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OPTIMIZATION OF MICROSTRUCTURE AND MECHANICAL BEHAVIOUR OF ALUMINIUM METAL MATRIX COMPOSITES PRODUCED BY STIR CASTING SUBJECTED TO FRICTION STIR PROCESSING

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ABSTRACT

In the fast tracking world the composite material plays huge role in the various industries. in th e industries there are several types of process which casting and are being important process. In the project,alu min iu m metal matrix co mposite material is produced by stir casting.The presence of ceramic reeinforcents causes difficult ies in casting of thes e materials and necessitated the present work. Three different speeds 560,710,900 rp m are to be selected and two welding speeds are 16,40 mm/ min and tool profiles are conical are to be selected Friction stir processing (FSP) is a solid state process where the material within the processed zone undergoes intense plastic deformation resulting in dynamically recrytallized grain structure .in the testing that the micro hardness,,microstructure,macrostructure test specimen were to be prepared as per A STM standard and the mechanical testing carried out.

KEYWORDS: FSP, AMC, SEM

A wide range of solid-state manufacturing technologies for joining and modification of material original properties are assuming increasing importance in industrial applications The electrical conductivity is a significant property undergoing modificat ion, but this property has not been characterized and fully exploited fro m the technological point of view [Elmo et.al., 2011]. In 6063-T4 A l alloy was friction stir welded at various tool rotations and using a specially manufactured tool with a height - adjustable and right-and threaded pin [Toktas and Toktas, 2011]. TheAl-A l2O3 (18%) co mposite was hot forged. Hot working resulted in fine recrystallized microstructure with particulates dispersed along grain boundaries. Formation of pancake microstructure with some in homogeneity in the microstructure along three faces of the forged composite was observed. The discontinuity across the interface between Al-Al2O3 was reduced to 0.125 light metal after forging. The as -cast and forged Al-Al2O3 co mposites showed higher wear resistance than pure Al. In lubricant med ia, there was no significant wear observed for either the as-cast or forged composite, whereas Al had shown higher wear at 50 N load [Siva et.al., 2011]. The fabrication of the precursor and the bonding of the A1050 precursor to the A6061 precursor can both be conducted by FSP. The results of point analysis, the Mg content gradually changed in the bonding region, that seamless FG alu minum foam can be fabricated by the FSP route [Hangai et.al., 2011]. Corrosion behavior of the investment-cast Ti-6Al-4V alloy in 5-pct HCl solution. The FS-processed samples exh ibited superior corrosion behavior compared with the base metal and the arc-welded samples. The inferior co rrosion resistance of the arc weld ment was attributed to the acicular α and β microstructure and the alloying element partitioning between the phases. [Atapour et.al., 2010]. FSP eliminates porosity and significantly refines eutectic Si particles. The extent of particle refinement varied with changes in proces sing conditions. A high tool rotation rate and a low-to-intermediate tool traverse speed generated a higher volume fraction of finer particles [Atapour et.al., 2010]. Friction stir processing (FSP) was used to locally refine a thin surface layer of the coarse, fully lamellar microstructure of investment-cast Ti-6Al-4V. Depending on the peak temperature reached in the stir zone during processing relative to the β transus, three distinct classes of microstructures were observed [Pilchak et.al., 2010].

FRICTION STIR WELDING PROCESS

In solid-state joining technique and was initially applied to alu minu m alloys. Frict ion stir processing (FSP) is a solid-state process where the material within the processed zone undergoes intense plastic deformation resulting in dynamically recrystallized grain structure. In the FSW procedure, the joining takes place through the movement of a rotating shouldered tool with profiled pin plunged into the joint line between two pieces of sheet or plate material. When the rotating pin tool moves along the weld line, the material is heated up by friction produced between the shoulder of the tool and the surface of the work piece to be welded.

The tool serves three primary functions, that is, heating of the workp iece, movement of material to produce the joint, and containment of the hot metal beneath the tool shoulder. Heat ing is created within the workpiece both by friction between the rotating tool pin

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and shoulder and by severe plastic deformation of the workp iece. The localized heating softens material around the pin and, co mbined with the tool rotation and translation, leads to movement of material fro m the front to the back of the pin, thus filling the hole in the tool wake as the tool moves forward. The tool shoulder restricts metal flo w to a level equivalent to the shoulder position, that is, approximately to the in itial workp iece top surface.

Explanation of various zones in the welded area

Unaffected material or parent metal

This is material remote fro m the weld that has not been deformed and that, although it may have experienced a thermal cycle fro m the weld, is not affected by the heat in terms of micro -structure or mechanical properties.

Heat-affected zone

In this region, which lies closer to the weld - center, the material has experienced a thermal cycle that has modified the microstructure and/or the mechanical properties. However, there is no plastic deformation occurring in this area.

Thermo mechanically affected zone (TMAZ)

In this region, the FSW tool has plastically deformed the material, and the heat from the process will also have exerted some influence on the material.

In the case of aluminum, it is possible to obtain significant plastic strain without recrystallization in this region, and there is generally a distinct boundary between the recrystallized zone (weld nugget) and the deformed zones of the TMAZ.

Weld nugget zone

The fully recrystallized area, sometimes called the stir zone, refers to the zone previously occupied by the tool pin. The term stir zone is common ly used in friction stir processing, where large volu mes of material are processed**.**

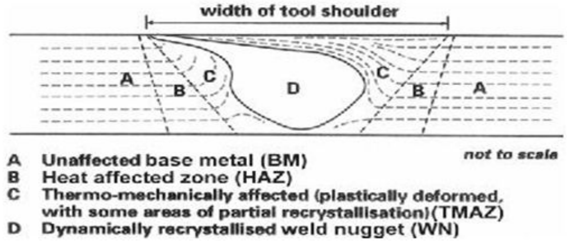


Fig 1 Effect of welding s peed

1. Welding speed decides the specific heat input per unit length of the weld.
2. The grain growth in the stir zone is promoted by an decrease in welding speed due to increase in process temperature.
3. Lower welding speed cause sub grain coarsening in the weld nugget.
4. The decrease in welding speed decreases the cooling rate resulted in larger equiaxed grains in the stir zone with reduced strained region.
5. Higher welding speed resulted in a structure with higher dislocation density because of the limited time available for recovery process.
6. Increase in the welding speed may decrease the grain size due to the decrease in the specific heat input.
7. The clustering of precipitates are more significant for the jo ints made at lo w weld ing speed.
8. The ultimate tensile strength decreases significantly, when the welding speed is increased, due to low heat input.

Figure 2: Friction Stir Process Machine and Component

Table 1: Machine Specification

Machine type	Retrofitted Vertical milling machine
Power o f the motor	5 kilo Watts
Input voltage	415 Volts
Rated current	15 A mpere
Type of feed	manual/automatic
Speed range	560 to 1400 rpm
Feed range	16 to 40 mm/ min
Change of speed	By clutch
Tool rotation	clockwise and anticlockwise

PROCESS PARAMETERS

Differ ENT Spindle Speed (RPM)

560, 710, 900

Differ ENT Welding Speed (MM/MIN)

16 , 40

Tool Geometry

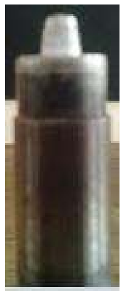


Figure 3: Conical Tool

Shoulder diameter D = 20 mm

Pin diameter d = 6 mm

Pin length L = 6.7 mm

Tool Material: High Carbon high chromium Steel

RESULTS Micro Hardness

Table 2: Micro Hardness

Distance in m.m.	560 RPM 16mm /min **Hardness in H.V. @ 0.5 Kg load.**	560 40	710 16	710 40	900 16	900 40
0.0 edge	32.6	28.9	25.6	31.8	32.4	32.6
2.0	34.7	31.1	28.9	34.9	33.5	30.2
4.0	35.2	32.8	31.0	37.2	32.6	31.6
6.0	34.8	33.4	33.1	46.7	33.1	34.7
8.0	36.4	31.7	31.7	50.3	34.8	33.0
10.0	46.7	33.5	31.8	45.1	34.0	34.0
12.0	43.6	38.9	35.4	41.7	36.3	32.6
14.0	37.8	37.2	33.9	37.1	35.1	33.1
16.0	34.7	36.7	31.6	35.9	33.3	31.9
18.0	31.8	38.5	29.5	34.2	32.6	31.8
20.0	32.4	39.2	28.2	36.5	43.9	29.8
22.0	31.0	41.3	29.3	35.0	40.8	29.5
24.0	29.0	38.4	30.4	33.7	34.4	30.8

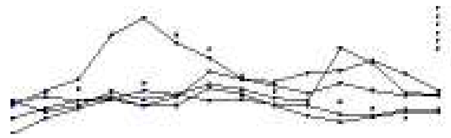


Figure 4: Micro Hardness Graph

In the present study, the bead on plate friction stir welding were carried out on alumin iu m metal matrix was successfully carried out. The following results were obtained.

Micro hardness observations:

As per comparing the hardness values, the process with high speeds having higher hardness values. Weld zone hardness higher than the other(parent & heat affected) zones. Weld center have low value of hardness in all samples.

Micro structure

Steps Parent metal Heat affected zone Weld zone

560rpm 16mm/min

560rpm 40mm/min

710rpm 16mm/min

710rpm 40mm/min

900rpm 16mm/min

900rpm 40mm/min

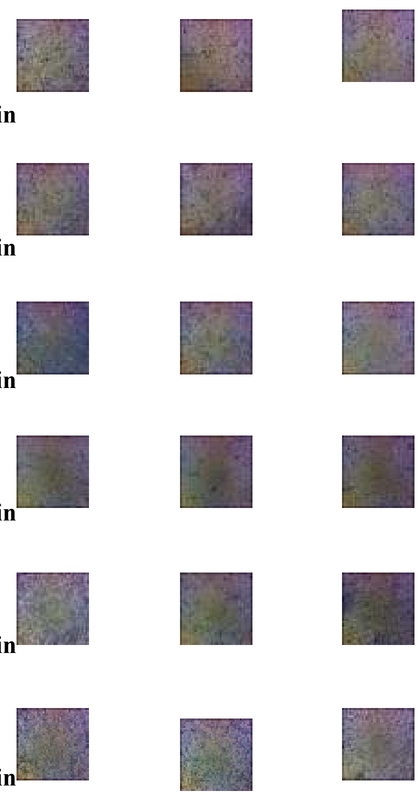
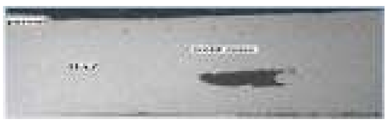


Figure 5: Micro Structure

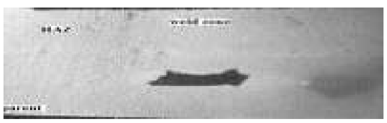
It has been demonstrated that FSW was an appropriate method to modify the microstructure and mechanical properties of Alumin iu m. The technique was energy efficient, environ mentally friendly, for localized microstructural modification and specific property enhancement. The FSW caused intense plastic deformation, material mixing, and thermal exposure, resulting in significant micros tructural refinement, densificat ion, and homogeneity of processed zone. Good interfacial conditions between particles and base metal can be formed during this solid-state process which avoids the chemical reactions on the interface. Fro m the microstructural observations with different speeds and with conical pin profile, it was found the grain refinement was better due to effective stirring action. It was also concluded that with increase in rotational speed of the tool grain refinement was better. It was also concluded that with increase in rotational speed of the tool grain refinement was better.

Macro structure

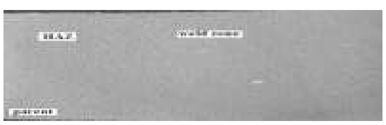
560 RPM 16 mm/ min



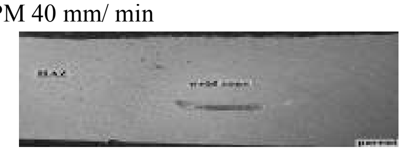
560RPM 40 mm/ min



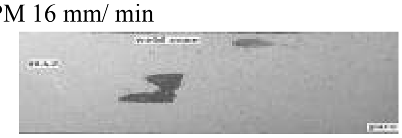
710 RPM 16 mm/ min



710 RPM 40 mm/ min



900 RPM 16 mm/ min



900 RPM 40 mm/ min

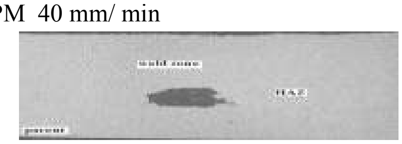
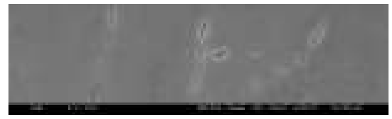


Figure 6: Macro Structure

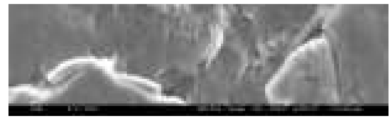
Grain formation in processed zone is good But in high speeds the effect is low.

SCANNING ELECTRO MICROSCOPE

560 RPM 16 mm/ min



560 RPM 16 mm/ min

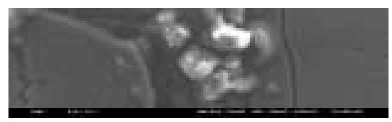


560 RPM 16 mm/ min

Figure 7(a): Scanning Electro Microscope

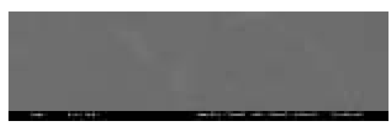
560RPM 40 mm/ min

560RPM 40 mm/ min



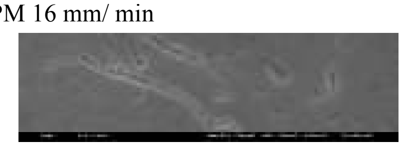
560RPM 40 mm/ min

710 RPM 16 mm/ min

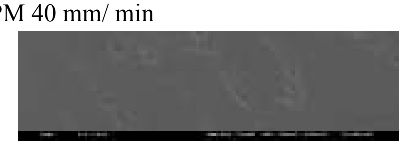


710 RPM 16 mm/ min

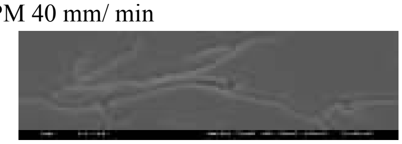
710 RPM 16 mm/ min



710 RPM 40 mm/ min



710 RPM 40 mm/ min

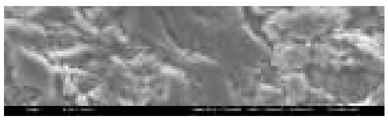


710 RPM 40 mm/ min

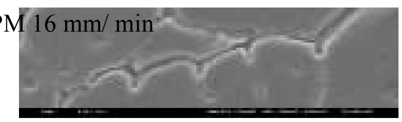
Figure 7(b): Scanning Electro Microscope

900 RPM 16 mm/ min

900 RPM 16 mm/ min



900 RPM 16 mm/ min



900 RPM 40 mm/ min

900 RPM 40 mm/ min

900 RPM 40 mm/ min

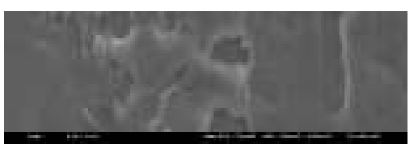


Figure 7(c): Scanning Electro Microscope

CONCLUSION

By carefully controlling the relat ive amount and distribution of the ingredients of a composite as well as the processing condition (speed and feed) the properties can be for friction stir processing.The difficu lty of achieving an the cast metal matrix co mposites have to be studied and proper measure were to be taken. The optimazt ion of 710rp m, 16mm/ min to be measured

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