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Effect Of Al2O3& Tib2 Reinforcement Particles On Tribological And Tensile Properties Of Al 6061 Alloy Surface Composite Via Friction Stir Processing.

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ABSTRACT:
In the current work, attempts were made to create friction stir processed Al-based nano composites (FSP). The microstructure of the nugget zone (NZ) was improved by the addition of Al2O3 and Tic nanoparticles, and the growth of granular material in the heat-affected zone was constrained (HAZ). The impacts of adding Al2O3 and Tic nanoparticles on the development of the grain structure and various mechanical properties of the friction stir-welded aluminium matrix were thoroughly investigated. The results showed that the addition of Al2O3 and TiB2 nanoparticles caused a remarkable refinement of grains in the nugget zone because of the pinning effect produced by nano-sized Al2O3 and TiB2 particles that prevent the grain growth followed by recrystallization during FSW, leading to a remarkable reduction in the amount of grain that was unable to be refined.

Keywords: *Friction Stir Processing, Nugget Zone, Grain Growth.*

1 INTRODUCTION:

Due to their low densities and excellent strength to weight ratios, aluminium and its alloys are extensively used in a variety of industries [1]. It is challenging to increase the dispersion of reinforcement particles on the metal surface using traditional surface modification techniques [2]. The properties of surface composites prepared using thermal spraying and laser beam procedures are reportedly deteriorated as a result of the formation of undesirable phases, according to earlier studies [3–4]. Therefore, the solid state method most suited for processing aluminium and its alloys is friction stir processing. Based on the fundamental ideas of FSW, it was created by Mishra et al. as a general tool for microstructural modification as well as to enhance surface modification [5]. Using traditional surface modification techniques, it is difficult to regulate the distribution of nano reinforcing particles on the surface of an aluminium alloy [6]. As surface-dependent degradations, wear and corrosion can be improved by making the appropriate changes to the surface microstructure and/or composition. A FSP technique can be employed to refine the microstructure and homogeneous dispersion of reinforcements on metallic surface [7]. Nevertheless, their poor resistance to wear and corrosion causes certain limitations for their application [8]. This exhibited better mechanical properties (hardness, tensile strength and percentage of elongation) than the base material [9]. These composites are a new type of material that exhibit good wear and corrosion resistance properties as compared to the matrix [10]. These Al Matrix Composites exhibit higher properties than that of parent alloy such as stiffness, improved tribological characteristics, weldability and high strength. Further these properties can be enhanced by using nano scale ceramic materials [11-12]. Sharma et al[13] have studied that was used to carry out the tribological tests. Das. et.al [14] have demonstrated dry sliding wear behavior, aluminum alloy reinforced with reinforced with Al_2O_3- TiB_2. A detailed analysis is carried out using SEM in order to find the influence of Al_2O_3 and TiB_2 particles on Al 6061.This investigation is helps to fabricate and study the influence of nano sized Al_2O and TiB_2 (average size is 35 nm) reinforcement particles with their volume percentages accordingly on microstructural and mechanical behavior of 6061-T6 Al alloy surface nano-composites by using FSP.

2 EXPERIMENTATION:

Materials:

The base material used in the present study is Al 6061 alloy plate with 6mm thickness. Aluminum 6061 alloy after artificial aging (temper T6) it exhibits full strength, good mechanical properties and weldability along with excellent corrosion resistance, 6061 alloy has a density of 2.70 g/cm^3 and its composition is shown in Table 1.

Al6061 is used as the base material and Al_2O_3 and TiB_2 particulates in powder form fabricated through powder metallurgy process method of an average particle size of 35 nm at a required volume percentage (such as 1.5%, 3% and 4.5%) was chosen as the reinforcement materials. Aluminum Oxide is one of the most commonly used non-metallic reinforcements, combined with Aluminum, Magnesium etc., to obtain composites. It provides unique combination of properties such as high strength-to-weight ratio, stiffness, hardness, wear resistance.

Table 1: The Chemical Composition of Al 6061 alloy.

CHEMICAL ELEMENT	Manganese (Mn)	Iron (Fe)	Copper (Cu)	Magnesium (Mg)	Silicon (Si)	Zinc (Zn)	Chromium (Cr)	Titanium (Ti)	Aluminium (Al)
AA 6061 wt %	0.15 Max	0.70 Max	0.15– 0.40	0.80 – 1.20	0.40–0.80	0.25 Max	0.04 – 0.35	0.15Max	BALANCE

Fabrication of Composites:

Friction stir processing is effective for improving the mechanical properties and eliminates casting defects and refines microstructures, thereby improving strength and ductility. Earlier researches [15] reported that thermal spraying and laser beam techniques were utilized to prepare surface composites, in which it degrades the properties due to creation of unfavorable phases so in order to avoid the problems FSP technique is used as best solid state technique for processing Al 6061 plates.

These plates held in position with the help of a clamp. The entire setup was kept in the vice of the converted milling machine and accordingly as shown in Figure:1. A non-consumable tool made from JIS-SKH 57 was used as the tool material, EN31 tool was used for the process. A concave shaped tool with a shoulder diameter of 20 mm was selected , pin dia. and pin length of 5 mm and 3.2 mm, respectively. [16**]**

The plates were shear cut to avoid any misalignment. The aluminium plate AA6061 - 100mm x 70mm x 6mm of required dimensions shown in Figure:2 are taken and grooves of different breadth and depth (1.5*1.5, 2*2, 2.5*2.5mm) are cut. The grooves are filled with nano sized Al_2O_3 and TiB_2 (The average size is 35 nm) reinforcement particles at a required volume percentage (such as 1.5%, 3% and 4.5%) and the region is processed with three different tools according to their requirement. Here the emphasis is laid on various combinations of the parameters like the plunge depth, cooling rate and backing plates. Tool RPM – 1120 rpm; Tool traverse speed – 80 mm/min.

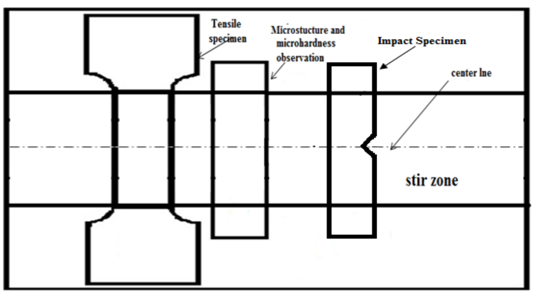


Figure 1. Schematic sketch of samples for testing

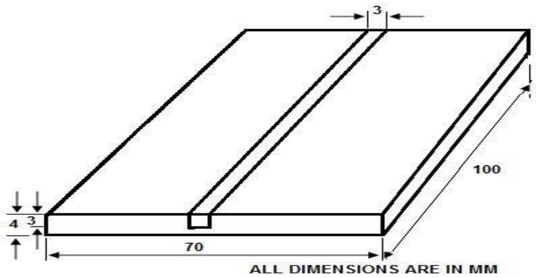


Figure 2. Schematic diagram of Aluminum alloy plate for FSP

Table 2: Friction Stir Processing Parameters

Specimen No.	Speed(RPM)	Tool Profile	Volume Percentage
1	900	Threaded	1.5
2	900	Square	3
3	900	Tapered	4.5
4	1120	Threaded	3
5	1120	Square	4.5
6	1120	Tapered	1.5
7	1400	Threaded	4.5
8	1400	Square	1.5
9	1400	Tapered	3

RESULTS AND DISCUSSIONS:

A) Macro and Microscopic Visual Examination of a Al 6061 Material at Different Magnifications Range:

Figure 3 Microstructures of different zones for all the 9 samples at Different magnification.

B) Hardness values of Al 6061 Composite Material reinforcing with Al_2O_3 and TiB_2 Nano Particles:

Vickers firmness HV1 was measured over the entire range of the weld at the weld's centre (2 mm listed below the surface). All of the examples demonstrate the firmness. Weld face, midway through the weld nugget, and close to the origin of the FSP joint are all places where firmness value can be recovered. The typical value was described in relation to the welding center's price range. It was shown that the element's hardness increases as turning rate increases by more than 1120 rpm. The results also show that when traverse rate increases from 31.5 mm/min, there is an 80–90% drop in stiffness compared to base steel.

Table 3: Hardness Values:

S. No	Sample ID	Charpy Impact Value
1	Sample 1	28
2	Sample 2	26
3	Sample 3	36
4	Sample 4	26
5	Sample 5	26
6	Sample 6	24
7	Sample 7	38
8	Sample 8	24
9	Sample 9	38

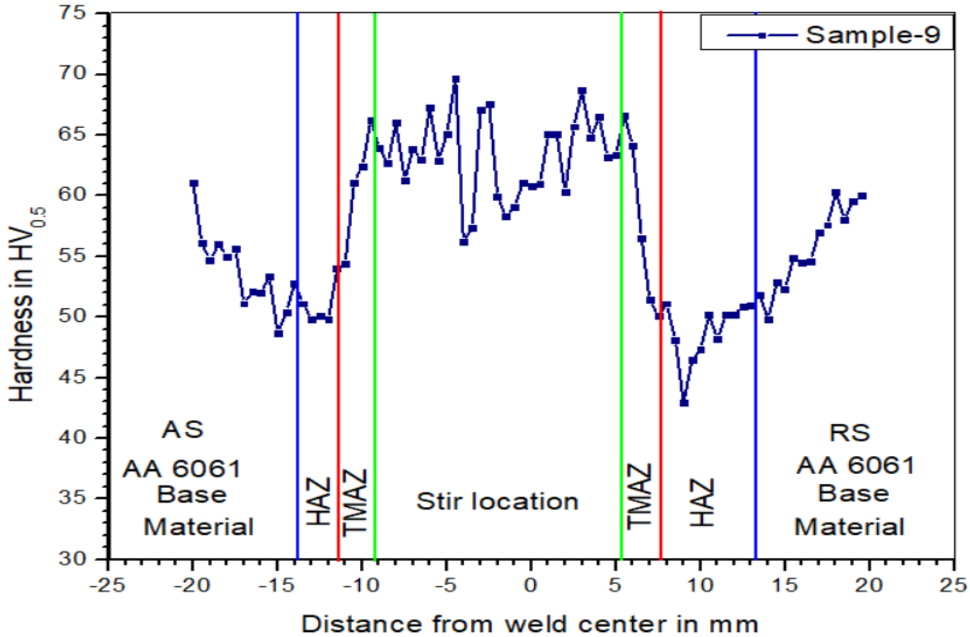


Figure 4: Micro hardness survey of Al/Al_2O_3 and Tib_2 surface nano composites and as-received Al alloy

Table 4: Tensile Test Results of all Samples of Al6061 Material:

Sample Description	Maximum stress in MPa	Yield Strength in MPa	% Elongation
1	72	163	10.7
2	39	171	13.5
3	100	173	11.6
4	70	147	8.6
5	66	166	12.5
6	81	173	15
7	80	150	9.12
8	86	154	8.18
9	74	92	4.4

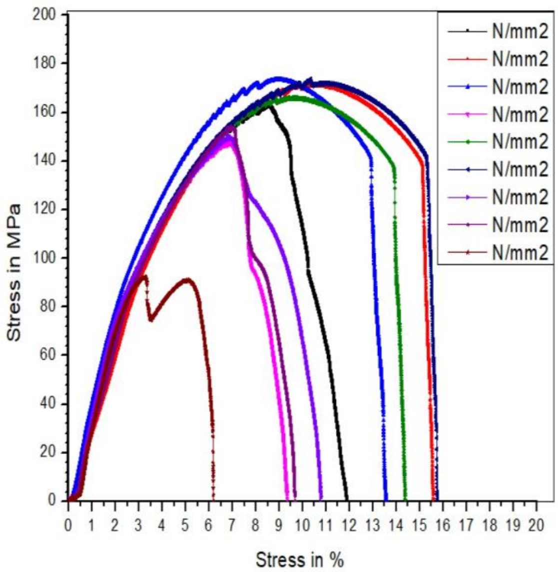


Figure 5: Stress Strain Curve of Al/Al_2O_3 and Tib_2 nano composites and as-received Al alloy

C) Wear Test:

The dry sliding wear behaviour of a MMCs was examined using the wear and friction monitor depicted in Figure. The aforementioned composites were used to create standard wear pin specimens for wear tests that were 8 mm in diameter and 30 mm in height. These specimens were then extracted using a wire cut EDM method, as indicated in Figure, and metallographic ally polished. The wear tests were performed in a heat-treated and cast environment at a constant sliding speed of 2.00 m/s. A total of around 2 km of sliding has been done for each wear test. The track diameter was 100mm, the load was 40N, the sliding speed was 0.314 m/s, the speed was 650 rpm, and the sliding distance was 113.097 m. Weight loss measurements were used to determine the dry sliding wear.

Table 5: Wear Test Results.

SAMP LE	LOAD (N)	WEAR TRACK (mm)	SPEED (RPM)	TIME (min)	TEMP (C)	WEAR (micron s)	F.F (N)	COF	INITIAL WEIGHT OF TEST SAMPLE (gm)	FINAL WEIGHT OF TEST SAMPLE (gm)	WEIGHT LOSS (gm)
1	40	100	650	5	ambient	70.85	13.77	0.46	0.91575	0.90945	0.00633
4	40	100	650	5	ambient	82.16	13.34	0.44	0.75245	0.67625	0.07695
5	40	100	650	5	ambient	91.56	12.46	0.42	0.79571	0.721458	0.07258
6	40	100	650	5	ambient	97.81	12.55	0.43	0.74589	0.71452	0.07381
7	40	100	650	5	ambient	115.82	12.72	0.44	0.66695	0.55442	0.00348

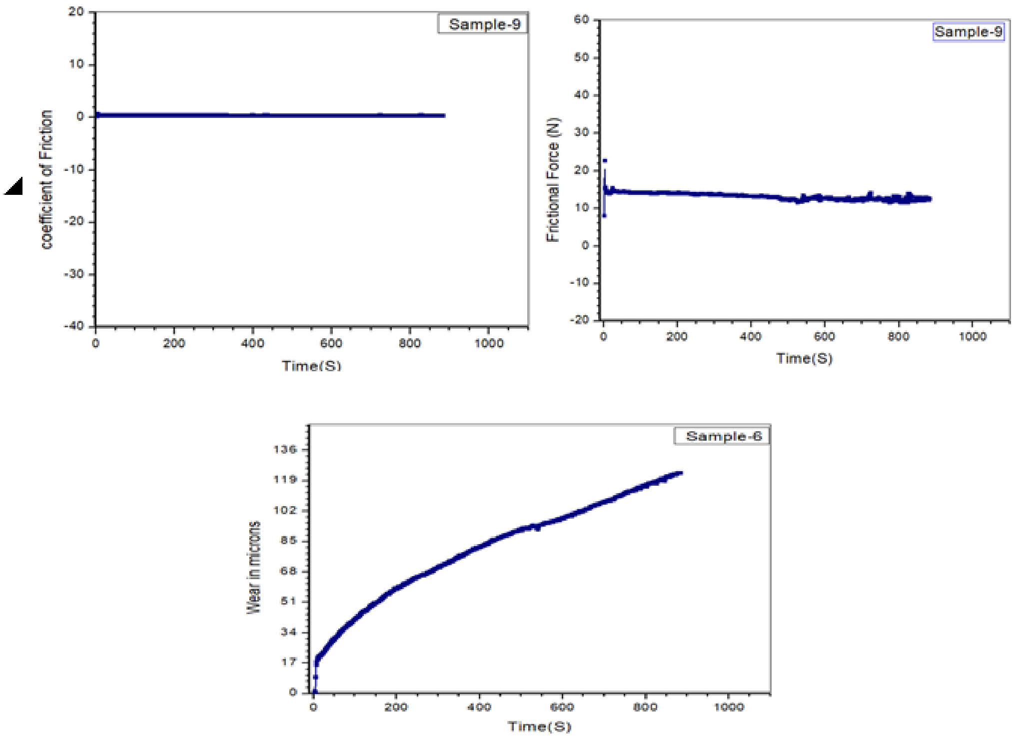
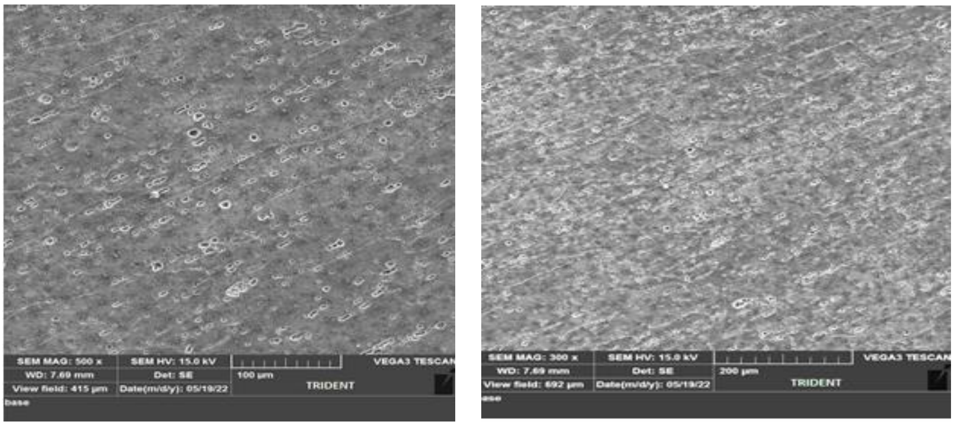


Figure 7: Wear Test Graphs

D) Scanning Electron Microscope (SEM):

The sample's SEM picture shows that the SiC particles dispersed on the Al 6061 plates' surface at the Nugget Zone. Because of ageing, there was more particle aggregation seen in the SEM image. The computer-assisted SEM analysis parameters that were used in this experiment were selected based on their suitability for characterisation of environmentally relevant particles. The SEM fractography of base metal Al alloy, surface nano-sized composites, and TiB2-1.5 vol%, Al-SiC-3 vol%, and Al-SiC-4.5 vol% is illustrated in Figure 8.



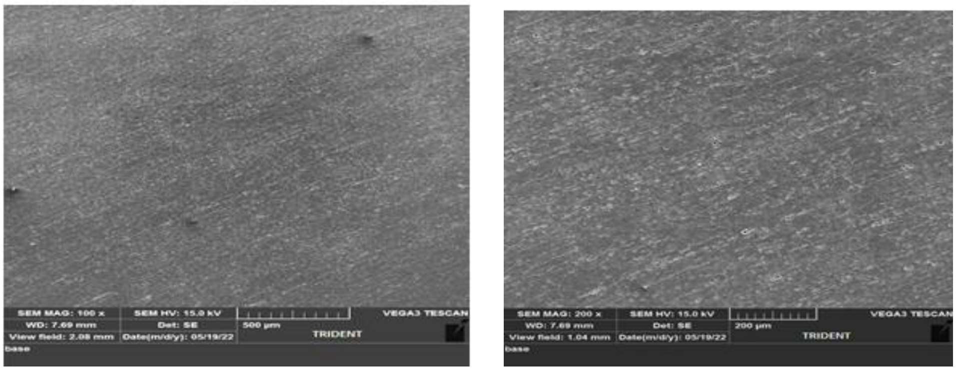
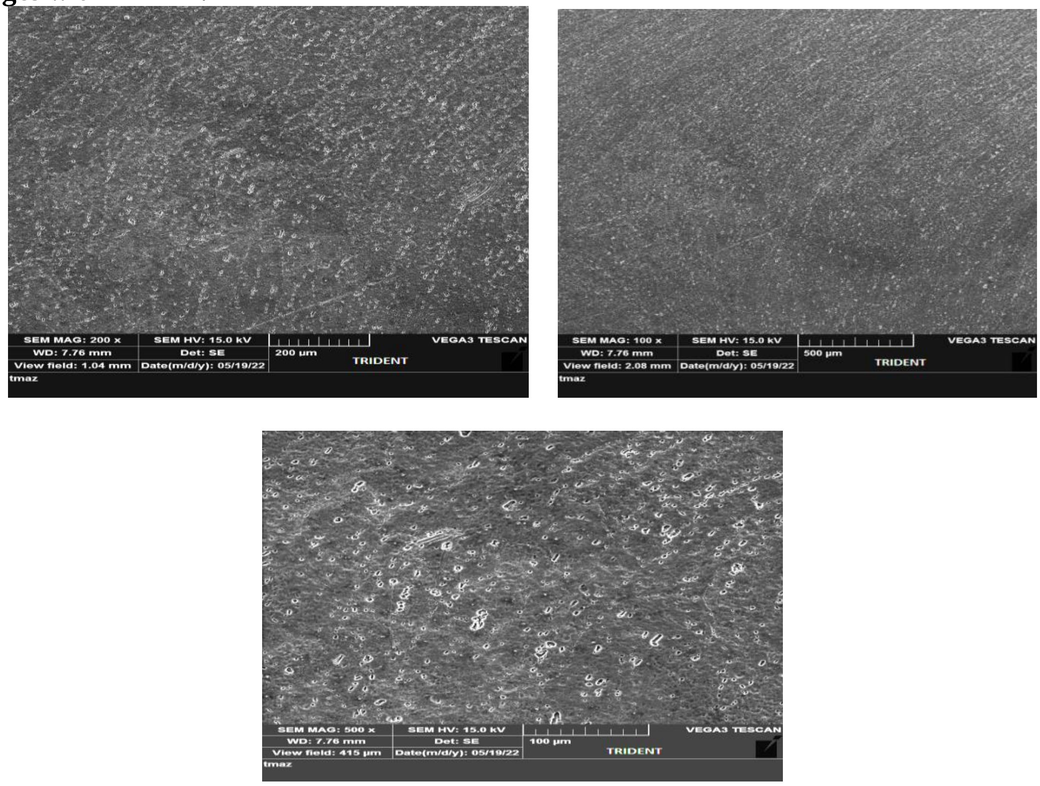
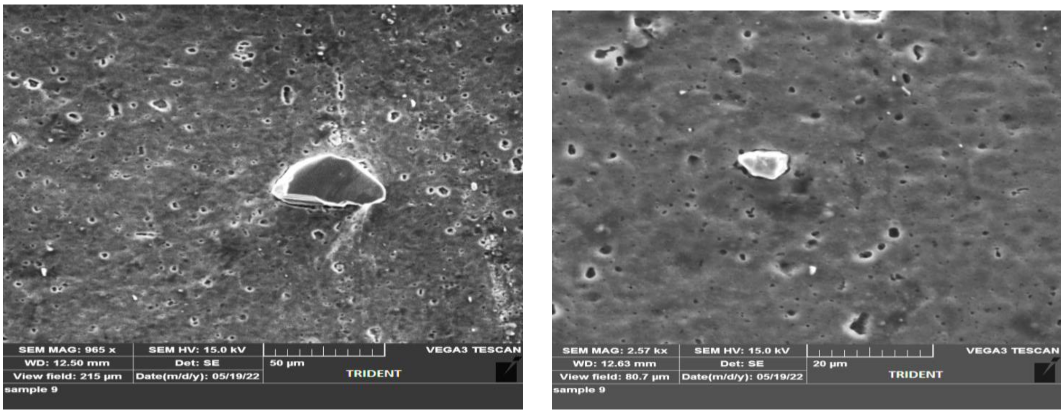


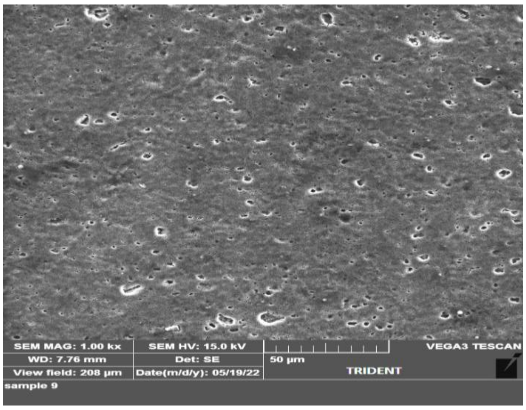
Figure 8: SEM micrographs of Al_2O_3 and TiB_2 reinforcement particles Base Materials.

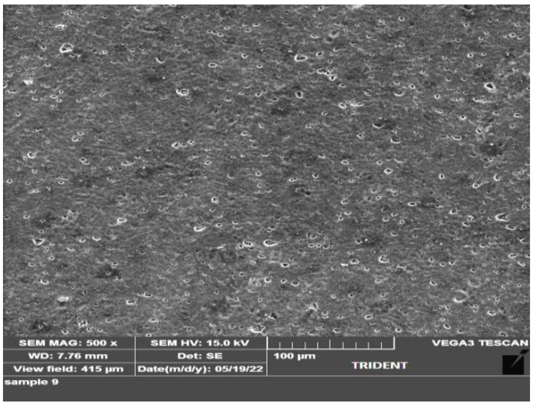
SEM Images with TMAZ:



SEM Images of WELD NUGGET Zone of Sample No 9:

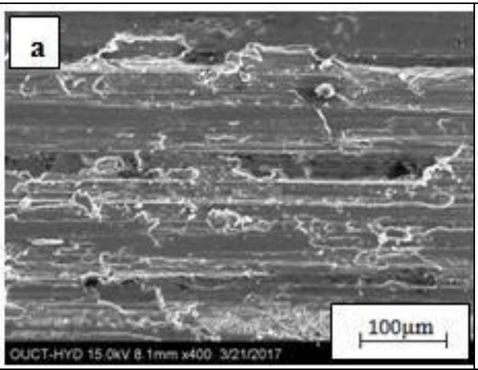




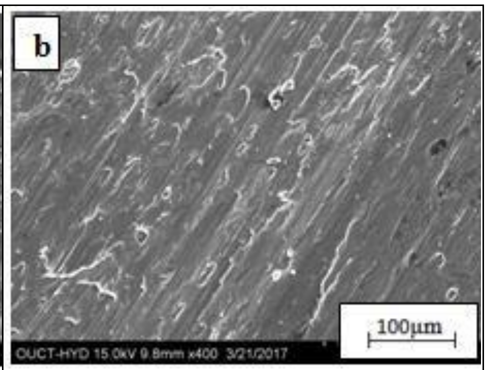


E. Wear Surface Analysis:

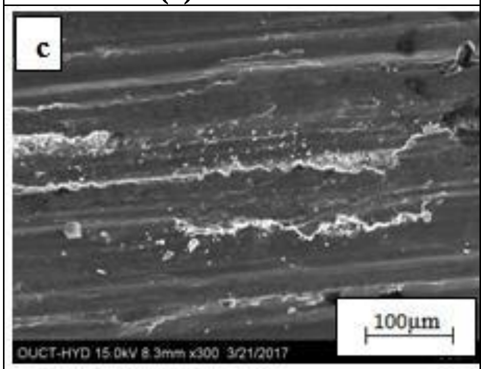
Figures depict SEM micrographs of Al 6061 matrix material SiC composites with worn surfaces at 100 times their original size in both as-cast and heat-treated states. Wear rate is a function of the number of SiC particles in composites, which are useful in enhancing the composites' wear resistance in both circumstances. Additionally, it can be assumed that SiC particles' ability to refine grains contributes to the wear rate reduction. Less deep grooves can be seen and the surface is significantly smoother than the one that was found when SiC is increased from 1.5 wt% to 3 wt% and 4.5 wt%. Al 6061 reinforced with SiC at 4.5 weight percent has a rougher worn surface than Al.



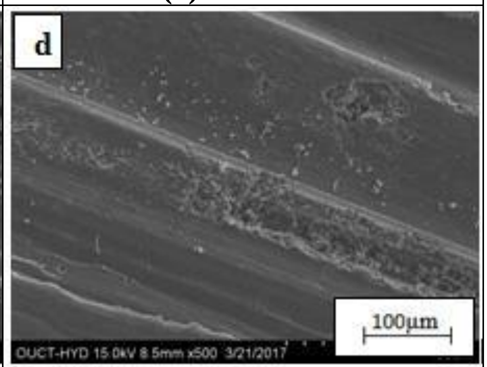
(a) 1.5 vol %



(b) 3.0 vol%



(c) 4.5 vol%



(d) Al alloy without wear

Figure 09: SEM micrographs of SiC particles after wear test.

CONCLUSION:

Al_2O_3 Nano Particles:

- By effectively using FSP to reinforce SiC particles on 6061-T6 Aluminum Alloy, the nano surface composite surface layer was created. The following results were reached after examining the impact of nanosized reinforcement particles, such as Al2O3 (average size is 35 nm), on the microstructure and mechanical characteristics of 6061-T6 Aluminum alloy based surface nano composites produced by FSP.
- Al2O3 microhardness is seen to decrease as volume percentage of the material increases.

When compared to the Al alloy in its as-received state, all of the tensile characteristics of Al surface nano composites had been lowered.

- It can be noticed that the tensile characteristics showed greater values at 4.5 volume percentage than they did at 1.5 and 3 volume percentage.
- The SEM and optical micrograph images

TiB_2Nano Particles:

- Metallurgical advantages: much less distortion, high security, great microstructure
- Because of high plastic contortion and also heat in the mixed area throughout FSP recrystallization and also microstructure development happens in mixed area as well as speed up dissolution and also coarsening within and also around the mixed area.
- The micro structural variants in various areas have substantial impact on various other residential properties.

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