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Mechanical and Wear Behaviour of Severe Plastic Deformed Al6063-Nano Al2O3 Composites Processed by Constrained Groove Pressing (CGP)

B Adaveesh, Mohan Kumar T S, Gnanashekar B

Abstract: ***Metal matrix composites have been developed to meet the demand for lighter materials with high specific strength, stiffness and wear resistance. Particulate reinforced aluminium matrix composites are attractive materials due to their strength, ductility and toughness. The aluminium matrix is strengthened when it is reinforced with hard ceramic phases. Most of the metal matrix compound undergoes severe plastic deformation (SPD). SPD is a method to obtain fine crystalline structure in different bulk metals and alloys which possess different crystalline structure. The objective of the present work is to synthesize Al-6063 alloy by stir casting method and varying weight percentage of nano Al2O3 in steps of 2, 4, and 6 wt %. The composites are prepared using the process of compressed groove pressing (CGP) with extreme plastic deformation. The composite is characterized for mechanical and wear behaviour. SEM microphotographs confirmed the distribution of nano Al2O3 particles in the Al6063 Matrix alloy. In addition, SEM micrographs of Al6063 alloy with nano Al2O3 after constrained groove pressing shown grain refinement. Improvements in Hardness, UTS, yield strength, bending strength, percentage elongation and wear resistance of the Al-6063 matrix are obtained with the addition of Al2O3 particulates and also the properties are further enhanced with CGP. The developed metal matrix nano composite may be an alternative material for manufacturing of bearings.***

Keywords: Nano Al2O3, Severe plastic deformation (SPD), compressed groove pressing (CGP), SEM microphotographs.

I. INTRODUCTION

In the automotive, aerospace, sport and wind power sector, the composites are more appealing for metal matrix. The MMC's are utilized in different applications because of their characteristics such as rigidity, impact strength, tensile strength, bending power and endurance strength. The compounds are acquired in the base matrix metal by causing the special refinement. By choosing the correct strengthening and matrix for developing the new composite material, the properties can be varied. There is therefore huge demand for MMC's.

At the moment, every form of industry has tried to decrease the product weight and increase the strength. In this pursuit of new materials, aluminum matrix composites (AMCs) fulfill the criteria; ceramic particles are widely used to strengthen AMCs [1, 2]. Because of lower cost and good aluminum wettability, SiC and Al2O3 were used frequently as reinforcement stage [3]. The development of current and the emergence of new production strategies allows for the strengthening of multiple potential reinforcement particles to improve the performance of AMCs without deviating from the primary light weight target. The natural mineral form of rutile TiO2 (Titanium dioxide), effectively accessible, less expensive and good mechanical, wear and corrosion properties [4].

Several manufacturing methods are used to produce AMCs, stir casting method is proven to be less cost to get additional particle coating it requires more cost [5]. In the aluminum matrix, the distribution of TiO2 particles was irregular and clustering was inevitable [6]. Mechanical friction produces beneficial particle distribution [7]. The time for the processing of the composites to consume a large amount of energy. As an energy-efficient method for synthesizing AMCs, friction stir processing (FSP) was used. The contact between a spinning device that cannot be ingested and the substrate content results in severe plastic deformation. The machine mechanically combines the compressed ceramic particles with the deformed substratum. The increase in temperature is not enough to melt the substrate material. The design of the solid state helps to eliminate the flaws in traditional casting paths. The process is not significantly affected by the physical and chemical properties of the ceramic particles. The gradient of density and the problems of wettability will not affect the resulting distribution of the reinforcement phase [8].

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In recent studies surface metal matrix composites (SMMC) produced using different methods like fusion-based techniques, high-energy laser melting treatment, high-energy electron beam irradiation, plasma spray, cast sinter and cold spray these methods have lot of disadvantages like particle agglomeration and matrix-reinforcement interfacial reaction. These issues related with MMC formation lead to find alternative ways that are simple straightforward and less tedious. [9]. this offers path to another course recommended by Mishra et al., Friction Stir Processing (FSP).

They were effective in delivering composite surfaces, ex-situ, utilizing the friction stir welding principle. Ceramic particles like SiC, Al2O3, TiC, B4C etc. reinforced in preparation of AMC's using friction stir processing. [10].

Nevertheless, there are very few reports of TiO2-reinforced AMCs. Mirjavadi et al. [11] incorporated TiO2 particles to enhance the friction-welded AA5083 aluminum alloy's tensile strength. To study the characteristics of interface shin et al. [12] mixed 15 vol% Aluminum and TiO2 AMC's in hot rolling process. To fabricate trimodal composite material, they used nanocrystalline and aluminum powder and assessed the properties of microstructure and tensile. Using mechanical alloying varying the weight percentage of aluminum from 0 to 12% and mixing the same with TiO2 AMCs and studied about the dry sliding wear behavior and microstructure properties [13].

H.H. Kim [14] has made CNTs / Al2O3-hybrid reinforcement aluminum alloy matrix A356 with infiltration. This manufacturing process is based on high temperature compression and hardness testing characteristics. CNTs and Al2O3 are well distributed in the infiltration process through hybrid reinforcements. Hybrid MMCs increased their compression strength by increasing Al2O3 in relation to aluminum alloy A356. Due to poor wettability in the matrix the excessive CNTs/Al2O3 are adversely affected. Additional hot-processing materials CNTs / Al2O3/A356, which can easily be modified due to recrystallization effect. H.S. Siddesha [15] has been working on the commercially pure aluminum microstructure and mechanical characteristic of the process produced by RCS. Throughout manufacturing, repeated corrugated and straightened processes (RCS) are used to compensate for parts of high strength metal plates throughout vehicles. An attempt to test RCS parameters such as transfer numbers, pressure frequency and plate thickness were carried out. The results show that the sum of passes has an important effect on the finishing of grain followed by the thickness and strain rate of the aluminum sheet. Jinghui Li [16] has focused on the improvement to grain and the mechanical properties affected by extreme plastic deformation of the Al-Zn-Mg-Cu alloy. Al-Zn-Mg-Cu alloy with equal channel angular press (ECAP) structure and mechanical properties and results of the microstructures show that grains are improved with low-angle grain frontiers manufactured in the ECAP.

Nano structured (NS) and (ultrafine-grained) UFGed materials can be processed using different approaches and most commonly used approaches are top-down and bottom-up approaches [17]. Bottom-up approach includes vapor deposition, alloying, and solidification for processing. SPD process is used in processing in case of top-down method. Because of advantages like no change c/s throughout the process of SPD over other processes, the production of Nano structured (NS) and (ultrafine-grained) materials through SPD processes was considered and developed. The SPD structural states are very uncommon and difficult to predict. One can only conclude that the defect structures of different dimensions are complexly combined. However, at least three major characteristics of SPD are the formation and development of micro and nano crystals, separated by high-angle boundaries, the virtual lack of strain hardening and the transition of stages, which include transition from crystal to amorphous conditions, with extremely unbalanced stages. [18]

II. EXPERIMENTAL PROCEDURES

A. *Aluminium-6063 alloy:*

Aluminium-6063 alloy (Al-6063) is a medium strength alloy and very much suitable for intricate extrusions. Magnesium and silicon are the most important alloy elements for Al-6063. Also known as an architectural alloy. 6063 is an alloy used mainly for aluminium extraction. Complex shapes to be formed with very smooth surfaces by using 6063 alloy. 6000 series alloys are very much strong and offers good protection to the metals. When hard anodizing process these series of alloys are endeavor clear coating to the surfaces. This type of alloy used in architectural applications like door frames, window frames, sign frames and ropes.

Table-I: Chemical Composition of 6063 alloy

Sl.No	Metals	Weight %
1	Si (Silicon)	0.2% – 0.6%
2	Mg (Magnesium)	0.45% – 0.9%
3	Fe (Iron)	0.35%
4	Cu, Mn, Cr , Zn, Ti	0.10%

Table-II: Properties of aluminium 6063 alloy

Sl.No	Properties	Value
1	Density	2.69 g/cm3
2	Melting Temperature	615^0C
3	Poisson ratio	0.3
4	Elongation	18 – 33 %
5	Young's modulus	68.3Gpa

6063 alloy mechanical properties are primarily dependent on the material's temperature or heat treatment. The following are some of the tempers:

Table –III Mechanical properties of 6063 alloy

Sl.No	Tempers	UTS (MPa)	YS (Yield Strength) (MPa)	Percentage of elongation (%)
1	6063-O	130	No Specified Yield strength	18
2	6063-T_1	110-120	62	12
3	6063-T_5	140	97	8
4	6063-T_6	190	160	8

6063 is also formed in tempers like T52, T53, T54, T55 and T832. 6063 alloy is highly suitable for welding process using tungsten inert gas welding.

This material can be reheat- treated after welding to restore a high temper for whole piece.

B. Al2O3- Nano particles

Aluminium oxide (Al2O3) nano particles are generally referred as 'Corundum' and it is also called as 'white oxide'. Most of the nano particles were prepared by Sol-Gel technology. Synthesis of Al2O3 nano particles were made by use of analytical grade chemicals. Some of the analytical grade chemicals are AlCl3 (Molychem), 25% of NH3 solution (Qualigen Fine chemical) and polyvinyl alcohol (PVA). Ball milling, pyrolysis, hydrothermal, laser ablation and sputtering are the techniques used for synthesis of Al2O3 nano particles. Alumina has several phases like alpha, delta, theta and gamma. Al2O3 nano particles having size of 200-300nm.

C. Stir Casting method

The temperature of the furnace was first increased over the composites, which totally melted waste from aluminium, then cooled below the temperature of the parts and kept them semi-solid. At this point the pre-heated nano Al2O3 was added with one another manually. The combination of machine or agitator is quite difficult. When composites in the metal matrix are semi molten the manual blending is performed and the automatic stirring is performed for ten minutes, at normal 400 rpm, when the manual blending is completed. At 7700C in the final mixing process the temperature rates of the carbon furnace should be controlled, so the slurry is taken into the sand mould within 30 seconds after completion. Solid sample testing like hardness or impact testing should be done repeatedly by changing the composition of Al2O3 composite powder (2%, 4% and 6%). Aluminium scrap weight plus Al2O3 weight was added.

D. Specimen Preparation

There are two types of sands used for sand moulding process which is green sand and synthetic sand. For the experimental green sand is used to make a moulded part. Categorize the Aluminium 6063 alloy (Al-6063) with the reinforcement material Aluminium oxide (Al2O3) nano particles into four types of composition based on weight percentage 0, 2, 4 and 6. Aluminium 6063 alloy (Al-6063) is heated in a furnace at 700^0C and required preheated Al-6063 alloy is come to a molten state, the reinforcement material Aluminium oxide (Al2O3) nano particles are added according to weight percentage. Initially pattern is placed in the mould box and fills the green sand entirely into the mould box. Place the riser and runner at respective position in the mould box. After sometime with the help of riser and runner, the pattern is removed without damaging the mould cavity. Then Pour the molten metal into the mould cavity and keep it for cooling for some time and break the mould and remove the casted part.

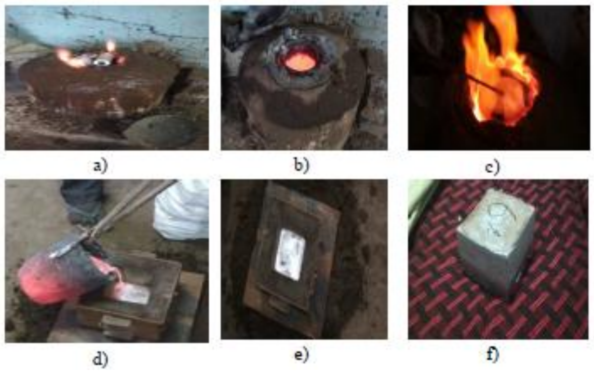

Fig. 1. **(a) Al metal heating in furnace (b) Metal comes to a molten state (c) Reinforcement mix with molten metal (d) Pouring molten metal (e) Molten metal kept for cooling (f) Casted part**

III. RESULT AND DISCUSSION

A. Micro structural studies

Scanning electron microscopy (SEM) is used to examine the micro structural studies. It was impersonated on polished and thermally etched samples. Further samples were cold mounted with epoxy resin. Struer spediment polisher (SSP) is used to polish the samples beginning with 200μm, 2μm and 1μm. After that, coated resin was removed by placing in micro-oven at 200^0C and the samples were thermally etched at 1350^0C for 30min. SEM imaging was conducted on a 3.3M pixel CCD optical microscope lens. Finally, SEM data was collected.

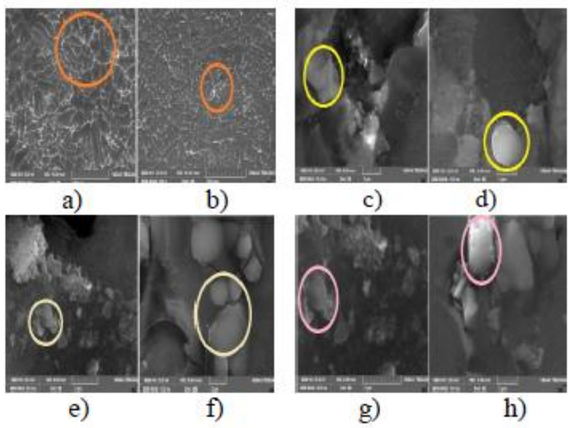

Fig. 2. Microstructure of (a) Al-6063 (b) Al-6063 with SPD (c) Al-6063-2% Al2O3 (d)Al-6063- 2% Al2O3 with SPD (e)Al-6063-4% Al2O3 (f) Al-6063-4% Al2O3 with SPD (g) Al-6063-6% Al2O3 (h) Al-6063-6% Al2O3 with SPD

From the above fig 2(a) it can be observed that the distribution of matrix (Al-6063) with reinforcement (Al2O3-nano particles) has clearly differentiated. The fig 2(b) has minimum ultrafine grain size pattern compared to the fig 2 (a) because of treating the matrix material with severe plastic deformation. If the ultrafine grain size pattern is minimal, then the study of severe plastic deformation will be much more efficient.

The fig 2(c) has 2(d) has the distribution of matrix material Al-6063 with the weight of 2% reinforcement material Al2O3 nano particles with SPD as well as without SPD. The fig 2 (e) has 2 (f) has the distribution of matrix material Al-6063 with the weight of 4% reinforcement material Al2O3 nano particles with SPD as well as without SPD. The fig 2(g) and 2(h) has the distribution of matrix material Al-6063 with the weight of 6% reinforcement material Al2O3 nano particles with SPD as well as without SPD.

B. Hardness Measurements

A polished test sample using a brinell hardness test was carried out to measure hardness of MMCs produced. At 1000 kg test load, tests were performed using ASTM E3 specifications. Different sample positions were calculated for the hardness and the medium quality was taken into account.

Brinell hardness test (BHN) were conducted on cast Al-6063 and Al-6063 with Al2O3 nano particles contained (0, 2, 4 and 6%) with load of 100 g at 50 per cent optical zoom and 10 seconds at each specimen at different locations is measured using the diamond indenter.

Table- IV: Al alloy micro hardness (6063) with different wt% of Al2O3 nano particles

Sl.No	Material (Al-6063)	Hardness (BHN) without SPD	Hardness (BHN) with SPD
1	0	43.6	49.55
2	2	49.2	58.6
3	4	58.5	69.2
4	6	63.2	76.9

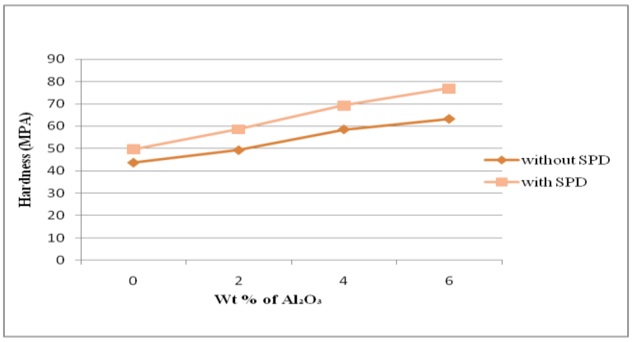

Fig 3. Hardness without SPD and with SPD

The fluctuations of hardness of the Al-6063 with nano Al2O3 composite materials is as shown in figure 3.It is clear that as the wt% of Al2O3 is increased, further the hardness of both the Al-6063-Al2O3 nano metal matrix composites and the matrix material with SPD and without SPD amplifies. By considering the matrix material and the matrix reinforcement composites without severe plastic deformation.

The effect on the hardness of nano-aligned Al-6063-Al2O3 nano parts without SPD of nano-Al2O3 particles in Al-6063 matrix material is increased by 8.86% for 2 wt%, 23.57% for 4wt% and 31.01% for 6wt% respectively. Similarly the effect of the Al2O3 nano enhancer on the strength of nano composites Al-6063-Al2O3 with SPD shows 11.76% for 2 wt%, 25.55% for 4wt% and 35.56% for 6wt%.

C. Ultimate Tensile Strength: (UTS)

The tensile analysis was carried out in accordance to ASTM E8 standard. The test samples were prepared with a dia of 8 millimeter and a length of 50 millimeter. Due to high ductility as well as higher strength of reinforcement (Al2O3-nano particles) which gives better bonding and uniform dispersion of reinforcement (Al2O3-nano particles) material. The UTS value mainly depends on increasing in strength and ductility of the composite.

Table-V: Ultimate tensile strength of Al alloy (6063) with different wt% of Al2O3nano particles

Sl.No	Material (Al-6063)	Ultimate Tensile Strength (MPa) without SPD	Ultimate Tensile Strength (MPa) with SPD
1	0	112.95	123.8
2	2	128.1	152.1
3	4	147.5	164.3
4	6	162.3	190.85

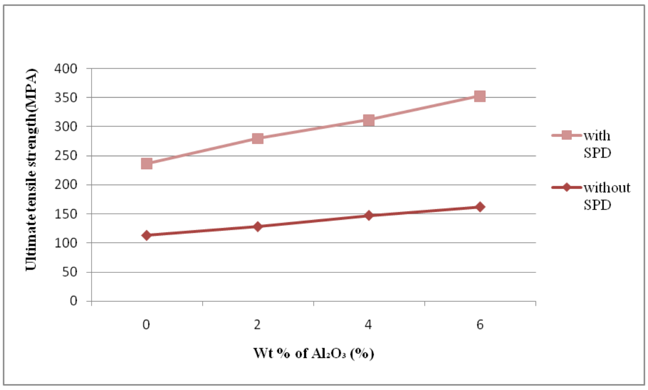

Fig 4. UTS without SPD and with SPD

Figure 4 indicates that as the wt% of Al2O3 is increased, the UTS of both the Al-6063-Al2O3 nano metal matrix composites and the matrix material with SPD and without SPD amplifies. By considering the matrix material and the matrix reinforcement composites without severe plastic deformation the effect on the UTS of nano-composites Al-6063-Al2O3 nano parts without SPD of nano-Al2O3 particles in Al-6063 matrix material is increased by 9.33% for 2 wt%, 21.28% for 4wt% and 30.40% for 6wt% respectively. Similarly the effect of the Al2O3 nano enhancer on the strength of nano composites Al-6063-Al2O3 with SPD shows 14.82% for 2 wt%, 25.55% for 4wt% and 34.56% for 6wt%.

D. Yield Strength

With the application of reinforcement to the matrix product, the yield strength increases, which could benefit from stronger interfacial even contact between the compliance and the matrix.

Table-VI: Yield strength of Al alloy (6063) with different wt% of Al2O3 nano particles

Sl.No	Material (Al-6063)	Yield Strength (MPa) without SPD	Yield Strength (MPa) with SPD
1	0	85.5	88.75
2	2	100	116.25
3	4	111.5	135.1
4	6	130.05	164.55

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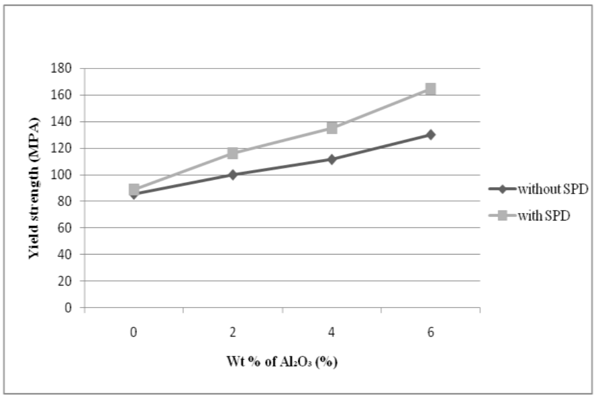


Fig 5. Yield strength without SPD and with SPD

Figure 5 indicates that as the wt% of Al2O3 is increased, the yield strength of both the Al-6063-Al2O3 nano metal matrix composites and the matrix material with SPD and without SPD amplifies. By considering the matrix material and the matrix reinforcement composites without severe plastic deformation the effect on the yield strength of nano-composites Al-6063-Al2O3 nano parts without SPD of nano-Al2O3 particles in Al-6063 matrix material is increased by 11.14 % for 2 wt%, 19.90% for 4wt% and 34.25% for 6wt% respectively. Similarly the effect of the Al2O3 nano enhancer on the strength of nano composites Al-6063-Al2O3 with SPD shows 16.71% for 2 wt%, 28.16% for 4wt% and 46.06% for 6wt%.

E. Percentage Elongation

Table-VII: Percentage elongation of Al alloy (6063) with different wt% of Al2O3 nano particles:

Sl.No	Material (Al-6063)	Percentage Elongation without SPD	Percentage Elongation with SPD
1	0	16.25	12.2
2	2	14.35	10.8
3	4	12.85	9.05
4	6	12.2	8.25

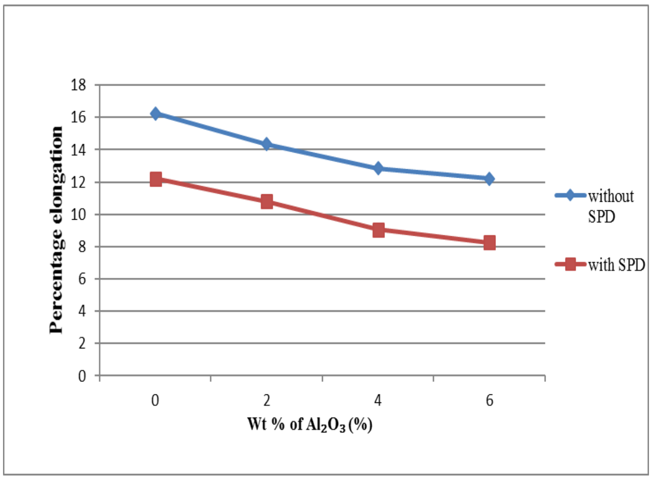


Fig. 6. Percentage elongation without SPD and with SPD

Figure 6 indicates that as the wt% of Al2O3 is increased, the percentage of elongation of both the Al-6063-Al2O3 nano metal matrix composites and the matrix material with SPD and without SPD amplifies. By considering the matrix material and the matrix reinforcement composites without severe plastic deformation the effect on the percentage of elongation of nano-composites Al-6063-Al2O3 nano parts without SPD of nano-Al2O3 particles in Al-6063 matrix material is increased by 11.69 % for 2 wt%, 20.92% for 4wt% and 24.92% for 6wt% respectively. Similarly the effect of the Al2O3 nano enhancer on the strength of nano composites Al-6063-Al2O3 with SPD shows 11.47% for 2 wt%, 25.81% for 4wt% and 32.37% for 6wt%. The Al-6063–Al2O3 nano composite without SPD as higher percentage of elongation compared to Al-6063–Al2O3 nano composite with SPD. The percentage of the extension in Al-6063 – Al2O3 nano composites could be decreased due to the nano-scale hard ceramic Al2O3 particulate strengthening in Al-6063 matrix material.

F. Bending Test

The bending tests were carried out on Al-6063 matrix material and Al-6063 with composite samples from nano Al2O3 metal matrix prepared in computerized universal trial system ASTM E8. The real diameter and 70 mm measuring distance were planned for bending specimens of 15 mm.

Table-VIII: Bending strength of Al alloy (6063) with different wt% of Al2O3 nano particles

Sl.No	Material (Al-6063)	Bending Strength (MPa) without SPD	Bending Strength (MPa) with SPD
1	0	93.6	100.65
2	2	108.75	122.35
3	4	122.1	137.65
4	6	128.6	152.2

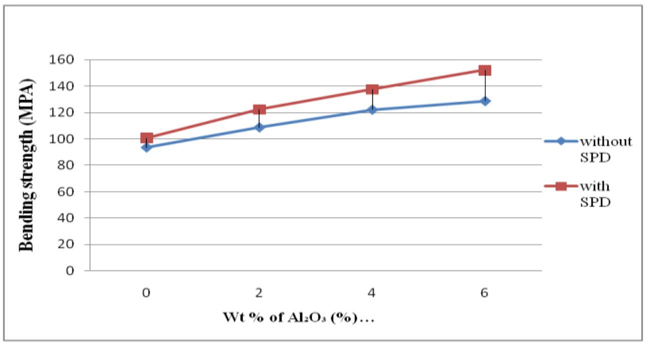


Fig 7. Bending strength without SPD and with SPD

Figure 7 indicates that as the wt% of Al2O3 is increased, the bending strength of both the Al-6063-Al2O3 nano metal matrix composites and the matrix material with SPD and without SPD amplifies. By considering the matrix material and the matrix reinforcement composites without severe plastic deformation the effect on the bending strength of nano-composites Al-6063-Al2O3 nano parts without SPD of nano-Al2O3 particles in Al-6063 matrix material is increased by 11.77 % for 2 wt%, 22.15% for 4wt% and 27.24% for 6wt% respectively. Similarly the effect of the Al2O3 nano enhancer on the strength of nano composites Al-6063-Al2O3 with SPD shows 14.25% for 2 wt%, 24.30% for 4wt% and 31.37% for 6wt%. Al-6063–Al2O3 nano composite with SPD as higher bending strength compared to Al-6063–Al2O3 nano composite with SPD.

G. Sliding wear test

Sliding wear assays on Al-6063 and nano Al2O3 composite metal matrix Al-6063 were performed at room temperature according to standard ASTM G99-95 with a computer-based Pin-On-Disk for wear assessment. Sliding test samples had a nominal dia of 8 millimeter and a measurement distance of 30 millimeter. Sliding wear test was carried out by the wear testing machine of Pin-On-Disk for wear assessment of the wear behaviour, surface robustness of 0.5 micron and hardness of 60 HRC. Wear tends to happen when the samples of the test roll on spinning disks. The disk is fitted with DC motor (1000 rpm) and a disk with a dia of 120 millimeter. By using a steel wiring and pulley system to add dead weight to 200 N, the load can be adhered to the test sample.

G.1 Impact of load on wear rate

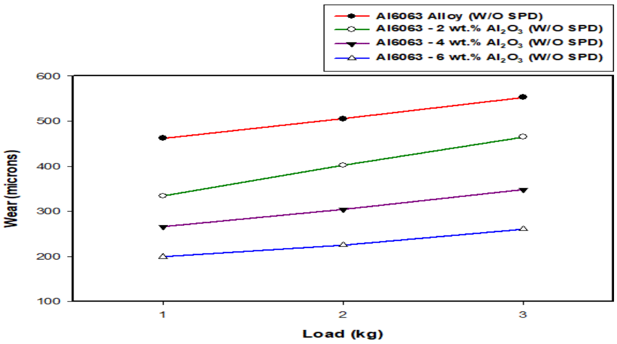


Fig 8. Impact of load on MMCs wear rate without SPD

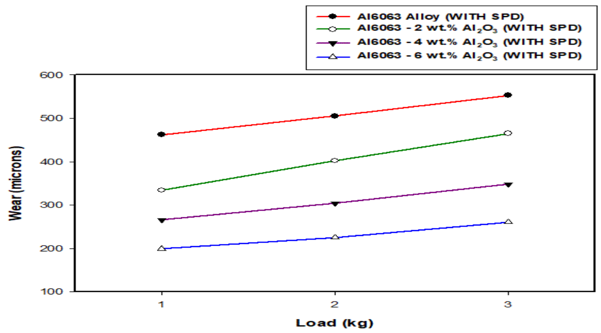


Fig 9. Impact of load on MMCs wear rate with SPD

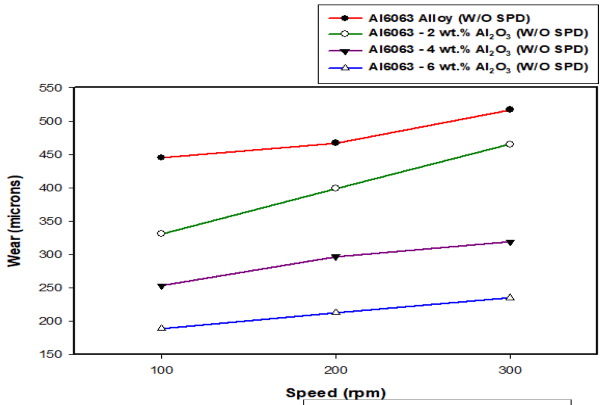
The fig. 8 and 9 shows that when the load is increased, the wear rate of both the nano metal matrix Al-6063 – Al2O3 composites content of the matrix with SPD and without SPD amplifies. By considering the matrix material and the matrix reinforcement composites without severe plastic deformation, the result outcomes are as follows. The wear rate of Al-6063 increases matrix content by 7.27% rising load to 2kg and boosts to 3 kg when load is applied, with that of 1 kg of packed Al-6063 matrix material, the wear rate of rises by 16.36%. The wear rate Al-6063–6wt% Al2O3 nano MMC is 9.08% higher with cargo increasing up to 2 kg and the wear ratio of Al-6063-6wt.% nano Al2O3 MMC with 1 kg of Al-6063-6 wt.% nano Al2O3 MMC is up 21.09% higher.

When considering the matrix material and the matrix reinforcement composites with severe plastic deformation the results outcome as follows. The wear rate of matrix material Al-6063 is increased by 8 percent, with a load of 2 kg and a wear rate of 3 kg increased by 18 percent with the wear rate of Al-6063 materials loaded with 1 kg Al-6063 matrix material. Wear rate is more by 10.02% in Al6063 and nano Al2O3 6 weight percent, as the load rises by 2 kg wear rate is 22.36% and when load rises by 3kg and Al-6063-6 wt % alpha Al2O3 MMC wearing by 1 kg.

Both the matrix material and matrix reinforcement composite without SPD and with SPD for remaining wt.% nano Al2O3 MMC as follows. Al-6063 -6 wt% wearing rate decreases in 2 kg Al2O3 MMC nano and Al-6063-4 wt% Al2O3 MMC nano wear level as against Al-6063 product wear rate decreases in 1 kg wear rate and Al-6063-6 wt wearing rate of 3 kg Al-6063 loaded nano Al2O3 MMC and decreases in wear rate by 2 kg loaded Al-6063-6 wt%.

G.2 Impact of sliding speed on wear rate

Fig 10. Impact of sliding speed on MMCs wear rate without SPD



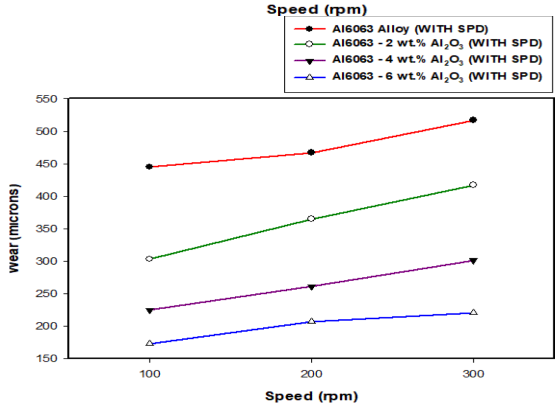


Fig 11. Impact of sliding speed on MMCs wear rate with SPD

Fig10 and 11 indicates the speed of sliding is increased, More the level of wear both the Al-6063-nano Al2O3 composites for metal matrix and material for matrix with SPD and without SPD amplifies. By considering the matrix material and the matrix reinforcement composites without severe plastic deformation, the result outcomes are as follows. The wear rate of Al-6063 increases the matrix product by 2% as the speed of sliding increments to 200rpm and sliding velocity expanded to 300rpm. The material matrix of Al-6063 is increased by 13.5% in wear. The wear rate of Al-6063-6 wt% nano Al2O3 MMC increases by 5% with sliding speed rising to 200 rpm and the wear rate of Al-6063- 6 wt.% nano Al2O3 MMC with 100 rpm sliding speed Al-6063-6 wt.% nano Al2O3 MMC increasing by 14%.

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By considering the matrix material and matrix reinforcement composites with severe plastic deformation, the results outcome as follows. With sliding speeds up to 200rpm and with sliding speed up to 300rpm, the wear frequency of the matrix material Al-6063 is 15% higher with that of the material Al-6063 matrix sliding speed of 100rpm. The Al-6063 – 6wt% nano Al2O3 MMC wear rate is up by 6% with load increasing to 200rpm, with a rise in wear speed to 300rpm results 16% increase in nano Al2O3 MMC wear rate of Al-6063 – 6 wt%.

Both the matrix material and matrix reinforcement composite without SPD and with SPD for remaining wt % nano Al2O3 MMC as follows. The rate of wear of Al-6063-6wt% nano Al2O3 MMC decreases at the speed of 200rpm and Al-6063-4wt% nano Al2O3 MMC's, shows a decline of the wearing rate in comparison with the wearing of Al-6063 matristic material at 100rpm slide speed and reduces the wear rate of 300rpm slide speed Al-6063-6 wt%.

G.3 Comparison of Al-6063-Al2O3 composites without SPD and with SPD

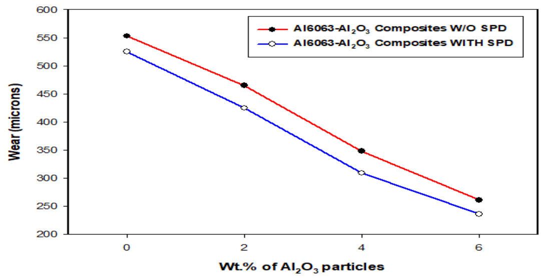

Fig 12. Comparison of Al-6063-Al2O3 composites without SPD and with SPD

Figure 12 illustrates that the influence of Al-6063-nanoAl2O3 composite with and without SPD. By considering the composite material Al-6063-nanoAl2O3 without severe plastic deformation, the result outcomes are as follows. The wear rate of Al-6063-Al2O3 composite is decreases by 16.07% as wt.% Al2O3 increases by 2% and the wear rate of Al-6063-Al2O3 composite is decreases by 50% as wt.% Al2O3 increases by 6% with that of matrix material. By considering the composite material Al-6063-Al2O3 with severe plastic deformation, the result outcomes are as follows. The wear rate of Al-6063-Al2O3 composite is decreases by 20.37% as wt.% Al2O3 increases by 2% and the wear rate of Al-6063-Al2O3 composite is decreases by 53.70% as wt.% Al2O3 increases by 6% with that of matrix material.

Comparing both Al-6063-Al2O3 composite without SPD (severe plastic deformation) and with SPD wear rate is reducing by increasing the wt.% Al2O3 particles. This reduction in wear rate provides the necessary composite greater strength than Al-6063- Al2O3 without SPD as composite with SPD.

IV. CONCLUSION

1. Al-6063 MMCs with 2, 4 and 6 wt. % of nano Al2O3 particulates reinforced composites were made with stir casting.
2. SEM microphotographs confirmed the distribution of nano Al2O3 particles in the Al6063 MMCs. In addition, SEM micrographs of Al6063 MMCs with nano Al2O3 after constrained groove pressing shown grain refinement.
3. The hardness of Al-6063 MMC increases with 2, 4 and 6 wt. % of nano Al2O3 reinforcement. ThehardnessofascastAl-6063 MMC is 43.6 BHN and in case of 6 wt. % of nano Al2O3composites, it is 63.2 BHN. Further, hardness of MMC's increases with severe plastic deformation.
4. Improvements in ultimate tensile strength and yield strength of the Al-6063 MMC are obtained with the addition of nano Al2O3particulates. The ultimate tensile strength of Al-6063 MMC improved from 112.95 MPa to 162.3 MPa in 6 wt.% of nano sized Al2O3 particulates reinforcement. The yield strength of the Al-6063 MMC is 85.5 MPa, with 2, 4 and 6 wt.% of Al2O3 composites are 100.1 MPa, 111.5 MPa and 130.05 MPa respectively. Further, UTS and YS values are improved with the effect of CGP process. After severe plastic deformation UTS and YS of as cast Al-6063 MMCs are 123.8 MPa and 88.75 MPa respectively.
5. With the addition of nano sized Al2O3 particulates the elongation of the Al-6063 MMC is decreased. Further, Al-6063-nanoAl2O3 composites exhibited more brittle property after CGP.
6. Bending strength of Al-6063 MMC has been enhanced with the incorporation of 2, 4 and 6 wt. % of nano Al2O3 particulates. Further, CGP process enhanced the bending strength of Al-6063 with nano Al2O3composites.
7. Both the applied load and sliding speed affected the wear behavior of Al-6063 MMC's. As load and speed increases, the wear loss increases. But, 2, 4 and 6 wt. % of nano Al2O3 composites exhibited superior wear resistance. Further, the composites with CGP process have exhibited more wear resistance.

REFERENCES

1. M. Megahed, M.A. Attia, M. Abdelhameed, A.G. El-Shafei, Acta Metall. Sin. (Engl. Lett.) 30, 781(2017) DOI: 10.1007/s40195-017-0568-5.
2. R. Gostariani, R. Ebrahimi, M.A. Asadabad, M.H. Paydar, Acta Metall. Sin. (Engl. Lett.) 31, 245(2018) DOI: 10.1007/s40195-017-0640-1.
3. B Adaveesh, Mohan Kumar T S, Deeepa," Processing and Property Evaluation of Nano Al2O3Reinforced Copper-5% Tin Composites for Bearing Applications", International Journal of Recent Technology and Engineering (IJRTE) ISSN: 2277-3878, Volume-8 Issue-2S8, August 2019.
4. K.V. Shivananda Murthy, D.P. Girish, R. Keshavamurthy, T. Varol, P.G. Koppad, Prog. Nat. Sci. Mater. Int. 27, 474(2017), DOI:10.1016/j.pnsc.2017.08.005.
5. C.S. Ramesh, T.P. Bharathesh, S.M. Verma, R. Keshavamurthy, J. Mater. Eng.Perform. 21, 74(2012) DOI: 10.1007/s11665-010-9803-1
6. M. Soltani, S.A. Hoseininejad, Sci. Eng. Compos.Mater. 20, 7(2013)
7. C.A.V. Kumar, J. Selwin Rajadurai, S. Sundararajan, J. Mater. Res. 31, 2445(2016) DOI:10.1557/jmr.2016.247
8. V. Sharma, U. Prakash, B.V. Manoj, Kumar. J. Mater. Process. Technol. 224, 117(2015) DOI:10.1016/j.jmatprotec.2015.04.019
9. E. R. I. Mahmoud, K. Ikeuchi & M. Takahashi (2008) Fabrication of SiC particle reinforced composite on aluminium surface by friction stir processing, Science and Technology of Welding and Joining, 13:7, 607-618, DOI: 10.1179/136217108X333327.

10. M. Tayyebi , D. Rahmatabadi, M. Adhami, R. Hashemi," Influence of ARB technique on the microstructural, mechanical and fracture properties of the multilayered Al1050/Al5052 composite reinforced by SiC particles", J M A T E R R E S T E C H N O L . 2 0 1 9;8(5):4287–4301, https://doi.org/10.1016/j.jmrt.2019.07.039.
11. S.S. Mirjavadi, M. Alipour, S. Emamian, S. Kord, A.M.S. Hamouda, P.G. Koppad, R. Keshavamurthy, J. Alloys Compd. 712,795(2017)DOI:10.1016/j.jallcom.2017.04.114
12. J.H. Shin, H.J. Choi, M.K. Cho, D.H. Bae, J. Compos. Mater. 48, 99(2014) DOI: 10.1177/0021998312469238.
13. Sahayam Joyson Abraham, Isaac Dinaharan, Jebaraj David Raja Selvam, Esther Titilayo Akinlabi," Microstructural Characterization and Tensile Behavior of Rutile (TiO2)-Reinforced AA6063 Aluminum Matrix Composites Prepared by Friction Stir Processing", Acta Metallurgica Sinica(English Letters), 2019, 32(1): 52-62, doi: 10.1007/s40195-018-0806-5.
14. H.H. Kim, J.S.S Babu, C.G Kang, " Fabrication of A356 aluminium alloy matrix composite with CNTs/Al2O3 hybrid reinforcements", Volume 573, 2013 pp. 92-99.
15. H.S. Siddesha, M. Shantharaja, "Investigation of microstructure and mechanical properties of commercially pure aluminium produced by RCS process", Volume 2, 2012 pp. 333-341.
16. JinghuiLi, Fuguo Li, Wenjing wang, Xinkai Ma, Jiang Li, " Achieving grain refinement and related mechanical property improvement of an Al-Zn-Mg-Cu alloy through severe plastic deformation", 2018, pp. 1059-1110.
17. M. R. Toroghinejad, F. Ashrafizadeh, R. Jamaati, On the use of accumulative roll 378 bonding process to develop nanostructured aluminum alloy 5083, Materials Science and 379 Engineering: A, Vol. 561, pp. 145-151, 2013.
18. A.M. Glezer, R.V.Sundeev, "General view of Severe plastic deformation in solid state", National University o Science and Technology Leninskiipr.4, Moscow 119049, Russia, 2014, pp.67-83.

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