MECHANICAL PROPERTIES OF FRICTION STIR PROCESSED COPPER ALLOY REINFORCED WITH SIC$_P$ AND Gr AS FILLER MATERIAL

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ABSTRACT

Friction stir processing (FSP) is most promising technique used to enhance ductility and induces super plasticity and thereby improve corrosion resistance properties. FSP has been applied to various cast aluminum and magnesium and copper alloys successfully to reduce casting defects and also improve their mechanical properties.

Literature Review study different paper has been presented. In present study the copper alloy is reinforced with Silicon carbide and graphite powder as filler material for friction stir process. There is various process parameters have been considered such as tool geometry, tool rotational speed, processing speed and axial load for the study. From the experimental research work it has been identified that as the speed increases more will be the uniform distribution of the filler particles along the length of weld for 710 rpm and Cu+90% SiCp + 10% Gr specimen give very good strength. They also found that for 900 rpm travers speed with Cu+80% SiCp + 20% Gr specimen has more value of hardness at the stir zone as compard with 710 rpm.

Key words: Friction stir processing, filler material

1. INTRODUCTION

Friction stir processing (FSP) was developed for microstructural alteration of metallic materials. Welding/processing parameters, tool geometry, and joint design apply significant effect on the material flow pattern and temperature allocation, thereby influencing the microstructural growth of material. In FSP, a rotating tool is plunged into a material and high plastic deformation is formed. FSP is used to improve ductility, induces super plasticity and recover corrosion resistance properties. FSP has been successfully applied to various cast aluminum and magnesium and copper alloys to eradicate casting defects and progress their mechanical properties. Metal transfer, generated between the tool shoulder and the plate, plays a major role in influencing the mechanical properties during friction stir process. Modes of metal flow are clearly visible in the microstructure characteristics, but they are not too distinct in macrostructure of processed samples. Tool geometry is the most powerful aspect of process development. The tool geometry plays a significant role in material flow and in turn governs the traverse rate.

2. LITRETURE SURVEY

Friction stir processing (FSP) is suitable for preparation of surface composites and surface alteration. In FSP a rotating tool with shoulder and pin is inserted into the surface of material, which creates frictional heat and dynamic mixing of material area underneath the tool [1], it leads to inclusion and/or spreading of the reinforcement particles in the matrix material such as Aluminum alloys, Magnesium alloys and Copper [2-4]. Devaraju et al. [5] obtained homogeneous distribution of SiC particles on a surface of Aluminum alloy 6061-T6 through FSP. Hybrid composites are manufactured by reinforcing with a mixture of two or more different types of particles which combines the individual properties of each type of particle. Essam et al. [6] made-up of Al–1050-H24/(20% Al2O3 + 80% SiC) hybrid composite by FSP and shows high hardness and superior wear resistance than the base metal matrix material. In FSP, tool rotational speed plays an important role as a process parameter and which has superior influence in uniform distribution of reinforcement particles, grain refinement and heat input during the process [7, 8]. From the literature study it has been found that the investigations made by various scientists and authors on FSP of copper. But still there is scope to investigate the effect of various process parameters such as shape of groove, tool geometry, travel speed and feed, different composition of filler materials and depth of groove. In the present project work concentrating on effect of composion filler material, tool speed and feed, depth groove on strength of copper material.

3. EXPERIMENTAL PROCEDURE

Friction stir processing (FSP) machine from the central workshop of venkateshwara industries has been utilized for conducting the process. This machine can be used for the work piece dimension of 150*150*4 mm. For the formation of the work piece, copper is used as a base material. So, the sample is cut from the given plate manually using hacksaw. After that, the sharp corner of the samples is rounded by filing for safety purpose. Since, for processing purpose and for filling the filler powder groove is cut on the work piece with the help of the Milling machine 3 mm thick milling cutter has been used for cutting the groove in the middle of the plate along longitudinal axis. The work piece dimension has been taken as 150*150*4 mm and groove dimension has been taken as 140 mm length, 3 mm depth and 3 mm width. The Tool used for friction stir processing is consisting of shoulder and pin. The Tool is made up of High Speed Steel

H13 (HSS). In our case I have used a circular pin tool of 6 mm each side with threaded.

Commercially available pure copper plates of 150 mm length, 150mm width and 4 mm thickness were used in this study. The optical photomicrograph of as received copper plate is shown in figure 1a. A groove was made in the middle of the plate using wire VMC and compacted with SiC+Gr powder as shown in figure 1b. A pinless tool was initially employed to cover the top of the groove after filling with SiC particles and Graphite powder to prevent the particles from scattering during FSP. A tool made of double tempered hot working steel as shown in figure 2 was used in this study. The tool had a shoulder diameter of 20 mm, pin diameter of 5 mm and pin length of 3 mm.

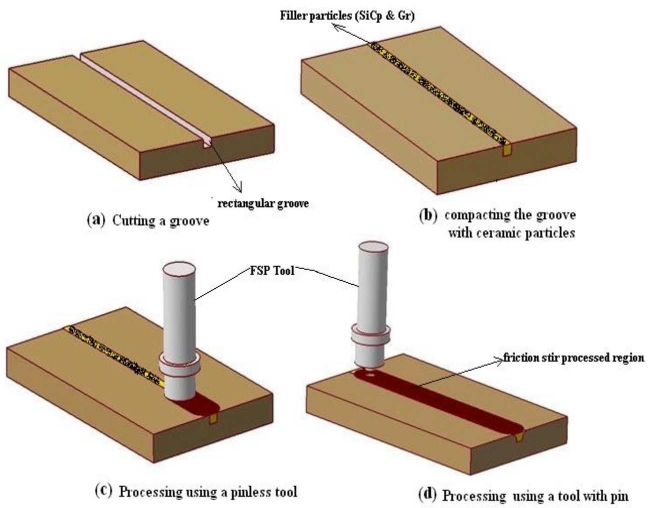


Figure (1) FSP procedure to fabricate surface composite

Fig (2) Tools used during Friction stir processing

Table 1 Specification of tool and processing parameters

Process parameters	Values
Tool rotational speed (rpm)	710, 900
Processing speed (mm/min)	25 mm/min
Axial force (kN)	5
Tool shoulder diameter (mm)	20
Tool shoulder surface	Flat
Pin diameter (mm)	6
Pin length (mm)	3.8
Pin profile	Rectangular
Groove width (mm)	3mm
Groove depth (mm)	1mm to 3mm
Groove length (mm)	140

TEST PROCESS PARAMETER

In the present work there are four specimens are prepared by varying composition of filler material and Travers speed using friction stir processing as shown in Table 2.

Table 2 composition of pure copper / SiCp-Gr specimen

Sl. No	Specimen type	Tool material	Process parameter	Composition of filler material
1	Specimen-I	HSS H13	710rpm, 25mm/min	80% SiC_P + 20% Gr
2	Specimen-II		710rpm, 25mm/min	90% SiC_P + 10% Gr
3	Specimen-III		900 rpm, 25mm/min	80% SiC_P + 20% Gr
4	Specimen-IV		900 rpm, 25mm/min	90% SiC_P + 10% Gr

TEST SPECIMEN

The friction stir welding technique was used to join the dissimilar Al6061 alloy and pure copper material. According to ASTM E8 the test specimen was prepared as shown in figure. 3.

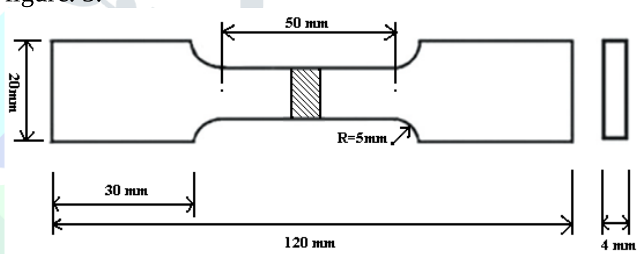


Figure.3 Test specimen

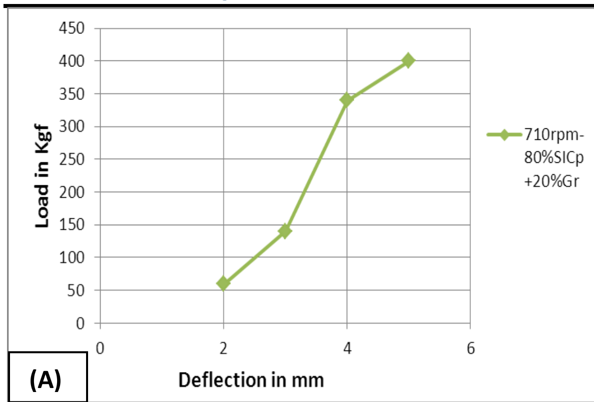
The tensile test and Hardness test was conducted to all specimen to determine the mechanical properties of FSP copper/SiC_p/ Gr materials.

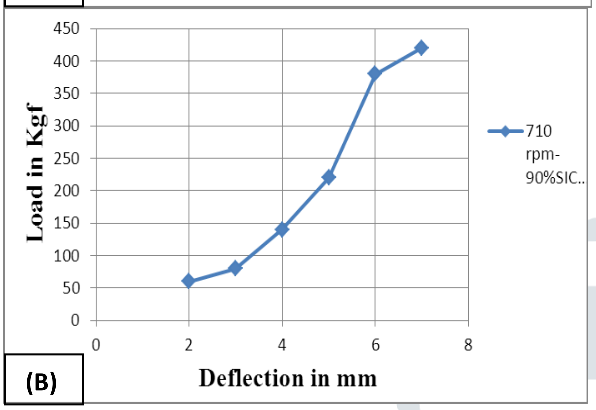
4. RESULTS AND DISCUSSION

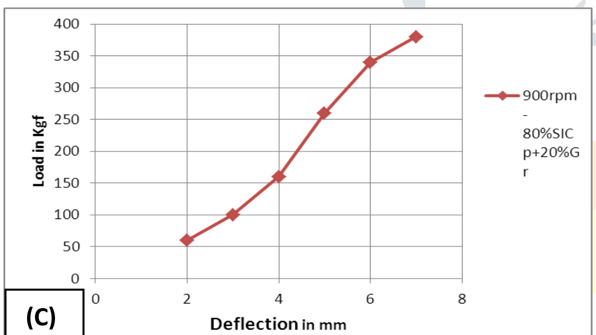
The experimental investigation on friction stir processing pure copper metal is reinforced with silicon carbide (SiC_p) and graphite (Gr) particle. The SiC_p and Gr were added to the groove made on the copper plate with dimension 140 mm*3 mm. For the first specimen the volume fraction of the filler material is Cu+80% SiC_p+20% Gr. Similarly for second the volume fraction of the filler material is Cu+90% SiC_p+10% Gr. The percentage of reinforcement, Travers speed and feed and applied load have significant effect on the strength of the material were plotted and discussed in the following section.

EFFECT OF SPEED ON SPECIMEN ALONG THE WELDING

The above figures show that variation of deflection against the load. The tensile test was conducted across welding with different speed and composition. It is clearly indicating that as the load increases the deformation also increases.







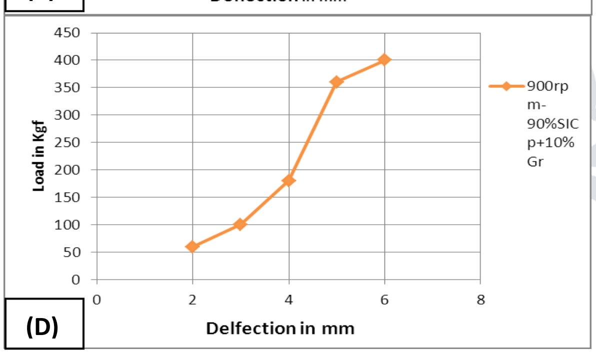


Figure A and B show that when the percentage of filler materials increases load carrying capacity of the material will also changes. The Cu+80% SiCp + 20% Gr specimen with 710 rpm traverse speed and 25 mm/min feed, the deformation and load carrying of material capacity of the material is less due to more percents of graphite present in it as shown in graph A. The Cu+90% SiCp + 10% Gr specimen give more strength as well as deformation as compared to the Cu+80% SiCp + 20% Gr specimen because of more percentage of SiCp particle and acting as a resistance against the deformation.

Figure C and D clearly representing that The Cu+80% SiCp + 20% Gr specimen with 900 rpm traverse speed and 25 mm/min feed, the load carrying of material capacity of the material is less. But deformation is more for the speed of 900 rpm as compared to the 710 rpm with same composition of specimen because when the speed is increases the particles present in the groove will distributed more uniformly.

When the percentage of graphite is decreases to 10% Gr by increasing 90% SiCp in the grooved copper plate specimen there is slight increases in load carrying capacity and decreases in deformation as compared to the Cu+80% SiCp + 20% Gr specimen with same traverse speed along the length of weld.

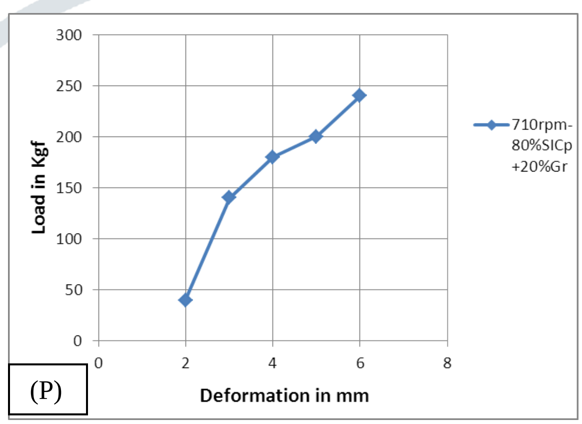
Form the above discussion it is found that both speed as well as percentage of reinforcement particle places an important role in the strength of the material. Finally it can be concluded that as the speed increases more will be the uniform distribution of the filler particles. When comparing with figure B and D along the length of weld for 710 rpm and Cu+90% SiCp + 10% Gr specimen give very good strength.

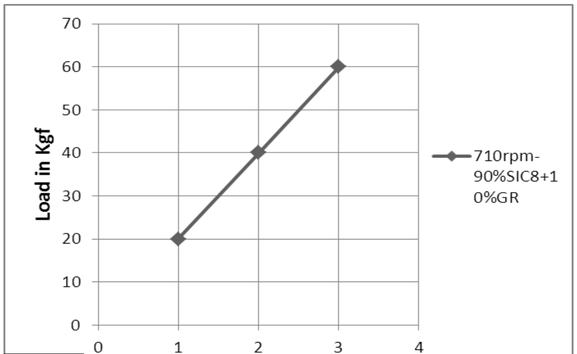
EFFECT OF SPEED ON SPECIMEN ACROSS THE WELDING

The graphs as shown in below represent variation of deformation with load. The tensile test was conducted across welding with different speed and composition.

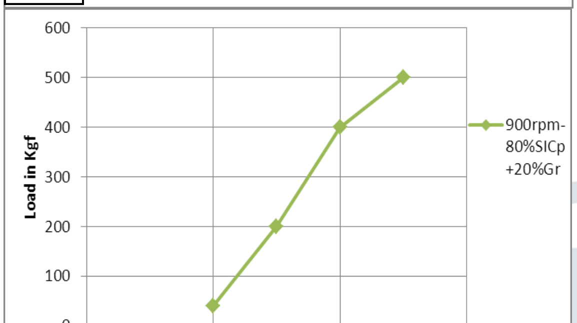
Figure P and R show that the Cu+80% SiCp + 20% Gr specimen with 710 rpm, 900 rpm traverse speed and with constant 25 mm/min feed, the deformation and load carrying of material capacity of the material is more in case of 900 rpm as compared with the 710 rpm specimen because of presence of hard SiCp particle, but less deformation since at 900 rpm graphite powder is thoroughly mixed with base material and is acting as a lubricating agent against the deformation. The fracture of Cu+80% SiCp + 20% Gr specimen with 710 rpm occur at load below the 240 kgf and in case of Cu+80% SiCp + 20% Gr specimen with 900 rpm failure take place at load of 500 kgf as indicated in graphs.

Figure Q and S clearly representing that the Cu+90% SiCp + 10% Gr specimen with 710 rpm, 900 rpm traverse speed and with constant 25 mm/min feed, the deformation and load carrying of material capacity of the material is more in case of 710 rpm as compared with the 900 rpm specimen since percentage of hard SiCp particle is more. At 900 rpm with same composition the specimen is fails suddenly without application appreciable load on it.





(Q)



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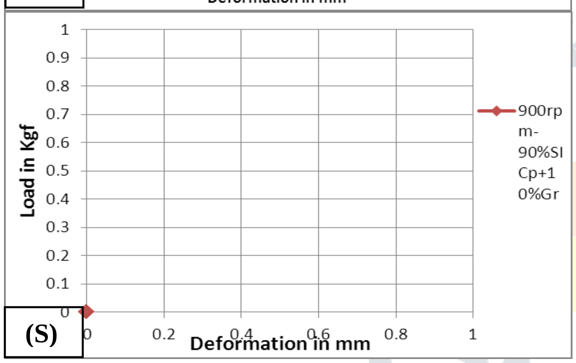
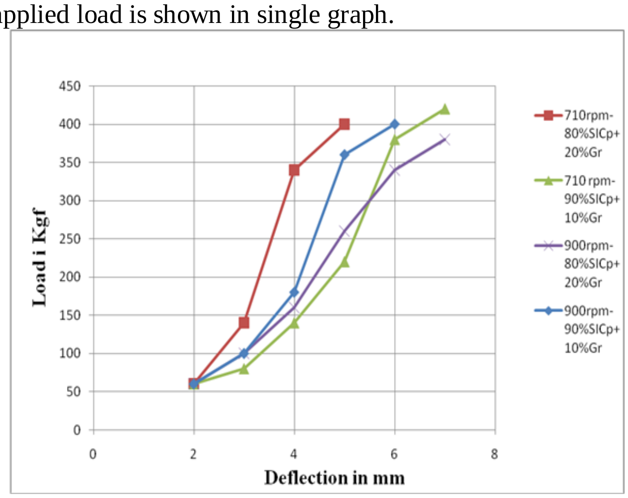


(S)

Form the above explanation it is found that in case across the welded test specimen for the 900rpm speed with Cu+80% SiCp + 20% Gr specimen has more load withstanding capacity as compared with other composition and speed.

COMPARISON OF SPECIMEN

The comparison of strength of all test specimens against the applied load is shown in single graph.



2.2 HARDNESS TEST

The hardness test was conducted for the different composition of specimen. Basically the hardness value of value of material has been collect at three different regions such as left, middle and right sides of the friction stir processed copper metal with SiCp and Gr as filler materials. The hardness values of different specimen is plotted in the below graph.

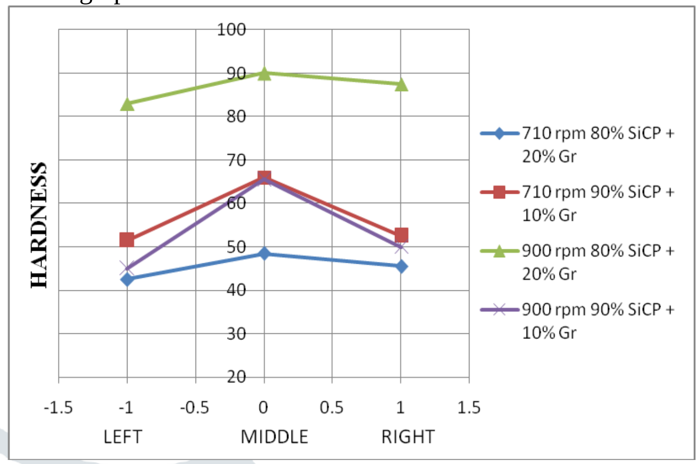


Figure 4.1 Hardness of FSP specimen

From the above graph can be seen clearly that when the reinforcement particles are added to the base metal the hardness of the metal will also increases. In case of 900 rpm travers speed with Cu+80% SiCp + 20% Gr specimen has more value of hardness at the stir zone as compard with 710 rpm. For the more speed more the uniform distributions of filler particles with base metal. Where as in Cu+90% SiCp + 10% Gr specimen, the hardness value at stir zone is approximately similar value.

5. CONCLUSION

1. The Cu+80% SiCp + 20% Gr specimen with 710 rpm traverse speed and 25 mm/min feed, along the length of the deformation and load carrying of material capacity of the material is less due to more percents of graphite present in it.
2. The Cu+90% SiCp + 10% Gr specimen give more strength as well as deformation as compared to the Cu+80% SiCp + 20% Gr specimen because of more percentage of SiCp particle.
3. The Cu+80% SiCp + 20% Gr specimen with 900 rpm traverse speed and 25 mm/min feed; the load carrying of material capacity of the material is less. But deformation is more for the speed of 900 rpm as compared to the 710 rpm with same composition of specimen because when the speed is increases the particles present in the groove will distributed more uniformly.
4. Finally it can be concluded that as the speed increases more will be the uniform distribution of the filler particles. When comparing with figure B and D along the length of weld for 710 rpm and Cu+90% SiCp + 10% Gr specimen give very good strength.
5. Across the length of welding, the deformation and load carrying of material capacity of the material is more in case of 900 rpm as compared with the 710 rpm specimen because of presence of hard SiCp particle, but less deformation since at 900 rpm graphite powder is thoroughly mixed with base material and is acting as a lubricating agent against the deformation.
6. The fracture of Cu+80% SiCp + 20% Gr specimen with 710 rpm occur at load below the 240 kgf and in case of

Cu+80% SiCp + 20% Gr specimen with 900 rpm failure take place at load of 500 kgf.

7. The deformation and load carrying of material capacity of the material is more in case of 710 rpm as compared with the 900 rpm specimen since percentage of hard SiCp particle is more. At 900 rpm with same composition the specimen is fails suddenly without application appreciable load on it.

8. In case of 900 rpm travers speed with Cu+80% SiCp + 20% Gr specimen has more value of hardness at the stir zone as compard with 710 rpm.

6. REFERENCE

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