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Tensile and Wear Property Analysis of Friction Stir processed Metal Matrix Composite of AA7075

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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 study, the FSP technique has been used for the fabrication of surface composites using AA7075 as base metal and Titanium Dioxide and Silicon Carbide powders are used as reinforcement. AA7075 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-SiC, AA7075-TiO_2 and AA775-TiO_2+SiC at constant tool rotation, tool travel speed and number of passes have been discussed. The mechanical characterization like ultimate tensile strength and wear resistance of fabricated composites are steadied. Wear Resistance is found to be improved compared to the parent metal. It is found that yield strength is also enhanced than the base material.

Keywords: Friction Stir Processing, Surface Composites, AA7075, Titanium Dioxide, Silicon Carbide, Tensile strength and wear resistance.

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] The hardness of friction stir processed aluminium alloy 7075 composites with silicon carbide and titanium dioxide reinforcement was increased.[9.]

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.

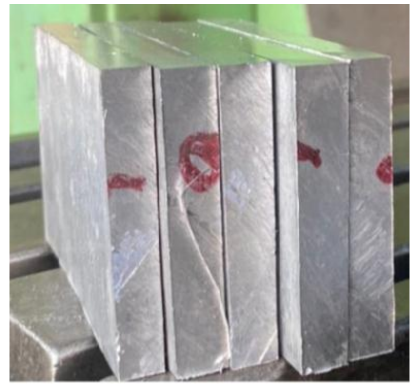

Fig.2: AA7075 plates of 100X60X6 mm

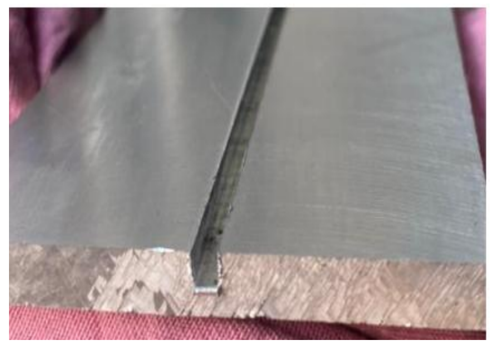

Fig.3: Groove of 100X2X4 mm

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.

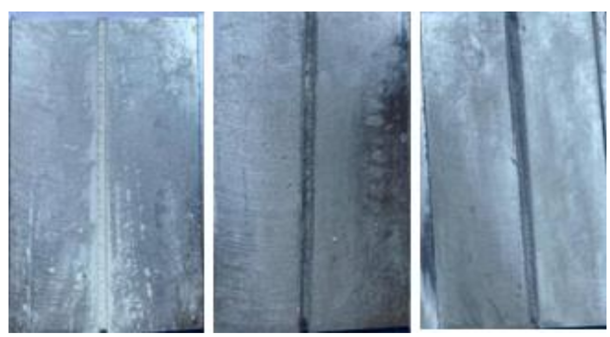

Fig.4: Specimens with reinforcement

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.

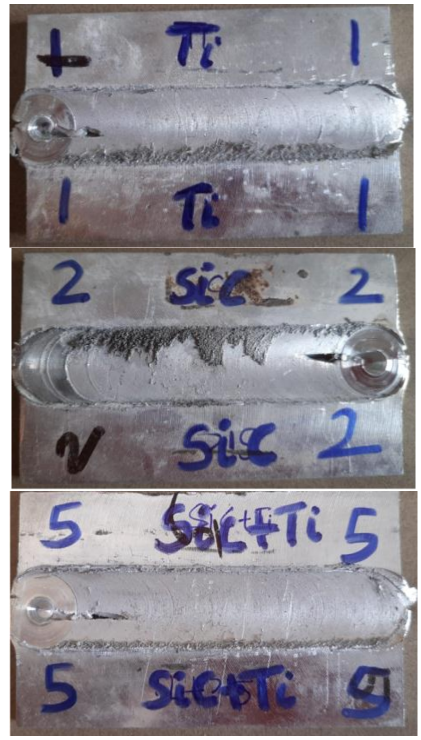

Fig.7: Friction Stir Processed Specimens

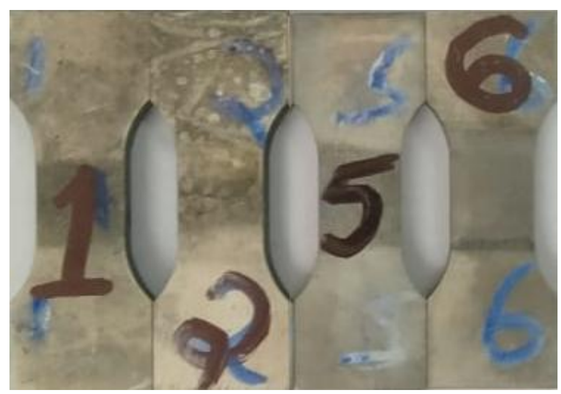

Fig.8: Tensile Test Specimens

The tensile test specimens are e fabricated as per ASTM-E8-2013 standards using Wire EDM as shown in figure 8. The test was conducted on UTM MCS/UTE-20T machine of column clearance 500 mm and Capacity of 200KN. The tensile test results are tabulated in table 1. The wear resistance specimens are fabricated as shown in figure 9. Specimens are circular shape of 12 mm diameter.

The wear test was performed on a Pin on Disc Machine for duration of 8 mints at 500 RPM speed with 5KN load. The pin diameter is 12 mm, Track radius is 20 mm, sliding distance 502.655 mm and sliding velocity is 1.0472m/s are considered. Wear Test results are tabulated as shown in Table 2.

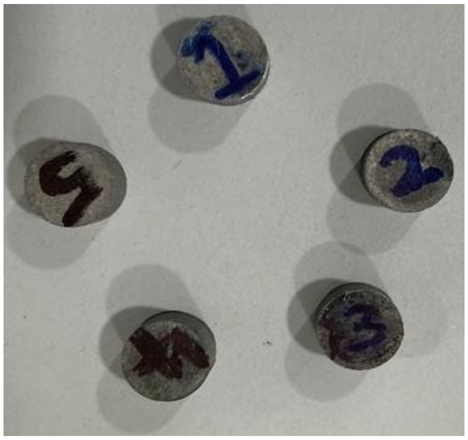

Fig. 9: Wear Test Specimens

Table 1: UTM Test results

Runs	Yield Strength (MPa)	Tensile Strength (MPa)	% of Elongation
AA7075+TiO_2	100.92	113.86	1.60
AA7075+SiC	182.58	223.00	4.40
AA7075+SiC+TiO_2	161.09	201.91	7.20
AA7075	140.00	228.00	10.00

Table 2: Wear Test Results

Runs	WEAR(micron)
AA7075+TiO_2	34.781
AA7075+SiC	77.674
AA7075+SiC+TiO_2	52.304
AA7075	30.709

The yield strengths of the friction stir processed composite materials of AA7075 are increased than base material i.e Aluminium Alloy 7075 but tensile strengths of friction stir processed composite materials of AA7075 are decreased than base material. It has been observed that Silicon carbide reinforced composites yield strength was more compared to Titanium dioxide and mixture of silicon carbide and titanium dioxide. Tensile strength of Friction stir processed composites was less compared to base material aluminium alloy 7075. Friction stir processed composites are brittle in nature due to addition of ceramic reinforcement powders that's whys tensile strength was decreased but yield strength was increased..

It is observed that the wear resistance of the reinforced aluminium alloy 7075 is greater than that of the unreinforced aluminium alloy 7075. The unreinforced aluminium alloy 7075 wear resistance is 30.709 Micron. Greater wear resistance is observed in aluminium alloy 7075 reinforced with SiC.

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 friction stir processed Aluminium Alloy 7075 composites yield strength was enhanced but tensile strength was decreased due to brittle in nature. Wear resistance of friction stir processed composite was increased compared to base material. Finally it has been observed that the mechanical properties are enhanced.

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