International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-9 Issue-3, January 2020

Measurement of Friction and Wear in Aluminum Alloy Al7075/Sic & Gr Processed By Friction Stir Method

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***Abstract*: Aluminum proved its effective usage in various applications because of its light weight and high strength. This work highly focused on fabrication of aluminum alloy Al7075 with addition of (10 wt. %) of silicon carbide (SiC) and (10 wt. %) graphite (Gr) by using friction stir processing. Initially reinforcement distribution examined by using SEM and EDS analysis. Co efficient of friction and wear was examined by pin on disc Tribometer. Based on the experimental results, improved mechanical properties and tribological properties were obtained compare to the base metal Al7075 aluminum alloy.**

Keywords: Aluminum, Friction stir processing, wear, silicon carbide, COF.

I. INTRODUCTION

Aluminum alloys are highly required in aerospace, automobile and marine applications [1]. Poor wear and frictional resistance are the major concern in aluminum alloy[2]. Hence surface modification is much needed to improve the wear and friction resistance [3-4]. Addition of ceramic particles and reinforcement in the base metal considered as the suitable method of improving surface characteristics in Al7075 [5-6]. Friction stir processing is the effective technique to get improved surface hybrid composites in metal matrix composites [7-8]. In FSP, Severe plastic deformation on base metal lead to fine particle deposition and enhanced material properties [9]. Distribution of reinforcement controlled by tool speed and rotation. Reinforcement like and Gr results good wear resistance. Addition of Al 7075 with Sic (7 wt. %) and graphite (3 wt. %) lead to improvement in wear and mechanical properties [10-12]. Based on the past study fabrication of aluminum alloy with silicon carbide (SiC 10 wt. %) and graphite (Gr 10 wt. %) by using friction stir processing was not done. This research is highly concentrated in improvement of mechanical properties, wear and friction in fabricated Al 7075 using FSP.

Revised Manuscript Received on January 30, 2020.
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II. MATERIALS AND METHODS

A. Materials

The aluminum alloy 7075-T6 with dimensions of 150 x 110 x 5 mm^3 purchased from Metal Mart, coimbatore and reinforcement SiC, Gr purchased from Sigma, Mumbai with size of ~300 mesh. In Table 1. Base metal composition was plotted.

Table- I: Base metal-Al 7075 composition

Cu	Si	Mn	Mg	Cr	Zn	Fe	Al
1.43	0.13	0.12	2.5	0.2	5.4	0.42	Bal

B. Friction Stir Processing

Fabrication of surface hybrid composite was done by semi-automatic vertical 4 axis friction stir processing machine. Fig.1 (a,b) represents the machine setup and representation of fabrication technique.

Fig. 1.(a). Friction Stir processing machine setup

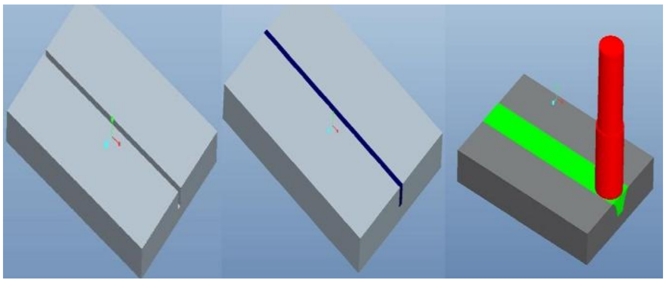

Fig. 1.(b). Fabrication Technique of Al7075 alloy with Sic and Gr

EN31 steel Friction stir processing tool with pin diameter of 4mm and 3 mm long was used to fabricate the composite specimen. Al7075 alloy was grooved at the centre with the dimension of 3mm width and 3mm depth and filled with powder form of SiC and Gr reinforcement. Tool tip diameter was made larger then the groove width to arrest the reinforcement particle with in the grooves. The FSP machine parameters are plotted in Table 2. and fabricated hybrid composite specimen shown in fig.2.

Table- II: FSP Machine parameters

S.No	Machine Parameters	Preferred Levels
1.	Tool	EN31 steel
2.	Tool rotation and speed	1000 rpm CW
3.	Feed rate	80mm/min
4.	Tilt angle	2.5°.

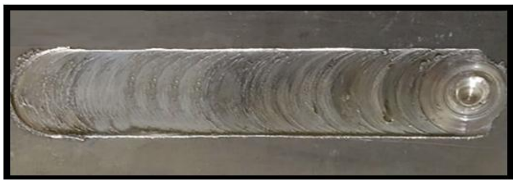

Fig. 2. Fabricated hybrid composite specimen

C. Hardness Test

Hardness test was carried out by using Vicker's digital micro harness tester with 200 gm load and 15s dwell time. The digital micro hardness tester is shown in fig. 3.

Fig. 3. Vicker's digital micro harness tester

D. Friction and wear

Pin on disc Tribo-meter was used to calculate the friction and wear on Al7075 and Al7075 with SiC and Gr specimen. Based on dry sliding wear condition, wear test was carried out with the sliding distance 1400 meters and force acted on the disc is 10N. The experiment was carried three times to obtain the perfect results with sliding velocity of 4m/s. The wear rate and coefficient of friction was carried out by using Eq.(1). and Eq.(2).

$$\text{Wear Rate} = \frac{\text{Mass loss/Density}}{\text{Sliding distance}} \qquad (1)$$

$$\text{Coefficient of Friction} = \frac{\text{Tangential force}}{\text{Normal force}} \qquad (2)$$

III. RESULT DISCUSSION

A. *SEM Analysis*

SEM Analysis on Fabricated aluminum alloy Al7075 with addition of silicon carbide (10 wt. % SiC) and graphite (10 wt. % Gr) was carried out using a scanning electron microscopy (Model: VEGA 3 TESCAN) with EDAX which is plotted in Fig. 4. Based on SEM, the equal distribution of SiC and Gr particle on the base metal was identified. SiC grains was identified on the SEM with the grain size of 10-12 µm. Using EDS analysis, accumulations of reinforcement spotted around the SiC particle but not around Gr. Self-lubricating property of Gr induced the less accumulation with the base metal. Less patches was observed on the composite surface and good metallurgical bonding was obtained.

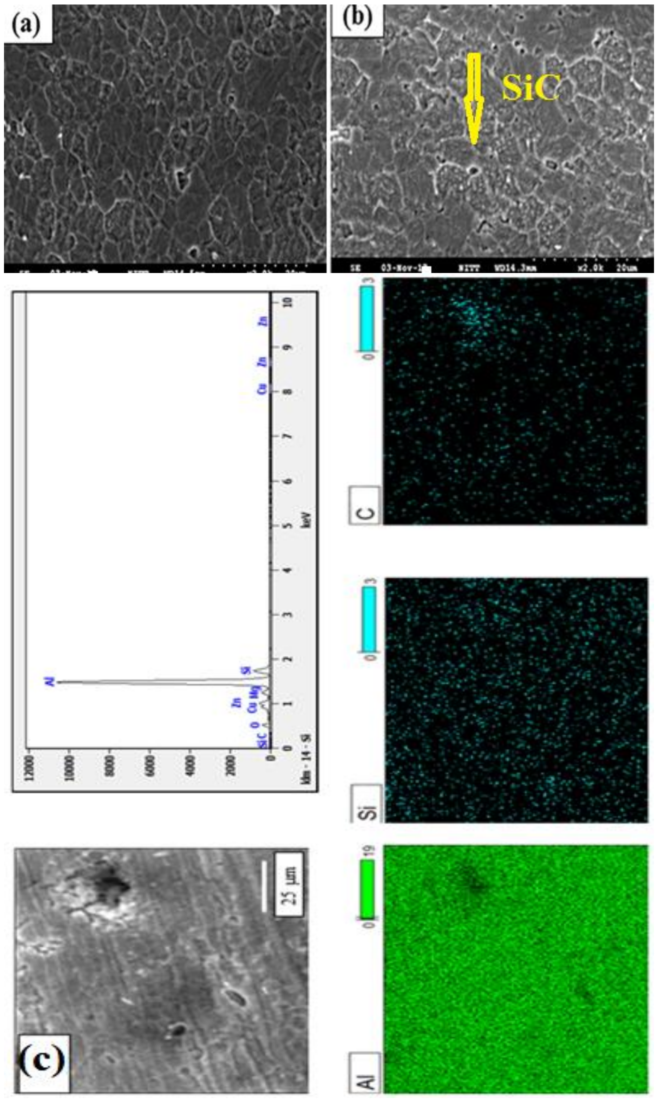

Fig. 4.

a) SEM image of Al7075

b) SEM image of Al7075 with 10wt. % of Sic and Gr

c) EDS analysis of Al7075 with 10wt. % of Sic and Gr

B. Hardness analysis

Micro hardness test was carried out on friction stir processing Nugget Zone and heat affected zone and base metal. Based on the analysis, High hardness 90 Hv was obtained in the nugget zone because of enhanced property of SiC with Al7075 and 87 Hv at the heat affected zone. Compare to nugget zone and heat affected zone minimum hardness was obtained at unprocessed base metal of 85Hv. Due to friction heat, increased in hardness was obtained at heat affected zone. The consolidated experimental result has ploted in Table 3. Micro harness of Al7075/SiC and Gr proved significant improvement compare to Al7075 base metal and represented in Fig. 5.

Table- III: Measurement of wear and COF

Parameter	Unprocessed Zone (UPZ)	Heat affected zone (HAZ)	Nugget Zone (NZ)
Hardness (Hv)	85	87	90

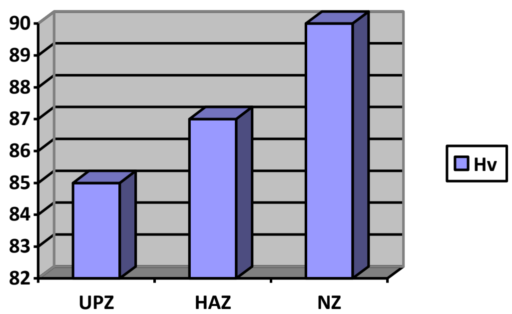

Fig. 5. Micro hardness level of composite specimen.

C. Friction & wear analysis

The Coefficient of Friction and wear was measured and plotted in Table. 4.

Table- IV: Measurement of wear and COF

S.No	Load (N)	Material	Wear Rate (mg/m)	Coefficient of Friction
1.	10	Al7075	0.0102	0.3669
2.	10	Al7075 + SiC+Gr	0.0078	0.3044

Wear test was conducted in both Al7075 and Al7075 with silicon carbide (10 wt. % SiC) and graphite (10 wt. % Gr) fabricated alloy. Based on the experimental results, Al7075 produced higher wear rate of 0.0102mg/m compared to fabricated surface hybrid Al7075/Sic & Gr. This is achieved due to the lubricating property of Gr reinforced with Sic and aluminum base metal. For CoF, fabricated specimen produced lesser friction of 0.344 compare to the base metal of Al7075. The friction and wear behavior is depending of load and sliding velocity. Based on the study load is the significant parameter on wear compared to sliding velocity and composition of reinforcements [11]. The graphical representation of wear and friction coefficient is shown below. In both wear and co efficient of friction, fabricated specimen produced good results compared to the base aluminum alloy Al7075.

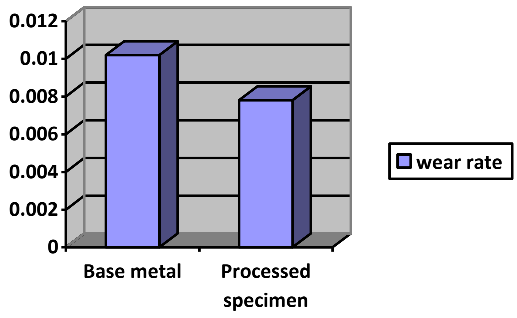

Fig. 6. Wear rate of Al7075 vs Al7075 with 10wt. % of Sic and Gr.

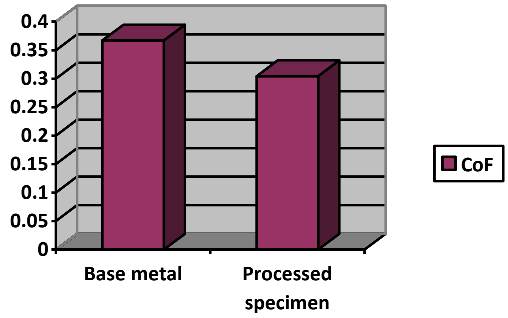

Fig. 7. CoF of Al7075 vs Al7075 with 10wt. % of Sic and Gr.

IV. CONCLUSION

The conclusions from the above experiment are summarized below.

- Even distribution of reinforcement was obtained in FSP with the grain size reduced up to 10-12 µm.
- Micro hardness was enhanced from 85Hv to 90 Hv in fabricated surface hybrid Al 7075/SiC & Gr composites because of reinforcement.
- Wear rated was reduced compare to Al 7075 because of lubricating property of Gr in Al 7075
- Load is the significant parameter on wear compared to sliding velocity and composition of reinforcements.

V. FUTURE SCOPE

Fabrication of Al7075 aluminum alloy with 10 wt. % of Sic and Gr by friction stir processing method mainly focused on improvement in mechanical property and wear parameter. Improved harness with less wear rate in the fabricated specimen evident that the fabricated specimen Sic and Gr composition in aluminum have a future scope various applications. Surface modifications, corrosion behavior under various circumstances, optimization in process parameters are having huge potential to perform research.

ACKNOWLEDGMENT

The authors highly acknowledge their thankfulness to National Institute of Technology, Trichy and Kongu Engineering College, Erode, Tamilnadu, India for their support to this work.

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