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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), derived from the friction stir welding (FSW) process, is an emerging novel, green and energy-efficient processing technique to fabricate surface composite. The FSP technique has been used in the present investigation to fabricate surface composites, using Aluminium 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. The present work details the fabrication of surface composites using various reinforcement combinations like AA7075- TiO_2, AA7075- and AA7075- SiC, TiO_2+SiC at constant tool rotation, tool travel speed and the number of passes have been discussed. The same being intended to improve hardness and thereby wear resistance. The fabricated surface composites are examined for microstructure using an image analyzer and found friction stir processed zone with fine microstructure than the base material. It is also observed that the average hardness of friction stir processed surface composite was higher than that of parent metal. Wear Resistance is found to be improved compared to the parent metal. It is found that Tensile strength is also enhanced than the base material.

Keywords: *Friction Stir Processing, Surface Composites, AA7075, Titanium Dioxide, Silicon Carbide, Mechanical and Metallurgical Analysis.*

1. Introduction

The friction stir processing principle is the same as the friction stir welding technique used for microstructural modifications [1]. FSW is used for joining purposes, 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 the shoulder and pin contact surfaces with workpiece material due to friction between surfaces. Material is plastically deformed and recrystallized at the stir zone. It was observed that surface properties of reinforced friction stir process materials were enhanced compared to 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 to be 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 a higher turning speed due to severe plastic deformation, and 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 defects at a rotational speed of 925 to 1000 rpm and traverse speed of 30 mm/min, and the hardness of the material was enhanced [1, 5].

Aluminium Alloy 6063 is friction stir processed using boron carbide (B_4C) and titanium diboride (TiB_2). All the samples of 100% B_4C, 25% B_4C-75% TiB_2 and 100% TiB_2 are processed and compared. It was observed to curtail the gap between fine reinforcement particles by increasing the proportion of TiB_2 particles because the TiB_2 particles are more compact than B_4C particles, which had a notable impact on the hardness6. Al7075/B_4C surface composites were fabricated using FSP at three traverse speeds and tested wear and hardness properties. It was observed that there is not much considerable impact on the particle distribution at stir zone and best. Microhardness and wear resistance of friction processed samples were decreased by increasing traverse speed due to

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insufficient stirring time and lack of distribution of particles [7].

After friction stir processing 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 was increased. In Al_2O_3, uniform distribution was observed, but in the case of CNTs, it was not visible because CNTs broke after the first pass and could not be observed after the third pass. There was 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 decreased in the case of only CNTs added. However, when Al_2O_3 and CNTs were added together as reinforcement, the ultimate tensile strength and yield strength increased remarkably [1, 8].

2. Experimental Analysis and Results

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

Fig. 1 FSP Tools with and without pin

Aluminium Alloy 7075 sheets were taken. The sheets were produced into plates with the dimensions 100X60X6 mm, as shown in figure 2. A groove 100X2X4 was developed on all the plates, as shown in figure 3.

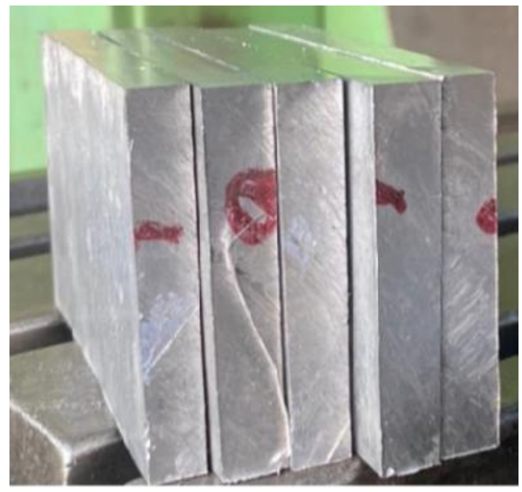


Fig. 2 AA7075 plates of 100X60X6 mm

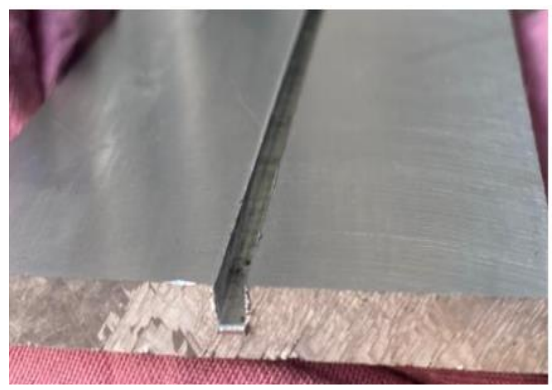


Fig. 3 Groove of 100X2X4 mm

The grooves are filled using powders. The three plates are filled with 15% volume of TiO_2, 15% volume of SiC, and 15% volume of TiO_2+ SiC, respectively, as shown in figures 4(a) and 4(b).

Fig. 4(a) Specimens with reinforcement (View 1)

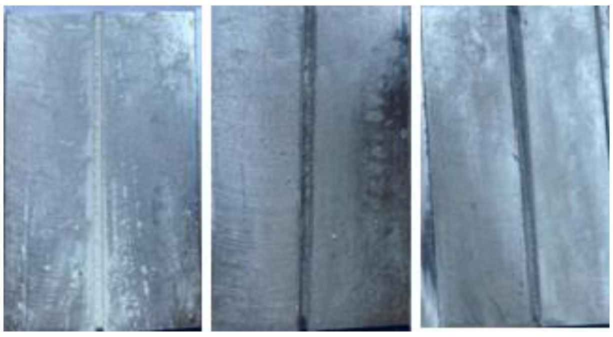


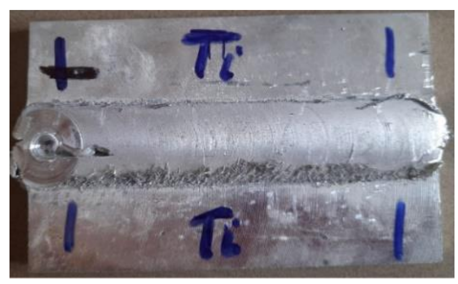
Fig. 4(b) Specimens with reinforcement (View 1)

The first pass is done with the tool without a pin, and the subsequent three passes are done with the tool having the pin. The friction stir process performed on the specimens without and with pin is as shown in figures 5 and 6, respectively. 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 2º.

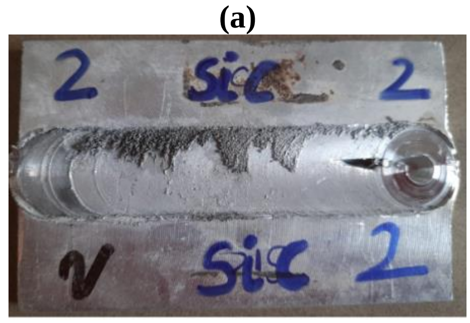
Fig. 5 FSP without pin

Fig. 6 FSP with pin

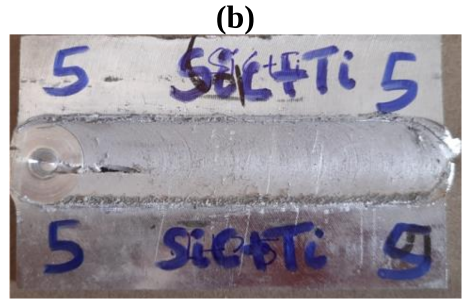
The rotational motion of the spindle starts, and the tool comes into contact with the surface of the plates. The probe is penetrated at the grove and developed to a depth so that the shoulder of the tool is firmly in contact with the plate that needs to be processed. The tool is given some time as it 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 three consecutive passes were performed. The process leaves a hole so that the part with the hole is cut and not used for the further process, as shown in figure 7. Micro Hardness test was performed using the Vickers hardness test on processed specimens. Hardness is measured and compared using base material hardness, as shown in figure 8. The hardness of friction stir processed specimens were recorded as shown in table 1.



(a)



(b)



(c)

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

3. Conclusion

AA7075 Specimens of 6mm successfully friction stir processed with reinforcement. The hardness of the FSP reinforced aluminium alloy 7075 is observed to be greater than that of the unreinforced aluminium alloy 7075. The base material hardness was increased from 89 HV to 149 HV. The maximum hardness was achieved using SiC and TiO_2 as reinforcement. The surface hardness of Reinforce friction stir processed material increases with all three types of reinforcement.

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