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Effects of Different Proportions of Aluminum oxide Nanoparticles for 6063 AA Nano-Composite on Mechanical Properties

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Abstract: This This work aims at an applied study of the process of adding different percentages of aluminum oxide to aluminum alloys that are widely used and the effect of these additives on a major set of physical properties, and the results obtained showed an increase in the strength and quality of samples reinforced with nano-materials compared to the base material

Keywords: Mechanical properties, 6063AA, Aluminum oxide, Nano Composite, Nano-materials

Introduction: Aluminum's many attractive properties include ease of fabrication [1], good resistance to corrosion, low density, high strength-to-mass ratio, and high resistance to fracture at various temperatures [2]. Because of these properties, aluminum is considered by industry to be one of the most economical materials [3] used in construction equipment applications, drilling rigs, commercial transport and commercial ships [4]. When aluminum alloys are exposed to moisture, air, or both, a layer of aluminum oxide forms on the surface of the aluminum. This layer has anti-corrosion property. It is relatively resistant to most acids but less resistant to alkalis. Pure aluminum does not have high tensile strength compared to its alloys. The addition of alloying elements such as manganese [5], silicon, copper and magnesium can increase the fatigue resistance properties of pure aluminum and produce alloys with specific properties as needed[6]. Aluminum's good thermal conductivity is a property that makes aluminum an important material for both cooling and heating applications. Along with being non-toxic [7], this property of aluminum is widely used in industrial, household and cooking utensils [8].

Arbuscular mycorrhizal (AM) fungi mediate interactions between plants and soils, and are important where nutrient or metal concentrations limit plant growth. Variation in fungal response to edaphic conditions may influence the effectiveness of the plant- association in some soil environments. (brooms edge) colonizes disturbed sites in the eastern United States, including acidic mine soils where aluminum (Al) is phytotoxic, and Al resistance in brooms edge has been associated with colonization by the AM fungus *Gloms carom*. In the present study, inter- and intra-specific variation to confer Al resistance to brooms edge was assessed among selected species of AM fungi. Broom sedge seeds were grown in sand culture inoculated with one of five isolates of three species of fungi (*G. carom*, , and *heterogamete*). Plants were exposed to 0 or 400 μM Al in nutrient solution and harvested after 4 or 9 weeks of growth. Mean infection percentage, plant biomass, and plant tissue Al and phosphorus (P) concentrations were measured. *G.*

carom conferred the greatest Al resistance to brooms edge, with the lowest variability among isolates for colonization and growth inhibition by Al [tolerance indices (TI) between 22.4 and 92.7%]. Broom sedge plants colonized by *A. morrowiae* were consistently the most sensitive to Al, with little variation among isolates (TI between 1.6 and 12.1%). Al resistance by *S. hetero gama* isolates was intermediate [9]

The kilogram-scale synthesis of a D_2/5-HT_{2A} receptor dual antagonist (±)-SIPI 6360 was developed as an alternative treatment for schizophrenia. Specifically, three conditions were modified and optimized, including the Vilsmeier conditions, to prepare quinolone **3**. In addition, the palladium-catalyzed hydrogenation was modified to synthesize dihydroquinolin-2(1*H*)-one **5**, and the reduction of β-chloramine was altered to form 3-chloropropanamine **8**. Ultimately these improvements led to the preparation of a 1.5 kg of (±)-SIPI 6360 batch in eight steps with an overall yield of 34% and purity of 99.8%.. [10]

Cabibbo et al investigated the A novel salt-resistant superabsorbent composite was prepared by copolymerization of partially neutralized acrylic acid, 2-acryloylamino-2-methyl-1-propanesulfonic acid (AMPS) and attapulgite (APT). To enhance the swelling rate (SR) of the copolymer, sodium bicarbonate was used as a foaming agent in the course of copolymerization. Furthermore, for improving the properties of swollen hydrogel, such as strength, resilience and dispersion, the copolymer was surface-cross-linked with glycerin and sodium silicate, and then the surface-cross-linked copolymer was blended with aluminum sulfate and sodium carbonate in post treatment process. The influences of some reaction conditions, such as amount of AMPS, APT, and initiator, and neutralization degree of acrylic acid on water absorbency in 0.9 wt.% NaCl aqueous solution both under atmospheric pressure (WA) and load (WA_P, $P \approx 2 \times 10^3$ Pa) were investigated. In addition, the effect of them on SR was also studied. The WA and WA_P of the superabsorbent composite prepared under optimal conditions in 0.9 wt% NaCl aqueous solution were 52 $g \cdot g^{-1}$ and 8 $g \cdot g^{-1}$, respectively. Besides, the SR was fast, and it could reach 0.393 $mL \cdot (g \cdot s)^{-1}$. Moreover, the swollen hydrogel possessed excellent salt resistance, hydrogel resilience and dispersion. . [11]

Yu et al steadied the The experimental analysis presented aims at the selection of the most optimal machining parameter combination for wire electrical discharge machining (WEDM) of 5083 aluminum alloy. Based on the Taguchi experimental design (L9 orthogonal array) method, a series of experiments were performed by considering pulse-on time, pulse-off time, peak current and wire tension as input parameters. The surface roughness and cutting speed were considered responses. Based on the signal-to-noise (S/N) ratio, the influence of the input parameters on the responses was determined. The optimal machining parameters setting for the maximum cutting speed and minimum surface roughness were found using Taguchi methodology. Then, additive model was employed for prediction of all (3^4) possible machining combinations. Finally, a handy technology table has been reported using Pareto optimality approach. [12]

Tanaka et al deliberate the Metal matrix composites (MMCs) are a special class of materials carrying combined properties that belongs to alloys and metals according to market demands. Therefore, they are used in different areas of industry, and the properties of this type of material are useful in engineering applications. Machining of such composites is of great importance to finalize the fabrication process with improved part quality. However, the process implies several challenges due to the complexity of the cutting processes and random material structure. The current study aims to examine machinability characteristics. Effects of turning a metal matrix composite built of Al_2O_3 sinter, saturated with an EN AC-44000 AC-$AlSi_{11}$ alloy, are presented in this paper. In the present study, a turning process of new metal matrix composites was carried out to determine the state-of-the-art material for various engineering applications. During the turning process, the cutting forces, a tool's wear, and surface roughness were investigated. Further, the SEM (scanning electron microscope) analysis of cutting inserts was performed. The influence of MMC structure on the machining process and surface roughness was studied. The Al_2O_3 reinforcements were used in different graininess. Effects of conventional turning of the metal matrix composite with Al_2O_3 sinter of FEPA (Federation of European Producers of Abrasives) 046 and FEPA 100 grade were compared. Results analysis of these tests showed the necessity of continuing research on turning metal matrix composites built of an AlSi alloy and Al_2O_3 ceramic reinforcement. The study showed the properties of MMCs that influenced machinability. In this paper, the influence of feed rate's value on surface roughness was carried out. The significant tool wear during the turning of the MMC was proved. [13]

The objective was to manufacture, using friction stir processing (FSP), nanocomposites consisting of coarse grained (CG) and ultrafine-grained (UFG) aluminum (Al) matrix reinforced by Al_2O_3 nanoparticles. The main focus of the study was to investigate the possibility of preserving high mechanical properties in the stir zone (SZ) of an UFG material, which is thermally unstable. The investigation consisted in characterizing the microstructure and evaluating the mechanical properties of the materials. Two FSP passes were sufficient to obtain a proper distribution of reinforcement in the Al matrix. Due to the FSP process, the average grain size increased from 1 μm for the base material to about 4 μm for the nano-composite and 12 μm for the sample processed without the reinforcement. However, due to the presence of the nanoparticles, a drop in tensile strength for the nano-composite was only from 164 MPa to 148 MPa. While in the case of sample processed without Al_2O_3 this value was significantly lower and estimated 93 MPa. Moreover, the addition of nanoparticles caused an increase in elongation to break from 9 % to 23 %, which is caused by to the proper distribution of the particles in Al matrix. [14]

Su et al studied the development of novel methods for industrial production of metal-matrix composites with improved properties is extremely important. An aluminum matrix reinforced by "in situ" α-Al_2O_3 nanoparticles was fabricated via direct chemical reaction between molten aluminum and rutile TiO_2 nano-powder under the layer of molten salts at 700–800 °C in air atmosphere. Morphology, size, and distribution of the in situ particles, as well as the microstructure and mechanical properties of the composites were investigated by XRD, SEM, Raman spectra, and hardness and tensile tests. Synthesized aluminum–alumina composites with Al_2O_3 concentration up to 19 wt.% had a characteristic metallic luster, their surfaces were smooth without any cracks and porosity. The obtained results indicate that the "in situ" particles were mainly cube-shaped on the nanometer scale and uniform matrix distribution. The concentration of Al_2O_3 nanoparticles depended on the exposure time and initial precursor concentration, rather than on the synthesis temperature. The influence of the structure of the studied materials on their ultimate strength, yield strength, and plasticity under static loads was established. It is shown that under static uniaxial tension, the cast aluminum composites containing aluminum oxide nanoparticles demonstrated significantly increased tensile strength, yield strength, and ductility. The micro hardness and tensile strength of the composite material were by 20–30% higher than those of the metallic aluminum. The related elongation increased three times after the addition of nano-α Al_2O_3 into the aluminum matrix. Composite materials of the Al-Al_2O_3 system could be easily rolled into thin and ductile foils and wires. They could be re-melted for the repeated application.. [15]

Al-Si matrix composites reinforced with In situ Al_2O_3, C nanotubes (CNTs), and graphene nano-platelets (GNPs) were prepared by ball milling, hot-isotactic pressing (HIP), and subsequent high-pressure torsion (HPT). Microstructures, interfacial bonding, and electrical and mechanical properties of the composites were analyzed. In situ Al_2O_3 particles and whiskers were formed via reaction between Al powder and SiO_2 powder. Grains of the composites were significantly refined and reinforcements were well dispersed in the matrix by HPT. A sub-micron equiaxed grain structure with an average grain size of 0.60 µm was obtained. Interface between the CNTs and the matrix was narrow and had no brittle phase. With an increase in the number of HPT cycles, micro hardness and electrical conductivity of the composites increased. Strengthening mechanism of the Al matrix composites was mainly fine-grain strengthening. Dislocation accumulation and grain boundary evolution caused by HPT were examined.[16]

Maji et al used frictional welding and processing to bond composites and aluminum alloys, to make aluminum matrix compounds. , the friction stir plates have distinctly altered microstructure regions and may make a big difference in mechanical properties and require heat treatment to achieve the organization of the crystal lattice. This researchers' work demonstrates the latest heat treatment technology for FSW/FSPed aluminum alloys. They study the effects of heat treatment time and temperature on microscopic phenomena, mechanical properties, and condition of the sediments resulting from different heat treatment processes. [17]

In this study, the effect of adding Aluminum oxide nanoparticles on the established weld joint will be investigated and the influence of this addition on the physical properties will be investigate.

Base Metal Alloys; The alloy used in this research is356 Aluminum Casting Alloy, because of its widerange of practical and multiple applications, Specifications AMS. 356.0 Former ASTM; 356.0, SG70A. SAE; 356.0: J452, 323, UNS number. 356.0: A356.0: MIL-C-21180 (Class 12), ISO: AlSi7Mg.

Chemical Composition; the Composition limits of 356.0: 0.25 Cu max, 0.20 to 0.45Mg, 0.35 Mn max, 6.5 to 7.5 Si, 0.6 Fe max, 0.35 Zn max, 0.25 Ti max, 0.05 other (each) max, 0.15 others (total) max,

bal Al. A356.0: 0.20 Cu max, 0.25 to 0.45 Mg, 0.10 Mn max, 6.5 to 7.5 Si, 0.20 Fe max, 0.10 Zn max,

0.20 Ti max, 0.05 other (each) max, 0.15 others (total) max, bal. Al. Consequence of exceeding impurity limits. High copper or nickel decreases ductility and resistance to corrosion. High iron decreases strength and ductility.

Applications; the typical usesof 356.0 aircraft pump parts, automotive transmission cases, aircraft fittings and control parts, water-cooled cylinder blocks. Other applications of this alloy require excellent weld ability, good weld ability with other alloys, pressure tightness and good corrosion resistance..

A356.0: aircraft structures and engine controls, nuclear energy installations, and other applications where high-strength permanent mold or investment castings are required.

Major Mechanical Properties; 0.2%. Proof Stress 185 (N/mm^2), Tensile stress 230 (N/mm^2) Elongation (2%) , Brinell Hardness 75 , Modulus of Elasticity 71 , Shear strength 120 ,Properties in excess of those quoted can be obtained with Strontium additions e.g.- Elongation 5%.

Mass Characteristics; the Density of Aluminum alloy under test is (2.685) g/cm^3 ($0.097\ lb/in^3$) at20°C (68°F).

Thermal Properties; One of the most important properties that make this alloy desirable in manyuses is its thermal properties, represented by the following liquid temperature is 615 °C (1,135 °F), solidus temperature is 555°C (1035°F) .and linear thermal expansion coefficient with different temperature which is shown in Table No. (1). Specific heat. 963 J/kg . K (0.230 Btu/lb.°F) at 100°C (212°),Latent heat of fusion 389kJ/kg, Thermal conductivity at 25 °C (77°F).

Table No. (1) Coefficient of linear thermal expansion.

Temperature range		Average coefficient	
°C	°F	p.m/m °K	p.in/in. °F
20-100	68-212	21.5	11.9
20-200	68-392	22.5	12.5
20-300	68-572	23.5	13.1

Nano Material; the reinforced material was Al_2O_3 with particales mean size of about (10) nm [20]. The material used to strengthen and improve the properties is aluminum oxide, and this material is characterized by a number of characteristics that make it one of the desirable materials in the process of manufacturing and producing materials that can work under different conditions of degrees[21] [22]. The modularity is clear in the distribution and redistribution of the peripheral dislocations Table (3) shows the chemical composition of Al_2O_3 in wt. % [23].

Table No. 2 the chemical composition of Al2O3 wt. % .

Element	TiO_2	CaO	Fe_2O_3	Alumina (&)	Others
Wt.%	1.8	1.1	0.8	97	0.02

Table No. 3 the physical properties of silicon oxide.

No.	Properties	Amount	Units
1	density	2.63	g/cm3
2	molar mass	60.08	g/mol.
3	crystal structure	--	Quartz
4	melting point	1712	oC
5	boiling point	2229	oC

Preparation Method; Stir casting is one of the most effective methods to produce nano-strengthened aluminum alloys [24]. Also, it is best to melt the metal and pour it into a suitably shaped mold to ensure a uniform crystal lattice distribution in the final product (mainly metal alloys and metal-based compounds) for the ultimate purpose [25]. The samples were prepared by making the base alloys to the required basic specifications, cutting them into cubes with sides of 1-1.5 cm, washing them several times with sodium stearate, then with ethyl alcohol, then with distilled water, and then drying them prepared. This process is followed by a kiln with agitation up to 670°C, after which reinforcements are gradually added [26]. See elsewhere for details. [27]

Results are Discussion; The standard tensile test was chosen because it gives a clear picture on a set of criteria, Tensile evaluated are, tensile strain at failure, ultimate tensile_stress, yield stress and elongation.[28] Table No. 4 shows the tensile test properties of Aluminum alloys with different ratios of Aluminum oxide. And figure no. 1 shows ultimate tensile stress and yield stress (5%) vs. different nano material ratios.

Table No. 4 the tensile test results of Aluminum nano-composites alloys

No.	Material	Ultimate stress (MPa)	Yield stress (MPa)	Elongation %
1	As received	230.0	185.0	2.0
2	AA/0.5wt.%Al_2O_3	250.7	199.8	2.18
3	AA/1.0wt.% Al_2O_3	269.1	214.6	2.28
4	AA/1.5wt.% Al_2O_3	285.2	225.7	2.42
5	AA/2.0wt.% Al_2O_3	280.6	221.7	2.37
6	AA/2.5wt.% Al_2O_3	273.7	205.9	2.20
7	AA/3.0wt.% Al_2O_3	266.8	198.6	2.13

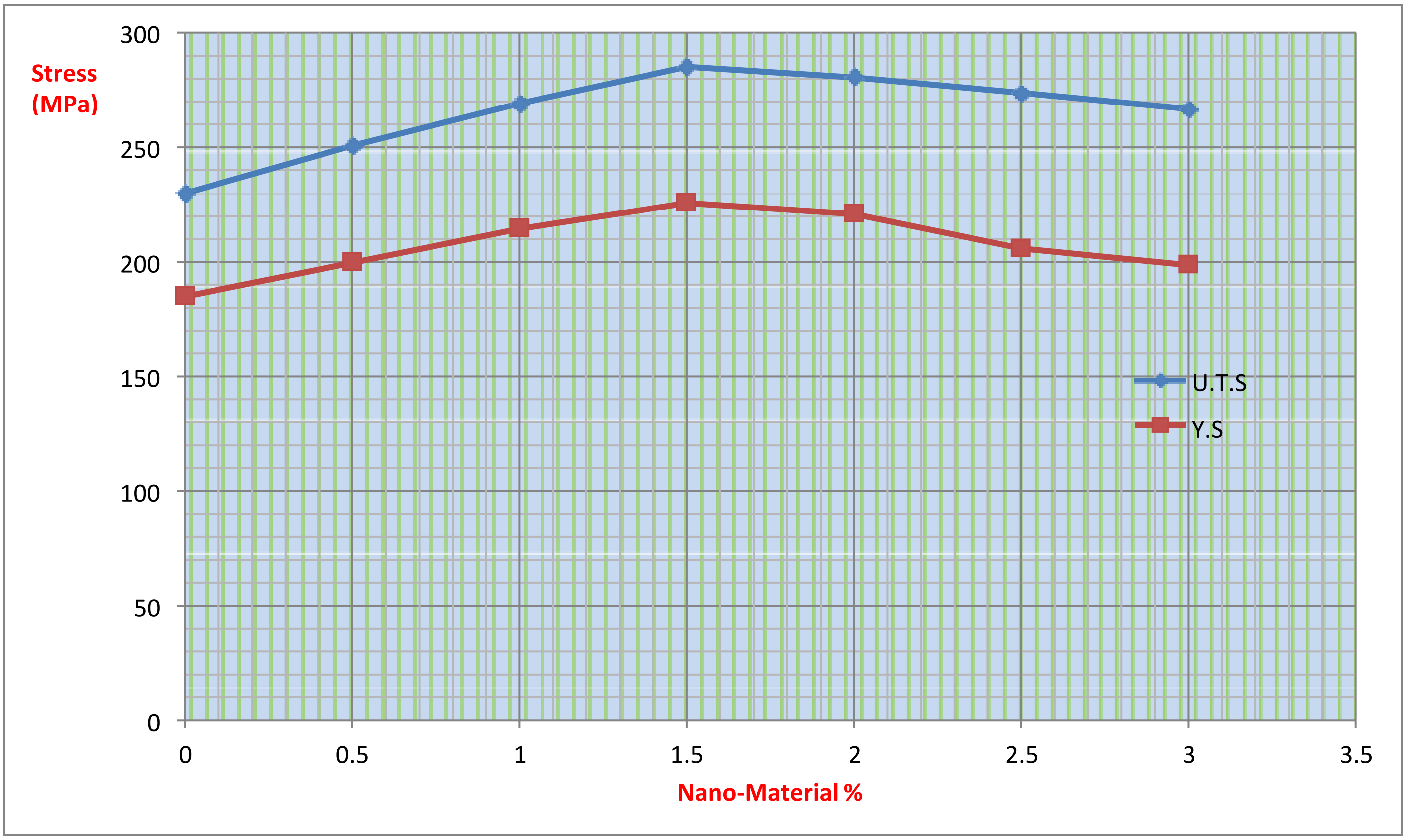

Figure no. 1 ultimate tensile stress and yield stress (5%) vs. different nano material ratios

From Table No. 4 and Figure No. one it appears that the weld joints are getting stronger as the percentage of silicon oxide increases. This could be due to several reasons, the priority of which is the increase in the rate of dislocations and the intensity of dislocations [29]. Which is a major reason for stopping the growth of microscopic cracks in each of the two stages of generation Or the growth of cracks, thus increasing the strength of the weld joint mainly. The abundance of silicon during the melting process and available from the nano-material can lead to an improvement in the mechanical properties of the welding area and the adjacent area, which is the thermally affected area, and this leads to an increase in the strength of the weld [30].

Figure no. 2 Improvements ultimate tensile stress and yield stress (5%) vs. different nano materialratios

Figure three shows the effect of adding different percentages of silicon oxide on the elongation, and from it it turns out that by increasing the nanomaterial, the elongation property of the weld joint increases.

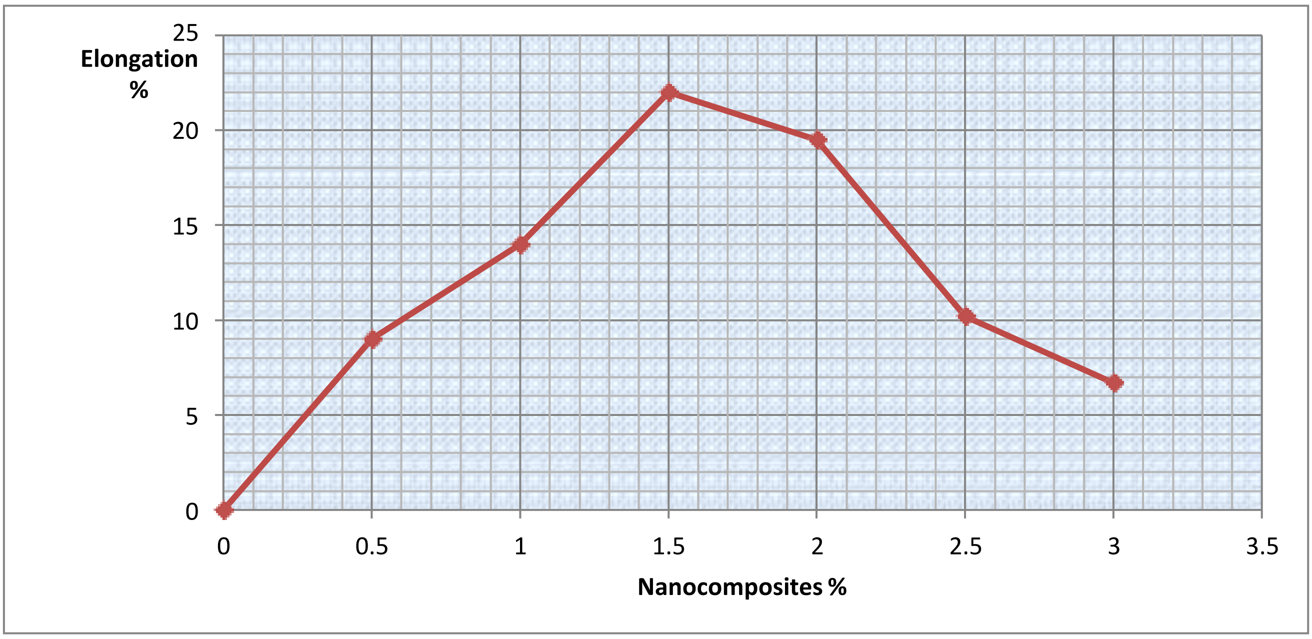

Figure -3 shows the effect of adding different wt. of silicon oxide on the elongation

4. Conclusion

A bundle of conclusions can be drawn from the work done above:

- The highest tensile strength endured by the material witnessed a significant improvement by addingreinforced nano materials, and it was the highest result at 1.x w.%.
- A trend towards improved yield stress was observed in most of the samples, and the main percentageof improvement was 2 wt. %.

As for ductility, the largest change was in the case of q, which amounted to 2 wt. %.

- Since the nano material used is silicon oxide, and since the effect of Mg, Si and Cr content in EN AC-Aluminum base alloyed on the strength and brittleness of the weld, it becomes clear that the properties of the tensile test are improved by increasing the additive

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