International Journal of Scientific Research & Engineering Trends
Volume 6, Issue 2, Mar-Apr-2020, ISSN (Online): 2395-566X

Dry Sliding Wear Behaviour Study on Friction Stir Processed of Aluminium 6061 Alloy

Md. Thamizuddin **Mirza Sohail Baig** **Syed Mohammed MehdiRazvi** **Supervision, Asst Prof. Mohammed Parvez**
Department of Mechanical Engineering,
ISL Engineering College, Hyderabad.

Abstract **– Recently friction stir processing (FSP) has emerged as an effective tool for enhancing sheet metal properties through microstructure modification. Significant grain refinement and homogenization can be achieved in a single FSP pass leading to improved formability, especially at elevated temperatures. FSP is a solid-state process where the material within the processed zone undergoes intense plastic deformation resulting in dynamically recrystallized grain structure. Most of the research conducted on FSP focuses on aluminium alloys. Despite the potential weight reduction that can be achieved using Titanium dioxide (B4C) alloys. In this work, we examine the possibility of using FSP to modify the microstructure and properties of commercial A7075-B4C&AL2O3 alloy particles. The effect of various process parameters on thermal histories, resulting microstructure and properties to be investigated.**

Keywords **– Al (6061) alloys, friction stir processing, pin on disc wear testing machine.**

I. INTRODUCTION

1. Background of Friction Stir Processing (FSP):

Friction Stir Processing(FSP) is a variant of Friction Stir Welding(FSW) that follows same working principle of FSW.

FSW was invented at TheWeldingInstitute(TWI) of UK in 1991 as a solid state joining technique ,and it was initially applied to aluminum alloys(Thomasetal.,1991).Arotating tool consisting of a pin and shoulder plunges into the workpiece,Generating heat through both friction and plastic deformation,a sitcreates weld seam.FSW is a more energy efficient technique as compared to electrical arc based and laser joining operations owing to the solid-state process nature, which requires significantly less power (Mishra and Ma,2005).

2. Friction Stir Processing(FSP):

FSP is an effective material processing technique to improve the mechanical and metallurgical properties of the base material. FSP was developed by using the basic principles of FSW (Mishraetal., 1999; MishraandMahoney,2001).However,instead of joining, FSP, a solid-state process, is used for microstructural modification. During SPaspecially designed,no consumable tool,which has two components namely a pin and a shoulder,isused.The tool is made to rotate a high speed and a downward force is applied to the tool so that the pin plunges into the base material and the shoulder just touchesthesurface.

II. LITERATURE REVIEW

R.S.Mishraetal.[1]in his research work, he reported the first results using friction stir processing(FSP) and the feasibility of friction stir processing to produce a micro structure amenable to high strainrate super plasticity in a commercial aluminumalloy,optimum super plasticity was observed in a friction stir processed 6061 Al alloy at 490°C with a strain rate of 1 ×10–2□–1.

PatrickB.Berbonetal.[2] in his study on friction stir processed aluminum alloys Al-Ti-Cuand Al-Ti-Niwere investigated and he concluded that the friction stir processing of nanophase aluminum alloysled to high strength of 650MPa with good ductility above10%.Improvements inductility were due to a significantly improved homogenization of the microstructure during FS processing. The FSP technique is amenable to produce ductile, very high specific strength aluminumalloys.

Z.Y. Ma et al. [3] in his investigation on friction stir processing of 6061 Al alloy he concludedthatfrictionstirprocessingwithdifferentprocessingparameters,resultingin two fine-grained 6061Al alloys with a grain size of 3.8 and 7.5 µm. Heat treatment at 490°C for 1 hour showed that the fine grain microstructures were stable at high temperatures. Superplastic investigations in the temperature range of 420 – 530°Cand strain rate range of 1 × 10–3 to 1 × 10–1 □–1 demonstrated that a decrease in grain size resulted in significantly enhanced super plasticity and a shift to higher optimum strain rate and lower optimum deformation temperature.

For the 3.8 µm 6061Al alloy, superplastic elongations of >1250% were obtained at 480°C in the strain rate range of 3 × 10–3 to 3 × 10–2□–1 whereas the 7.5 µm 6061Al alloy exhibited a maximumductility of 1042%at500°Cand3×10–

The analyses of the superplastic data for the two alloys revealed a stress exponent of 2,aninverse grainsize dependence of 2,and an activation energy close to that for grain boundary self-diffusion. This indicates that grainboundary sliding is the main deformation mechanism for theFSP6061Al.

III. EXPERIMENTAL PROCEDURE

1. MaterialSelection:

- **6xxx series alloys:**

These are heat treatable alloys with magnesium and silicon as the major alloying element(magnesium and silicon addition sofaround1%).

The addition of magnesium and silicon to aluminum produces a compound of magnesium silicide, which provides the materialist ability to become solution heattreated for improved strength.They are used instructural applications.They have moderate tensile strength and are less strong than 2xxxand7xxx alloys.These alloys areFSP-edwith fill ermaterial. Examples are 6025, 6061,6063, 6082etc.
Aluminum 6061 is selected from the 6xxx seriesAlloys.
Aluminum plate dimensions:
130mm×75mm×10mm

2. Machining:

In machining slotting operation is performed to make as lot equidistance along the width of the plate of drilling 5mm depth and 4mm dia.

3. Friction Stir Processing:

Friction Stir Processing is performed on the vertical axis milling machine modelF N2EV manufactured by HMTL Limited as shown in the figure below.
Workpiece is clamped on the base of vertical axis milling machine and the too list fixed, then Alumina powder is poured in the slot of the work piece and then the tool is made to rotate at the desired speed and slowly the pin made to penetrate into the metal and shoulder touches the surface of metal, the tool rotated at constant speed until plastic deformation occurs due to heat generated by friction between the tool and the work piece after the metal reaches plastic state and deformation occurs then the tool is made to traverse at specific speed in the desired direction leaving behind the friction stir processed region.

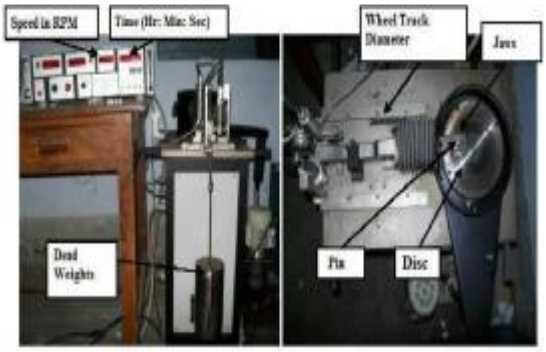


Fig.1. Wear testingmachine.

3.1. Experimental Procedure of Wear Test

Dry sliding wear tests for different number of specimens was conducted by using a pin-on-disc machine (Model: Wear & Friction Monitor TR-20) supplied by DUCOM is shown in Figure 3.3
The pin was held against the counter face of a rotating disc (EN31 steel disc) with wear track diameter 50 mm. The pin was loaded against the disc through a dead weight loading system. The wear test for all specimens was conducted under the normal loads of 20N, 40N and a sliding velocity of 2 and 4m/s.
Wear tests were carried out for a total sliding distance of approximately 1200 m under similar conditions as discussed above. The pin samples were 10 mm in length and 10 mm in height. The surfaces of the pin samples were slides using emery paper (80 grit size) prior to test in order to ensure effective contact of fresh and flat surface with the steel disc. The samples and wear track were cleaned with acetone and weighed (up to an accuracy of 0.0001 gmusing microbalance) prior to and after each test. The wear rate was calculated from the height loss technique and expressed in terms of wear volume loss per unit sliding distance.
In this experiment, the test was conducted with the following parameters:

- 1.Load
- 2.Speed
- 3.Distance

Weight loss of alloy and composite

3.2. Pin–on-disc test

In this study, Pin-on-Disc testing method was used for tribological characterization. The test procedure is as follows:
Initially, pin surface was made flat such that it will support the load over its entire cross-section called first stage. This was achieved by the surfaces of the pin sample ground using emery paper (80 grit size) prior to testing

3.3. Weight Loss

The alloy and composite samples are cleaned thoroughly with acetone. Each sample is then weighed using a digital balance having an accuracy of ± 0.1 mg.

Weight loss of the alloy and composite samples in grams is shown in Table I

Table –I: Weight loss of alloy and composite with 2m/s and 4 m/s.

Weight loss of alloy and composite							
S.No.	Specimen Name	Sliding Speed 2m/s			Sliding Speed 4m/s		
		Initial weight (gm)	Final weight (gm)	Weight loss (gm)	Initial weight (gm)	Final weight (gm)	Weight loss (gm)
	Al/MoS$_2$(1)	8.2712	8.246	0.0252	8.27122	8.2422	0.02902
	Al/MoS$_2$(2)	8.0907	8.073	0.0177	8.09076	8.067	0.02376
	Al/B$_4$C (1)	8.1635	8.1494	0.0141	8.16358	8.14182	0.02176
	Al/B$_4$C (2)	8.1625	8.1474	0.0151	8.16348	8.14182	0.02166
	Al/MoS$_2$+B$_4$C (1)	8.0055	7.9927	0.0128	8.00555	7.985	0.02055
	Al/MoS$_2$+B$_4$C (2)	8.3557	8.3444	0.0113	8.35572	8.33629	0.01943

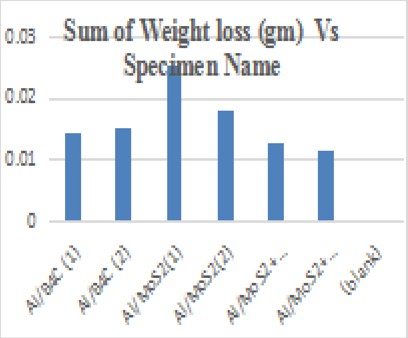


Fig .2. Weight loss of alloy and composite with 2m/s

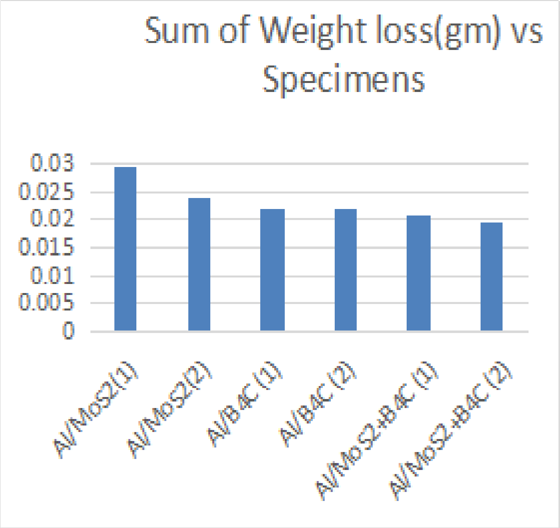


Fig. 3.Weight loss of alloy and composite with 4m/s.

Specimen Wear rate (mm3/m)
2 m/s 4 m/s

Table –II: Specimen vs wear rate(mm3/m).

Specimen	**Wear rate (mm^3/m)**	
	2 m/s	**4 m/s**
1	6.58676928	40.494847 35
2	1.70248684	20.06797604
3	1.27498018	17.07768475
4	1.13700184	14.43573299
5	0.90552998	8.4144354
6	0.71441887	6.3132563

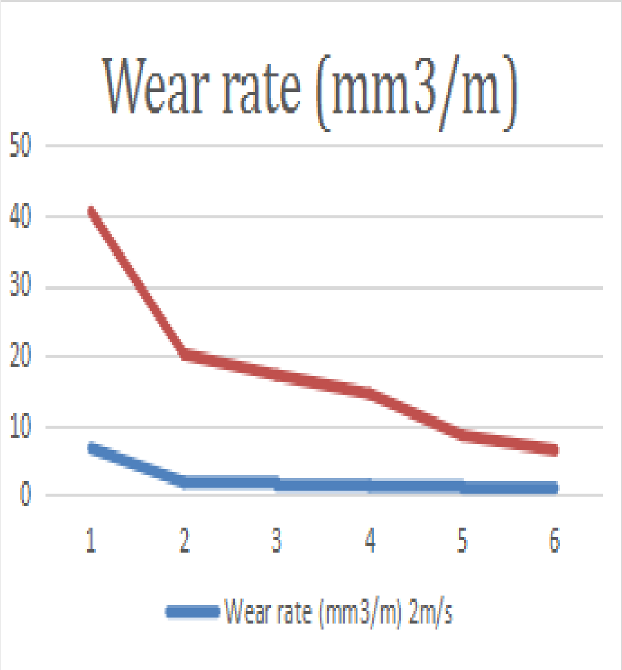


Fig.4. Specimen vs wear rate (mm3/m) with 2 and 4m/s

Table –III: Specimen vs wear resistance(m/mm3).

Specimen	**Wear resistance (m/mm^3)**	
	2 m/s	**4 m/s**
1	0.151819497	0.0246945
2	0.587376053	0.049830636
3	0.784325918	0.058555947
4	0.879506053	0.069272548
5	1.104325668	0.118843387
6	1.386655302	0.22547785

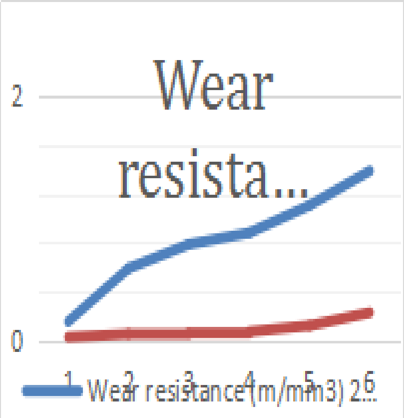
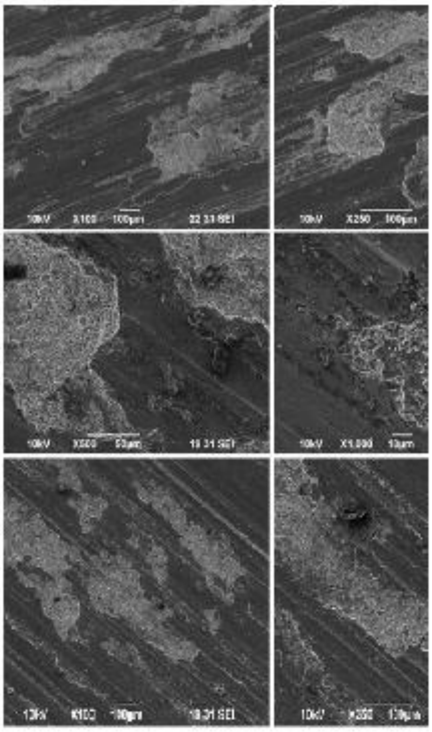


Fig.4. Specimen vs wear resistance with 2 and 4m/s

3.4. Sem Micrograph of AA6061 with Different Composition With 2M/S

The worn surface of the Al/MoS2/B4C composites is shown in Figure 3.10. It clearly exhibits the presence of deep permanent grooves and fracture of the oxide layer, which may have caused the increase of wear loss. However, the worn surfaces of the twocomposites exhibit finer grooves and slight plastic deformation at the edges of the grooves. The surface also appears to be smooth because of the graphitereinforcementcontent.

At a sliding speed of 4 m/s, the wear rate shows a lowering trend which indicates the less removal of material from the surface. The micrograph shows the removal of material by delamination. Apart from this, cracks are generated along with particle pull out at the surface. Below Figure shows the presence of a large number of grooves over the entiresurface.



V. CONCLUSIONS

FSP process is suitable for fabrication of surface composites in solid state condition. It is also suitable for selective surfacing applications. In the present investigation, the Al 6061/B4C, and Al6061/B4c/Mos2surface Nano composites were successfully fabricated by the FSP. The mechanical properties and tribological characterization of the composite layer produced by four passes was studied. The obtained results can be summarized as follows.

1. FSPed composite specimens (mono and hybrid) exhibited uniform dispersion of reinforcement particles in the matrix and higher hardness and strength than the FSPed Al alloy (without particles) and base alloy.
2. Al–B4C Nano reinforced composite exhibited the highest hardness and tensile strength. However, it had lower ductility observed when compared to Al–TiC and Al–B4c/Mos2nano reinforced composites. The micro hardness value for Al–TiC, Al–B4c/Mos2and Al– B4C surface composites were about 118 ± 1 Hv, 124 ± 2 Hv and 127 ± 2 Hv respectively while that for sample FSPed without particle and base material where about 107 ± 5 Hv and 83 ± 1 Hv respectively.
3. The wear rates of the composite specimens were found to be lower than the base alloy and FSPed base alloy at all applied loads (20–100 N). The Al–B4c/Mos2composite wear specimen was found to have higher wear resistance, despite lower hardness than Al–B4C composite. TiC particles acted as a

solid lubricant and B4C particles acted as a load bearing element in the hybrid composite.

4. Mild wear was observed in the composites at lower loads (20N) and the mechanism of the wear was mainly due to oxidization. At 40 and 60 N loads, the type of wear was observed to change from mild to severe wear and mechanism of the wear was observed to be an abrasive, and severe plastic deformation. At higher loads of 80 and 100 N, the type of wear changed from severe to very severe wear and the mechanism was observed as abrasive, and delamination wear.
5. Improved wear resistance of the Nano surface layer might be attributed to a lower coefficient of friction when compared to the base alloy and FSPed base alloy.

REFERENCES

[1]. Miracle D B, Comp Sci Tech 65 (2005) 2526.
[2]. Sharma V, Prakash U, and Kumar B V M, J Mater Process Technol 224 (2015) 117.
[3]. Mishra R S, and Ma Z Y, Mater Sci Eng R 50 (2005) 1.
[4]. Arora H S, Singh H, and Dhindaw B K, Int J Adv Manuf Technol 61 (2012) 1043.
[5]. Cam G, and Mistikoglu S, J Mater Eng Perform 23 (2014) 1936.
[6]. Saadatmand M, and Mohandesi J A, Trans Indian Inst Met 68 (2015) 319.
[7]. Zarghani A S, Bozorg S F K, and Hanzaki A Z, Wear 270 (2011) 403.
[8]. Shahraki S, Khorasani S, Behnagh R A, Fotouhi Y, and Bisadi H, Metall Mater Trans B 44 (2013) 1546.
[9]. Moghaddas M A, and Bozorg S F K, Mater Sci Eng A 559 (2013) 187.
[10]. Khodabakhshi F, Simchi S, Kokabi A H, Nosko M, Simancik F, and Svec P, Mater Sci Eng A 605 (2014) 108.
[11]. Yuvaraj N, Aravindan S, and Vipin, J Mater Res Tech 4 (4) (2015) 398.
[12]. Liu Q, Ke L, Liu F, Huang C, and Xing L, Mater Des 45 (2013) 343.
[13]. Hosseini S A, Ranjbar K, Dehmolaei R, and Amirani A R, J Alloys Compd 622 (2015) 725.
[14]. Asl A M, and Khandani S T,