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RESEARCH ARTICLE

FABRICATION OF AA-6063/SiC COMPOSITE MATERIAL BY USING FRICTION STIR PROCESSING.

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Abstract

Friction stir processing (FSP) is a solid state process known for its ability to modify microstructures and provide improved properties over conventional processing technologies. The development of friction stir processing (FSP) is based on the friction stir welding (FSW) technology. Both FSW and FSP have the same process principle and share the same facilities. In the present study, an attempt is made to fabricate the AA6063/SiC composite material by doping SiC with help of Friction Stir Processing. The selected material was Friction stir processed at constant tool rotational and welding speed of 1400 rpm and 65 mm/min respectively. High chrome high carbon non-consumable cylindrical left handed thread pin profile tool with 4.8 mm pin length and 6 mm pin diameter was used to generate frictional heat and plastic deformation. SiC particles are doped in a series of holes of 2 mm diameter and 4.8 depth made in AA 6063 plate for fabrication of composite. The mechanical and metallurgical properties of fabricated composite material were investigated. From results it was observed that fabricated AA6063/SiC composite material have better tensile strength and micro hardness as compare to base material. Doping of SiC particles during Friction Stir Processing causes grain refinement.

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Introduction:-

Friction stir processing (FSP) is a solid state process known for its ability to modify microstructures and provide improved properties over conventional processing technologies. The development of friction stir processing (FSP) is based on the friction stir welding (FSW) technology. Both FSW and FSP have the same process principle and share the same facilities as shown in Figure 1. In FSP, a specially designed rotating pin, is first inserted into the material to be processed with or without a proper tool tilt angle and then move along the designed paths. The pin with help of shoulder produces frictional heat due to pressure and plastic deformation around the pin within the processing zone. As the tool pin moves, material is swept around the tool pin and retreating side of the tool (where the local motion due to rotation opposes the forward motion) and the surrounding un-deformed material [11]. The extruded material is deposited to form a solid phase behind the tool. It is evident that FSW and FSP share the same mechanism as schematically illustrated in Figure 1.

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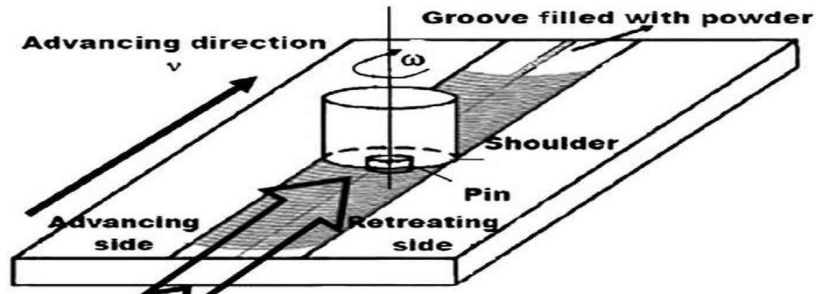


Figure.1:- Schematic diagram of Friction Stir Processing [3]

Experimentation:-

Friction Stir Processing of AA6063 Alloy :-

The material under investigation was Aluminium 6063 alloy under the form of rolled plates of 5 mm thickness and chemical composition of AA-6063 alloy is presented in Table no. 1.

Table 3.1:- Chemical Composition of Aluminium Alloy 6063.

Al	Mg	Si	Fe	Cu	Mn	Zn	Cr	Ti
BAL	0.014	0.300	0.500	0.065	0.018	0.004	0.002	0.028

Specimens of size 100 mm x 77 mm with grooves of 2 mm diameter and depth of 4.9 mm at a centre to centre distance of 5mm were grooved on AA6063 alloy plate. Friction stir processing of prepared specimen were performed perpendicular to the rolling direction for fabrication of AA6063/SiC composite material. Specimens are processed by single pass Friction Stir processing by doping SiC particles of size approximate 4 μm . The selected specimens were processed by adopting constant tool rotational speeds and welding speed of 1400 rpm and 65 mm/min respectively. A tool made up of High chrome high carbon steel with 20 mm tool shoulder diameter, 6 mm pin diameter and 4.8 mm long was used for present research work. The machine used for the production of composite material was fully automated vertical milling machine. Table 2 shows the Friction stir processing parameter used for experimentation.

Table 2:- Friction Stir Processing parameter used for experimentation.

Plate No.	Tool Rotational Speed (rpm)	Welding Speed (mm/min)	Reinforced particles
1	1400	65	SiC
2	1400	65	Without

A special designed fixture was firmly fixed on the machine bed with help of clamps and then plates were held in the fixture properly for Friction Stir Processing. The set up is shown in Figure no. 2



Figure 2:- Tensile testing specimens.

Mecahnical and Metallurgical Testing:-

Mechanical testing includes tensile, impact and micro hardness testing. For tensile testing, the specimens are prepared according to ASTM E8M-04 and testing was done on Universal testing machine. Figure 3 shows the dimensions of actual tensile tested specimens.

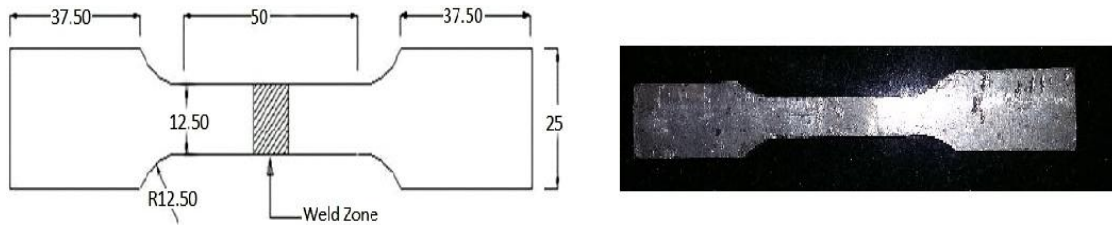


Figure 3:- Tensile testing specimens.

For microstructure testing the specimens were grinded with 400 grit followed by 600, 800, 1000, 1200, 1500, 2000, 2500 and 3000 grit (SiC) paper until a uniform surface finish was attained. Initial polishing was undertaken using (1 μ m) diamond compound for 5 minutes and final polishing was completed using aluminum oxide. The polishing conducted in one direction until all evidence of prior polishing was eliminated. The sample was then rotated 90° and the process were repeated. Enchant having ASTM code E602-78I (Methanol 25ml, Hydrochloric acid 25ml, Nitric acid 25ml and Hydrofluoric acid 1drop) was applied for (15) seconds.

Result and Discussions:-

Results obtained from, tensile testing, Micro hardness testing and Microstructure Testing are discussed in detail.

Ultimate Tensile Strength of AA6063/SiC Composite Material:-

Fabricated AA6063/SiC composite material has high tensile strength at the rate of 220 N/mm² as compared to base material. The tensile strength of base material is 208 N/mm². The tensile strength of fabricated composite material is increased with the presence of reinforced particles (silicon carbide). The presence of reinforced particles increases the nucleation sites and consequently reduces grain size of the matrix and result in formation of fine grains. Silicon carbide is uniformly dispersed with base metal and result in strong bonding between the SiC particles and aluminium AA 6063 [4]. Micro particles of reinforced particles precipitate on grain boundary and prevent grain growth hence fine grain structure. Homogenous dispersion of SiC particles in base metal and good bonding between SiC particles and base metal resulted in increase of ultimate tensile strength of composite material [5].

Microhardness characteristics of AA6063/SiC composite material:-

Microhardness of the stir zone of fabricated AA 6063/SiC composite has high micro hardness (95 Hv) as compared to base material. Micro hardness at stir zone increases due to presence and pinning effect of hard SiC particle. The presence of reinforced particles is considered for more effective formation of fine grain structure due to the restrain of grain boundary and the enhancement of the induced strain [12]. The SiC particle are uniformly mixed with aluminium 6063 and strong bonding are formed between them, which also help in increase the hardness of stir zone. The dynamic recrystallization during FSP produced finer grain in weld zone. [8][9].

Microstructural Characteristics Of AA6063/SiC:-

The typical microstructure of as received conditions (base material) is shown in Figure 4. The microstructure comprises of the coarse grains of aluminum with the hardening precipitates of Mg₂Si.



Figure 4:- Microstructure of Base material AA 6063.



Figure 5:- Microstructure of Stir Zone of welded joint

Figure 5, shows the dispersion of Silicon carbide particles in the stir zone at tool rotational speeds of 1400 rpm and welding speed of 65 mm/min. It is revealed that homogeneous dispersion of SiC particles is achieved at selected parameters. The dispersion of SiC particles is considered for more effective formation of fine grain structure due to the restraint of grain boundary and the enhancement of the induced strain. Mainly, the micro hardness value depends upon the presence and uniform distribution of these particles.[11]

Conclusion:-

The correlation of mechanical properties and microstructure with the process parameters for the fabrication of AA6063/SiC composite material is a unique approach which has been the main motivation behind this project. Following conclusions were derived from the results of this experimental work.

- Friction Stir Processing successfully fabricated the AA6063/SiC composite material with selected FSP parameters.
- Fabricated AA6063/SiC composite material has improved tensile and micro hardness properties.
- The micro structure studies revealed that grain refinement and homogeneous dispersion of SiC particles is achieved with the selected friction stir processing parameters.

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