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ANALYSIS OF MECHANICAL CHARACTERISTICS OF ALUMINUM NANOCOMPOSITES USING MULTIWALL CARBON NANO TUBES

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Abstract:

Aluminum and its alloys are increasingly being used in different fields like automobile industries, aerospace industries and many other applications due to its lightweight and specific strength properties. Tensile strength, impact resistance and wear resistance are the weaker sides of aluminum hindering its widespread applications in manufacturing sector. An attempt has been made for improving these properties by introducing carbon nanotubes with aluminum metal to form a Nano composite. Aluminum is used as the metal matrix with Multi-walled carbon nanotube (MWCNT) as the reinforcing element. Mechanical properties of the composite as well as a comparison with properties of the metal is carried out and machining parameters for the industrial sector is also attempted in the study.

Key Words: Aluminum LM25, Nan composites, Multiwall Carbon Nano Tubes & Mechanical Characteristics of Aluminum Nano Composite.

1. Introduction:

Aluminum is extensively used nowadays in manufacturing IC engine components, gears, pipe fittings, bushes, bearings, pumps etc. replacing the conventional ferrous alloys. Composites came into existence when a need to combine the properties of different combination of materials occurred. A reinforced phase, in the form of fibre, powder, sheets or particles; when infiltrated or dispersed in the matrix phase, that could be in slurry, porous or foam structure; a new material with better properties than the parent phases is obtained with a proper choice of manufacturing process and processing parameters. Nano composites are a newer kind of composites where the reinforcing phase has its one, two or three dimensions at Nano level (10^{-9}). In the study, the matrix phase is Aluminum and the reinforcement is multi-wall carbon nanotube. The grade of Aluminum alloy used is Aluminum LM25. Nano composites differ from conventional composites because of its high surface-to-volume ratio of its reinforcing phase. Macro-scale properties can be substantially increased with addition of a minuscule nano-scale reinforcement. Cast Aluminum alloys yielding cost-effective products when infiltrated with a small amount (0.1% - 5%) of CNT can increase electrical and thermal conductivity. LM25 Al alloy has 91.5% Al, 6-7% Si, 0.25% Fe, 0.05% Mn, 0.2% Cu 1-1.2% Mg, 0.1% Ti in its combination providing low density, high castability, and low coefficient to thermal resistance and improved corrosion resistance. Frequent works had been performed in the area of CNTs and composites to aid the impertinent needs from the automotive and aerospace industries. CNTs; being the strongest and stiffest material yet discovered; are used in combat jets, bridge reinforcements, concrete reinforcements. Their conductivity and electromagnetic properties enable their usage in nanowires, conductive films, electric motor brushes, optical recognition etc. Basic ideas of Nano-technology and their significant applications in modifying material properties used in the large scale applications was given by Micro and Nano-technology enterprise works. The major properties of carbon nanotubes are that, they are the strongest and stiffest materials yet discovered in terms of tensile strength and elastic modulus. Electrical-Carbon nanotubes caninfluence strongly electrical properties. Multiwall carbon nanotubes with interconnected inner shells show also super conductivity. The thermal conductivity and chemical kinetics are the other plus properties of the composite. One dimensional transport- carbon nano tube are frequently referred as one-dimensional element because of the nano-scale dimensions electrons propagates only in tube's axis direction.

2. Literature Review:

Amal et al [1] studied on conventional powder metallurgical techniques to reinforce the metal matrices. A powder rolling technique was used to fabricate CNT-reinforced Aluminum strips. The Al-CNT mixture was blended in a mixer-shaker at 46 rpm prior to rolling process. The strength of the formed strips was evaluated for different wt% CNT samples and author stated 0.5% wt composite strips exhibited enhanced mechanical properties than Aluminum. Biing-Hwa Yan et al. [2] studied on finishing process effects in the process of spiral polishing process. In micro-lapping process, dine in silicon and other micro-manufacturing process, the required surface finish need to be met and these surfaces were observed and studied in this work. Del stark et al of Brussels [3] in 2006 investigated on the development of nano composite materials formed by different methods. Conducting organic polymers and CNTs were focussed on their study; considering recent development purpose. HülyaCebeci et al. [4] studied on multifunctional properties of carbon nanotubes and carbon nanotube polymer composites. The composite were studied to enumerate the major properties getting enhanced on using CNTs as additives. Enrique Lavernia et al. [5] investigated on mechanical properties of nanostructures materials, defined as having a mean grain size that falls in the 50-200 nm ranges, is reviewed and the underlying mechanisms are discussed. Particular emphasis is placed on nanostructures materials that are processed via two synthesis approaches consolidation of Nano-crystalline powders and electrode position. There view demonstrates that processing history significantly influence mechanical behaviors as revealed by the following observations. Russelmcenzi [6] book on applied composite materials introduced the various property variations possible in composites especially when there is an application oriented approach done in developing the composite. X D Yang et al [7] studied on synthesis on carbon nano tube reinforcement in Aluminum powder by in situ chemical vapour deposition method. The effect of Ni/Al catalyst on reaction time for CNT/Al composite was studied. FESEM and TEM characterization of the composite was performed and the study emphasizes on a new way to prepare carbon nanotubes. Hansang et al [8] studied on fabrication of multi walled CNT reinforced Aluminum MMC by stir casting method. The study showed that an 80% increase in hardness was observed with a small percent addition of the composite. Moreover, a 2 wt.% addition of MWCNT made a 20% increase in strength of the MMC.

3. Materials and Experimentation:

Aluminum carbon nano tubes were prepared using a series of processes. Metal matrix was produced by using sand casting. Sand casting is one of the most popular and simplest types of casting. Sand casting allows for smaller batches to be made compared to permanent Mould casting and at a very reasonable cost. Three Aluminum rods of diameters 20 mm and 380 mm length dimensions. These Aluminum rods were machined on lathe. For making composite material an Aluminum alloy(LM25) as a matrix material because it is light metal and can be used for many purposes like making automobile parts, Airplane bodies etc.The composition of LM25 are Fe-0.259%, Si-6.812%, Mn-0.049%, Cu-0.186%, Ni 0.019%, Ti-0.093%, Sn-0.006%, V-0.006%, Zn-0.090%, Pb-0.030%, Mg-0.769%, Al-91.676%. In carbon nanotube, a multi-wall carbon as it is comparatively cheaper than single wall carbon nano tube. Three samples are made one without carbon nanotubes, the other two with 3gm and 7gm of carbon nanotubes. The cast samples were then tested for hardness, tensile test, Izod test and wear test. The hardness test is carried out by Rockwell hardness test and the results are projected. Similarly tensile test, Izod test, wear test of the three samples are also found out. The tested samples were then machined. The machining process was turning process in a lathe. Sand casting required a lead time of days for production at high output rates (1–20pieces/hr.-Mould) and was unsurpassed for large-part production. Green (moist) sand had almost no part weight limit, whereas dry sand had a practical part mass limit of 2,300–2,700kg. Minimum part weight ranges from 0.075–0.1 kg. The sand was bonded together using clays, chemical binders, or polymerized oils. The mould consisted of silica, clay and water. When the water was added it developed the bonding characteristics of the clay, binding the sand grains together. When applying pressure to the mould material it can be compacted around a pattern, which was either made of metal or wood, to produce a mould having sufficient rigidity to enable metal to be poured into it to produce a casting. Process also uses coring to create cavities inside the casting.

4. Testing and Results of Aluminum with MWCNT:

A. Izod Impact Test:

The substitute material suggested here is to be used as a structural member in aircraft and marine applications. Hence different properties need to be investigated before a valid suggestion. The machined Aluminum bars were then subjected to tests such as hardness, tensile test, impact test, and wear test analysis. The results were compared with each other. Impact test is studied in the following table

Table 1: Izod Impact Test

Part	**Frictional**	**Energy spent**	**Energy**	**Impact**
Description	Energy Absorbed By the Bearing Without Specimen (joule) "a"	In breaking Or bending The specimen (joule) "b"	Absorbed by the Specimen (joule) C = a - b	Strength (j/mm^2)
Aluminum Lm 25	142	140	2	0.03125
Aluminum With "3" gram Mwcnt	142	134	8	0.125
Aluminum With "7" gram Mwcnt	142	138	4	0.0625

Specimen size used was 75*10*10 having a notch depth of 2 mm. From this comparison optimum and minimum values of nano composites impact strength are clarified and then results are graphically plotted.

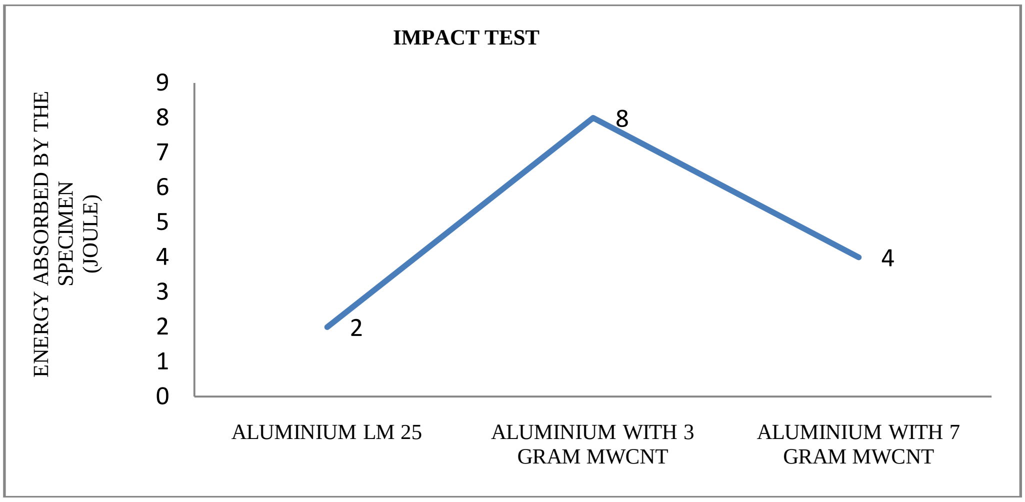


Figure 1: Impact test Graph

B. Rockwell Hardness Test:

Hardness testing was done for the newly formed material and the results were compared with that of the Aluminum monolithic alloy. The results were tabulated as shown Table 2. From the result 3gms of MWCNT mixed Aluminum gave more hardness comparatively pure Aluminum and 7gms of MWCNT mixed Aluminum.

Table 2: Hardness test

S.No	Material	Diameter of the indentor (mm)	Scale reading		Average scale reading	Rockwell hardness number (RHN)
1	Aluminum lm 25	1/16 ball	1	71	71	71
			2	70		
			3	72		
2	Aluminum with 3 gram Mwcnt	1/16 ball	1	75	75	75
			2	80		
			3	69		
3	Aluminum with 7 gram Mwcnt	1/16 ball	1	76	74	74
			2	75		
			3	72		

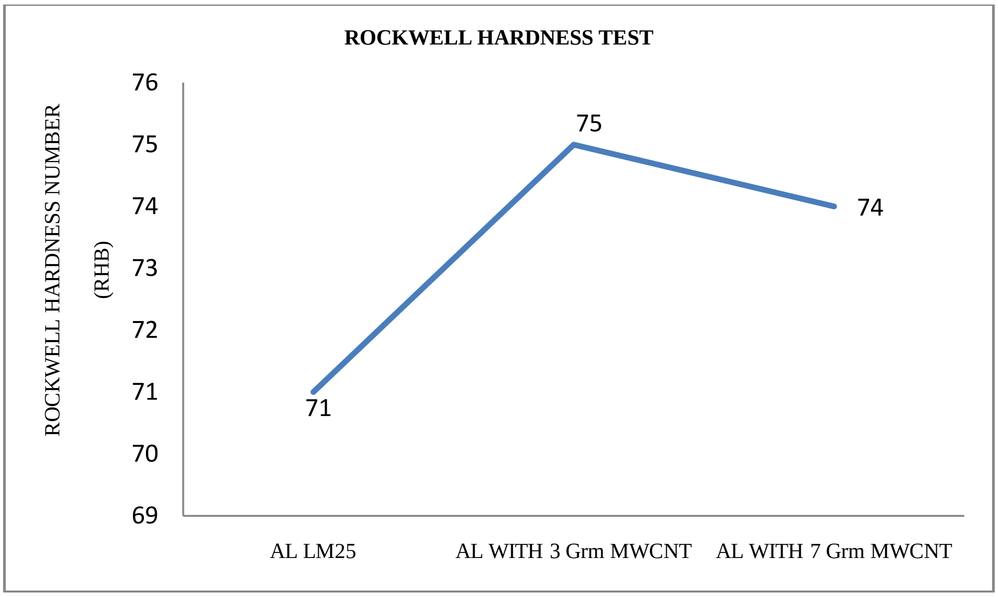


Figure 2: Rockwell Hardness testing graph

C. Tensile Test:

Optimum and minimum hardness were plotted in graphs. Tensile testing was performed on the Aluminum specimen as well as the MWCNT added specimen by following ASTM standard aspect ratio. The gauge length and diameter for the machine used was 270 mm and 11 mm diameters. From the result report nano composites had more strength than Aluminum alloy. In that mixture of 3gram and 7gram multiwall carbon nano tubes gave optimum and minimum strength. Results showed that 3gram of multiwall carbon nano tube gave more strength than 6gram of multiwall carbon nano tubes. From the result, calculation of the minimum and maximum points of strength could be easy.

Table 3: Tensile Test

Material Type	Ultimate Strength (N/mm²)
Aluminum Lm25	197
Aluminum Lm25with 3grm Mwcnt	272
Aluminum Lm25with 7grm Mwcnt	233

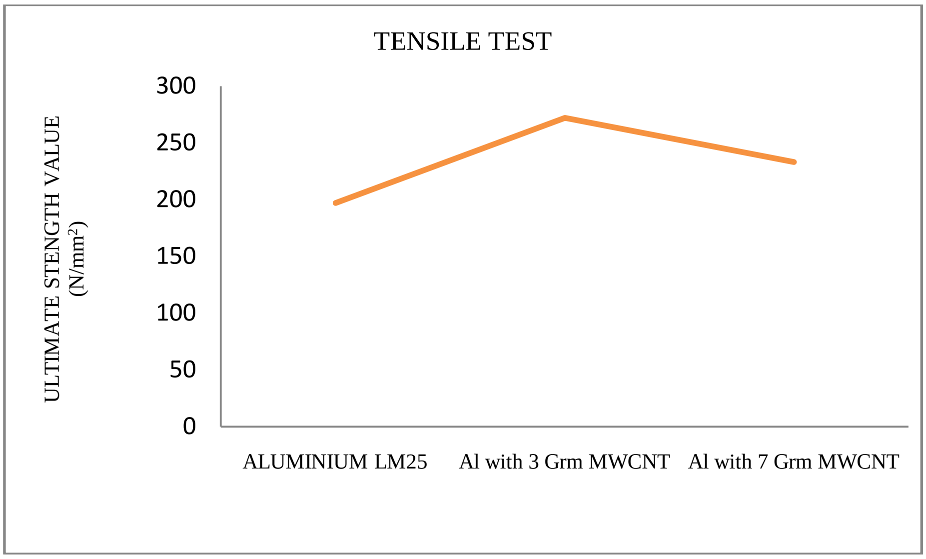


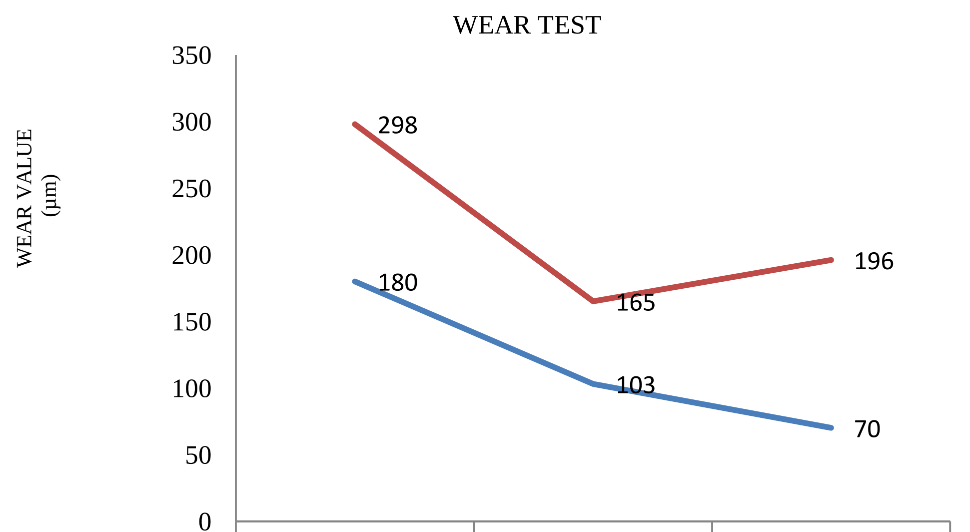
Figure 3: Tensile testing Graph

D. Wear Test:

The material was subjected to wear and friction test. The specimen size for performing the process was taken as length equaling 100 mm, and diameter as 8 mm. From the result nano composites had less wear resistance in both, with and without load conditions. Also the optimum and minimum wear resistance values are obtained in 3gm and 7gm multiwall carbon nano tubes mixture in Aluminum LM25. The same results were obtained when the specimen with and without coating was subjected to friction testing at loaded and no loaded condition.

Table 4: Wear Test

Part Description	Wear Value	Friction Value
Aluminum lm 25 Without load	180	0.7
Aluminum Lm 25 with load	298	9.3
Aluminum with 3 gram Mwcnt Without load	103	0.3
Aluminum With 3 gram Mwcnt with Load	165	6.1
Aluminum With 7 gram Mwcnt without Load	70	0.2
Aluminum With 7 gram Mwcnt With load	196	8.1



	ALUMINIUM LM 25	ALUMINIUM WITH 3 gm MWCNT	ALUMINIUM WITH 7 gm MWCNT
WEAR TEST WITHOUT LOAD	180	103	70
WEAR TEST WITH LOAD	298	165	196

Figure 4: Wear Test Graph

E. Tested Specimen Photos:

Figure 5: Tensile testing specimens

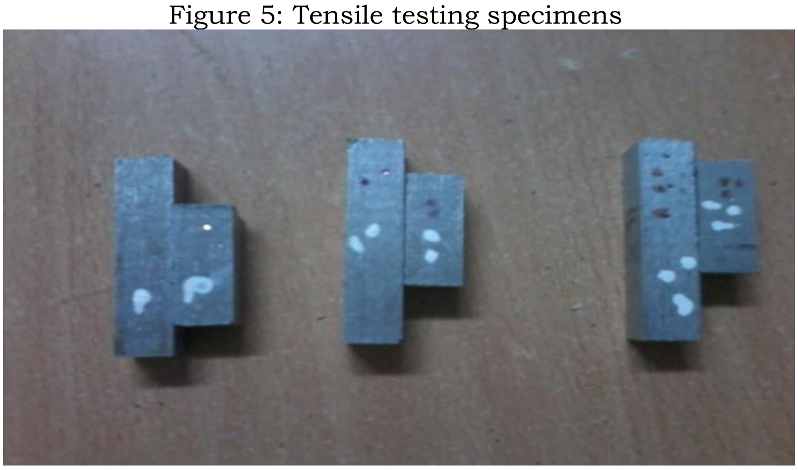


Figure 6: Impact Testing Specimens

5. Conclusion:

From the four different type of testing the nano composites gave better tensile strength, wear resistance, friction, hardness and impact strength, micro structure than the Aluminum alloy. Usage of nano composites instead of Aluminum alloy in the engineering field like automobile, aerospace and marine field where mechanical properties need to be more precise then what we get in alloys for preventing wear and friction like in the automobile cylinder. Regarding these applications, field cost could not cause a big problem, which resulted as the demerit of using nano composites. So to our conclusion nano composites can be handy and useful in such fields.

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