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# Fabrication of Surface Metal Matrix composite of AA7075 using Friction Stir Processing

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**ABSTRACT**

Friction stir processing (FSP), a process, derived from the friction stir welding (FSW) process, is an emerging novel, green and energy efficient processing technique to fabricate surface composite. In the present investigation, the FSP technique has been used for the fabrication of surface composites, usingAluminium Alloy 7075 as parent metal and Titanium Dioxide and Silicon Carbide powder particles as reinforcement. Aluminium Alloy 7075 has been selected as the matrix phase, as being widely used by the automotive and aerospace application and has the highest strength among all commercial Al alloys. In present work details about the fabrication of surface composites using various reinforcement combinations like AA7075-TiO2, AA7075-andAA7075-SiC,TiO2+SiC at constant tool rotation, tool travel speed and number of passes have been discussed. The same being intended to improve hardness. It is observed that the average hardness of friction stir processed surface composite was 4 higher than that of parent metal.

**Keywords:** Friction Stir Processing, Surface Composites, AA7075, Titanium Dioxide, Silicon Carbide, Hardness.

## I. INTRODUCTION

Friction stir processing principle is same as friction stir welding technique which is used for microstructural modifications[1]. FSW is used for joining purpose but FSP is developed to modify the surface properties of base materials[2, 3]. The pin of the solid FSP tool plunges into the material. While rotation of the tool heat is generated at contact surfaces of shoulder and pin with work piece material due to friction between surfaces. Material is plastically deformed and recrystallized at stir zone. It was observed that surface properties of reinforced friction stir process materials were enhanced when compared with unreinforced friction stir processed materials. The hardness of SiC reinforced friction stir processed of AA6061-T4 is enhanced by 20 HV at 1600 RPM rotational speed and 80 mm/min traverse speed and observed that SiC particles were dispersed and grain size reduced which causes the grain size refined[1, 4]. To improve the properties like melting point, strain rate sensitivity and tribological of

AA7075, boron carbide particles of different sizes like 160 μm, 60 μm and 30 μm were added using friction stir processing[1,5]. It was observed that the surface cracks are formed along the tool traverse direction at higher turning speed due to severe plastic deformation and also observed that the improper mixing of boron carbide reinforced particles due to low rotational speed like less than 750 rpm. Surface metal matrix composite was formed without any defects at rotational speed of 925 to 1000 rpm and traverse speed of 30 mm/min and hardness of material is enhanced[1, 5]. Aluminium Alloy 6063 is friction stir processed using boron carbide (B4C) and titanium diboride (TiB2). All the samples of 100% B4C, 25% B4C-75% TiB2 and 100% TiB2 are processed and compared.It was observed that the curtailment of gap between fine reinforcement particles by increase the proportion of TiB2 particles because the TiB2 particles are more compact than B4C particles that had the notable impact on the hardness[6]. Al7075/B4C surface composite were fabricated using FSP at three different traverse speeds and tested wear and hardness properties. It was observed that there is no much considerable impact on the particles distribution at stir zone and best. Micro hardness and wear resistance of friction processed samples were decreased by increasing traverse speed due to insufficient stirring time and lack of distribution of particles[7]. After friction stir processed of AA6061with $Al_2O_3$ and CNTs Particles, It has been observed that the dispersion of particles was found to be more uniform as the number of the pass were increased. In $Al_2O_3$ Uniform distribution was observed but in the case of CNTs, it was not visible because after first pass CNTs are breaking and they could not be observed after third pass. There is a considerable enhancement in yield strength and ultimate strength than base material when $Al_2O_3$ was added. There was an increase in yield strength but ultimate strength was found to be decreased in the case of only CNTs added. But when both $Al_2O_3$ and CNTs were added together as reinforcement the ultimate tensile strength and yield strength increased remarkably.[1, 8]

## II. EXPERIMENTAL PROCEDURE

The machine used for friction stir processing was a conventional vertical milling machine which was transformed into a friction stir welding machine and friction stir processing machine by designing a fixture that makes the milling machine capable of performing friction stir welding and friction stir processing. The fixture was fitted on the milling machine table. Two types of tools were used for this process the first tool without pin, and the second tool used for processing was with pin. The tool has a shoulder diameter of 20 mm and a tapered pin of 3-6 mm diameter of a height of 4.5mm as shown in figure 1.

**Fig.1 :** FSP Tools With and without pin

AluminiumAlloy 7075 sheets were taken. The sheets were produced into plates with the dimensions 100X60X6 mm as shown in figure2. A groove100X2X4 was developed on all the plates as shown in figure3.

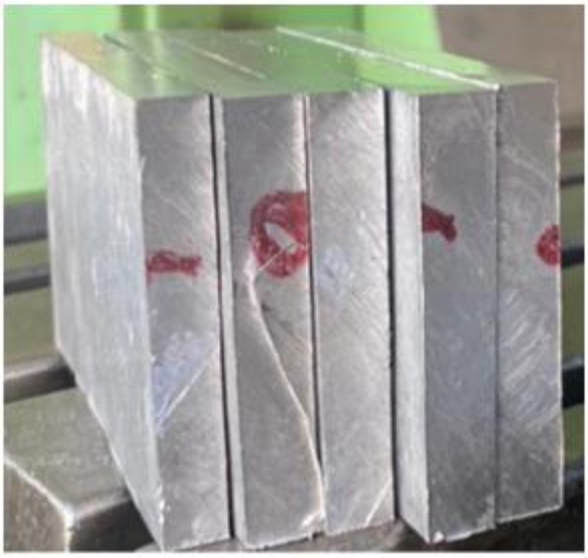


**Fig.2: AA7075 plates of 100X60X6 mm**

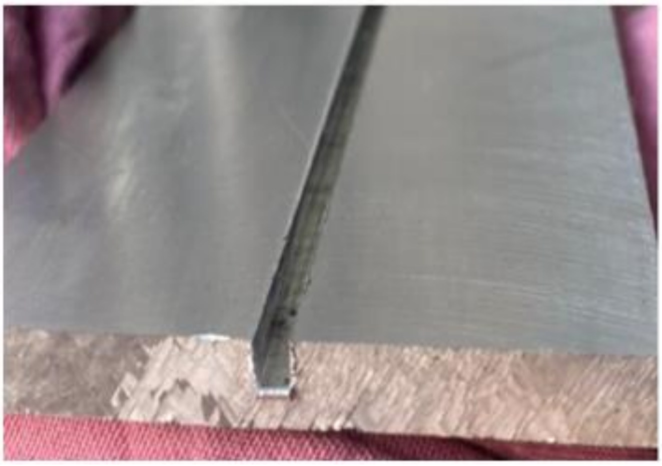


**Fig.3: Groove of 100X2X4 mm**

The grooves are filled using powders. The three plates arefilled with 15% volume of $TiO_2$, 15% volume of SiC and 15% volumeof $TiO_2$+SiC respectively as sown in figure 4.

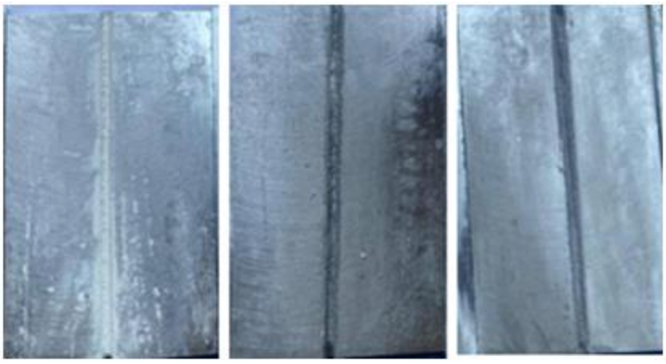


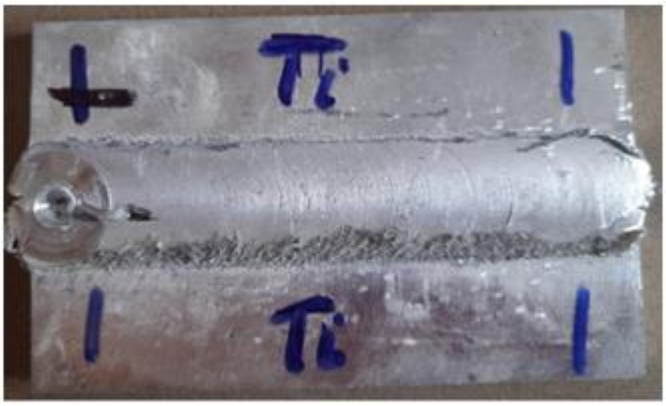
**Fig.4: Specimens with reinforcement**

The first pass is done with the tool without a pin and the next three passes are done with the tool having the pin. Friction stir processing has been done at a rotational speed of 1110 RPM. 20 mm/min Traverse speed and 5KN Axial load and tilt angle is $2^0$.

**Fig.**5: FSP Process without pin

Fig.6: FSP Process with pin

The rotational motion of the spindle starts and the tool comes into the contact with the surface of the plates and the probe is penetrated at the grove developed to a depth so that the shoulder of the tool is firmly in contact with the plate that needs to be processed. The tool is given some time as it rotates in contact with the surfaces to soften the material due to the frictional heat produced, this time is called dwell time, and after the dwell time, the tool is given forward motion. The tool without a pin is withdrawn after the first pass is done. The tool with the pin is fixed and consecutive three passes were performed. The process leaves a hole in such a way that the part with the hole in it is cut and not used for the further process as shown in figure 7.Micro Hardness test was performed using Vickers hardness test on processed specimens. Hardness is measured and compared using base material hardness as shown in figure 8. Hardness of friction stir processed specimens was recorded as shown in table 1.



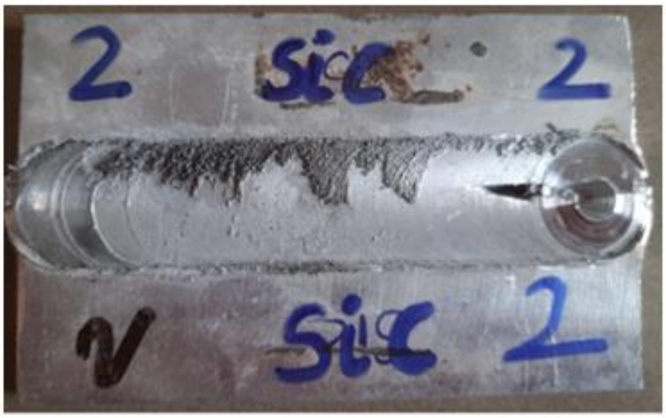





**Fig.7: Friction Stir Processed Specimens**

**Fig.8: Hardness Test Specimens**

**Table 1: Results of hardness Test**

| Runs | Hardness (HV) |
|---|---|
| AA7075+$TiO_2$ | 144 |
| AA7075+SiC | 142 |
| AA7075+SiC +$TiO_2$ | 149 |
| AA7075 | 89 |

## III. CONCLUSIONS

AA7075 Specimens of 6mm successfully friction stir processed with reinforcement.It is observed that the hardness of the FSP reinforced aluminium alloy7075 is greater than that of the unreinforced aluminium alloy 7075.The base material hardens was increased from 89 HV to 149 HV. The maximum hardness was achieved at mixture of SiC and Ti $O_2$ as reinforcement. Surface hardness of Reinforce friction stir processed material is increased with all three types' reinforcement.

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