high potential to gain new insights on each particular system and subsequently achieve further developments in this field.

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