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Mechanical Behavior of Silicon Carbide Reinforced Friction Stir Welded Joint of Aluminium Alloy 6061

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Abstract: **In this work the Mechanical behavior of reinforced welded butt joints of AA6061 aluminium alloy fabricated by friction stir welding process has been investigated. 10%, 15%, 25%, 30% volume fractions of Silicon carbide (SiC) particulates of 400 mesh were added at weld interface. This work was focused to study the effect of Sic as reinforcing material along with different volume proportions on the mechanical properties of friction stir welded joint of AA6061.The experimental results indicated that the reinforcing material and percentage of reinforcing material has a major effect on the mechanical properties of welded joint. The results of reinforced friction stir welded joints were correlated with parent material and without reinforced friction stir welded joint. The best results have been obtained at 25% volume fraction of silicon carbide particulates at weld interface. But at the same time percentage of elongation decreases and the behavior of material changes from ductile to brittle.**

***Key Words**: Friction Stir Welding, Reinforcing material, Silicon Carbide, Aluminium Alloy AA6061, Mechanical properties*

1. INTRODUCTION:

Aluminum alloys are preferred engineering material for automobile, aerospace and mineral Processing industries for various high performing components that are being used for varieties of applications owing to their lower weight, excellent thermal conductivity properties. Among several series of aluminum alloys, heat treatable Al6061 are much explored, Al6061 alloy are highly corrosion resistant and are of excellent extricable in nature and exhibits moderate strength and finds much applications in the fields of construction (building and high way), automotive and marine applications. [1].

Importance of reinforcement at weld interface of friction stir welded joint is to enhance the mechanical properties at weld portion. Mechanical properties are enhanced by adding different reinforcement particulates at different volume proportions. Selection and percentage of reinforcement is according to requirement and applications. Aluminium alloys with a wide range of properties. Among all aluminum alloys, AA 6061 alloy plays major role in the aerospace industry in which magnesium and silicon (0.3-1.5 w%, Si, Mg) are the principal alloying elements. It is widely used in the aerospace applications because it has good formability, weldability, machinabilty, corrosion resistance, and good strength compared to other aluminum alloys. Aluminum alloys are generally classified as non-weldable because of the poor solidification microstructure and porosity in the fusion zone.

Also, the loss in mechanical properties as compared to the base material is very significant. These factors make the joining of these alloys by conventional welding processes unattractive. Some aluminum alloys can be resistance welded, but the surface preparation is expensive, with surface oxide being a major problem. The Welding Institute (TWI) of UK in 1991 as a solid-state joining technique, and it was initially applied to aluminium alloys. The basic concept of FSW is simple. A non-consumable rotating tool with a specially designed pin and shoulder is inserted into a butting edge of sheets or plates to be joined till the shoulder contact the top surface of workpice and traversed along the line of joint to produce the weld. The tool serves primary functions (a) heating of workpiece, (b) deform the material (c) movement of deform material to produce the joint. The heating is accomplished by friction between the rotating tool and the workpiece and plastic deformation of workpiece. The localized heating softens the material around the pin and combination of tool rotation and translation leads to movement of material from the front of the pin to the back of the pin. As a result of this process a joint is produced in "solid state". [3].

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2. EXPERIMENTAL PROCEDURE

2.1 Materials and Welding Parameters: Friction stir welding technique by applying automatic CNC machine was used to produce butt welds. The parent alloy used was AA6061 aluminum plates with thickness of 4 mm. The nominal compositions (in wt %) is displayed in Table 2. The butt joint configuration was prepared to add the reinforcement particles and to produce the joints. The direction of welding was normal to the rolling direction of Aluminium plates. A non-consumable welding tool made of high carbon steel (H13) was applied to fabricate the joints. The composition is displayed in table 1. The welding conditions and the chosen tool parameters used for welding in this work used to produce the joints in this investigation are listed in Table 3. To improve the mechanical properties at weld joining, the Silicon carbide of 400 mesh reinforcement particles were added at weld interface with different proportions such as 10%, 15%, 25%, 30% by creating separate geometries at weld interface. After inserting reinforcement particulates at separate geometry which was created to add the reinforced particles, geometry has been closed by processing the tool of diameter 24 mm at 560 R.P.M without pin. The friction stir welding was produced.

Table 1: Chemical composition of H13 Tool

Element	C	Mn	Cr	Mo	V	Si	Fe
Weight (%)	0.40	0.35	5.20	1.30	0.95	1.0	Reminder

Table 2: Chemical composition of AA6061

Element	Mg	Si	Fe	Cu	Cr	Mn	Zn	Ti	Al
Weight (%)	0.9	0.62	0.33	0.28	0.17	0.06	0.02	0.02	balance

2.2 TOOL AND REINFORCEMENT MATERIAL:

Fig.1: FSW Tool

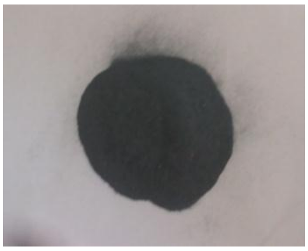

Fig.2: Silicon carbide powder of 400 Mesh

Table 3: Welding conditions and process parameters used in this work

PARAMETER	VALUE
Rotation speed (rpm)	1120
Welding speed (mm/min)	40
Tool shoulder diameter (mm)	18
Pin diameter (mm)	7
Pin length (mm)	3.5
Tilt angle (◦)	0
Pin Shape	Conical

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2.3 FRICTION STIR WELDED SPECIMENS

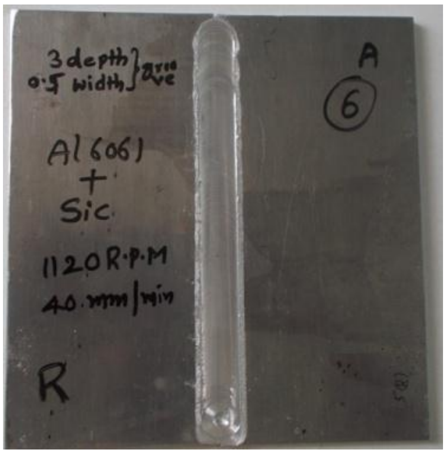
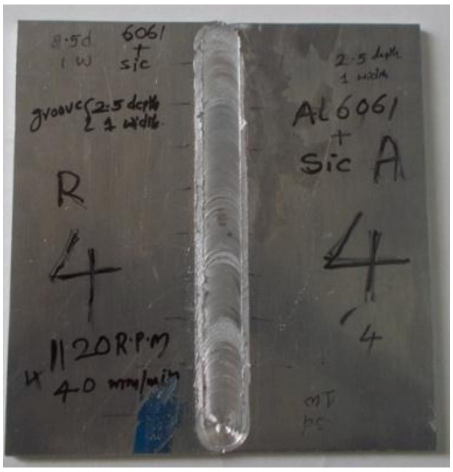


Fig.3: FSW Joint With 10% Sic By Volume Fig.4: FSW Joint With 15% Sic By Volume



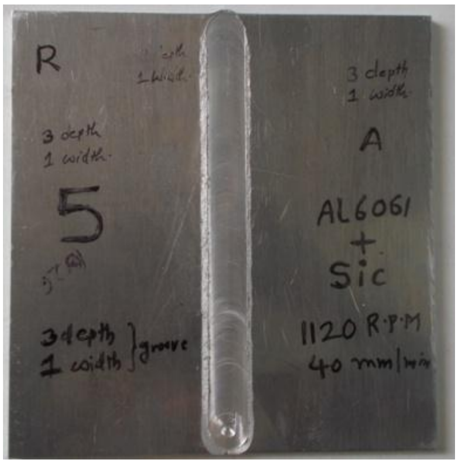
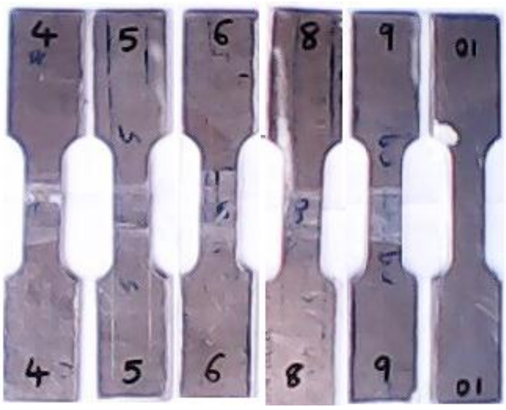


Fig.5: FSW Joint With 10% Sic By Volume Fig.6: FSW Joint With 10% Sic By Volume

2 TENSILE TEST SPECIMENS:



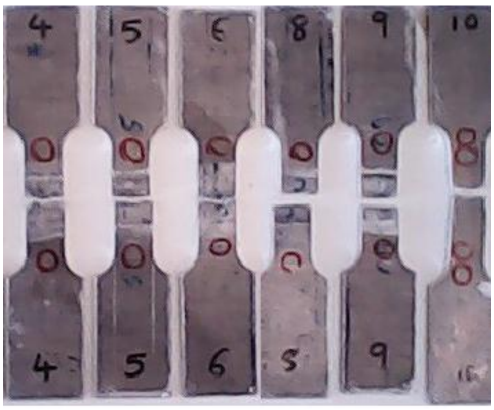


Fig.7: Tensile Test Specimens Fig.8: Tensile Tested Specimens

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3. RESULTS AND DISCUSSION

3.1Mechanical properties of base metal and FSW without reinforcement

Table 4: Mechanical properties of base metal and FSW without reinforcement

Mechanical properties	Base Metal AA6061 (without weld)	FSW Joint Without reinforcement
Ultimate Tensile strength (MPA)	315.269	163.815
Yield Strength (MPA)	265.260	138.157
% Of Elongation (%)	17.240	9.00
Impact Strength (Charpy) (J)	9	12
Hardness (BHN)	55	68
Bend	180^0	180^0

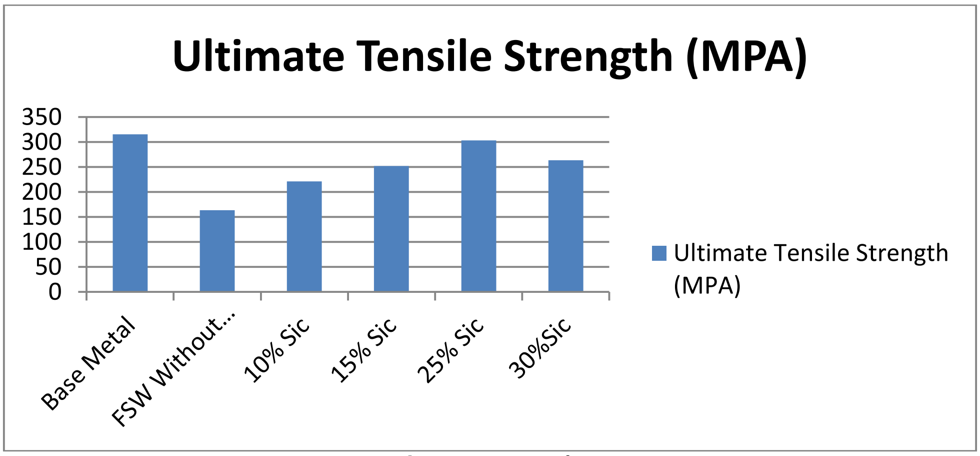
Table4 reveals that the mechanical properties of friction stir welded joint of aluminium Alloy 6061. From the results it was concluded that after friction stir welding of aluminium alloy 6061, the mechanical properties such as ultimate tensile strength, yield strength and percentage of elongation were decreased.

Table 5: Mechanical properties of FSW with Sic as reinforcement at weld interface

S.NO	% of Silicon carbide (By Volume)	Ultimate Tensile strength (MPA)	Yield Strength (MPA)	% Of Elongation (%)
1	10	221.15	191.18	7.47
2	15	252.00	217.42	7.02
3	25	303.05	263.68	6.09
4	30	263.28	261.03	3.80

Table 6: Mechanical properties of FSW with Sic as reinforcement at weld interface

S.NO	% of Silicon carbide (By Volume)	Impact Strength (Charpy) (J)	Hardness (BHN)	Bend
1	10	8	93	Not bending to 180^0
2	15	8	96	
3	25	6	104	
4	30	6	101	



Graph 1: comparison of UTS

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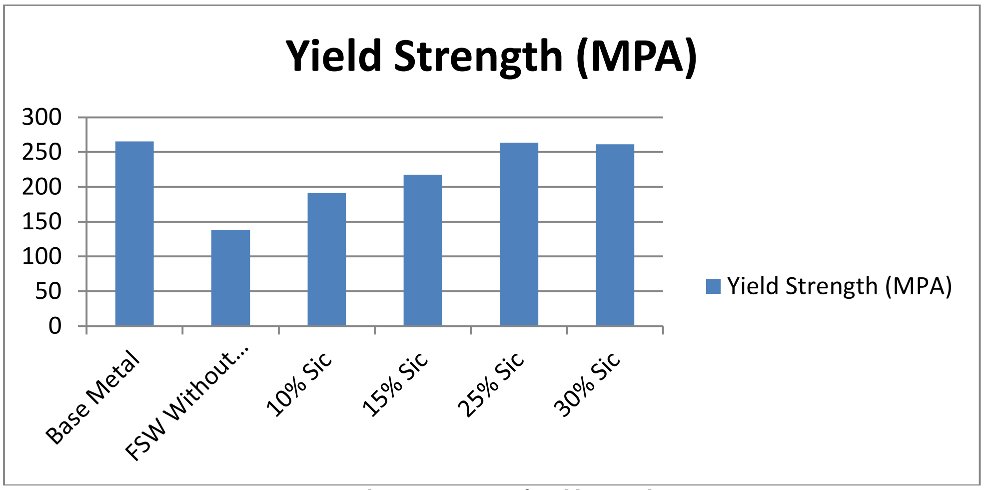
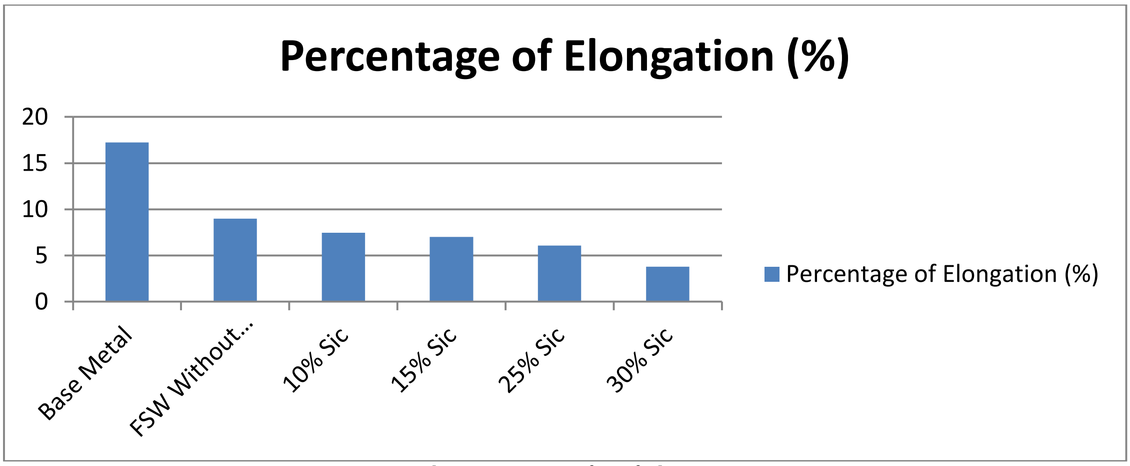


Graph 2: comparison of Yield Strength

3.2 ULTIMATE TENSILE AND YIELD STRENGTH:

The graph (1) reveals that the ultimate tensile strength of friction stir welded joint without reinforcement at weld interface decreases about 52% over the parent metal and increases about 96 % and 83.5% by addition the reinforcement from 10% to 25% and 25% to 30% respectively. When the reinforcement increases from 25 to 30 percentages the ultimate tensile strength decreases by 12.5% compare to the 25 percentages of reinforcement.

Similarly graph (2) shows the increase in yield strength of friction stir welded joint about 99.4 percentages as the reinforcement silicon carbide content increases from 10 to 25 volume percentage compare to the friction stir welded joint without reinforcement at weld interface. When the reinforcement increases from 25 to 30 percentages the yield strength of the joint decreases by 1% compare to the 25 % reinforcement. In both cases the addition of SiC from 10% to 25% as reinforcement at welded portion increasing the tensile properties of friction stir welded joint and decreases the tensile properties when the addition of SiC from 25% to 30% .



Graph 3: comparison of % of Elongation

3.3 PERCENTAGE OF ELONGATION:

Graph (3) is a graph showing the effect of reinforcement content on the percentage of elongation of Friction stir welded Joint of AA6061. It can be seen that as the Silicon carbide content increase, the percentage of elongation of the welded joint decreases. Quantitatively as SiC content is increased from 10 to 30 Volume percentages, is a reduction in percentage of elongation 78%. The brittle nature of the reinforcing materials (SiC) plays a significant role in degrading the percentage of elongation of the friction stir welded joint.

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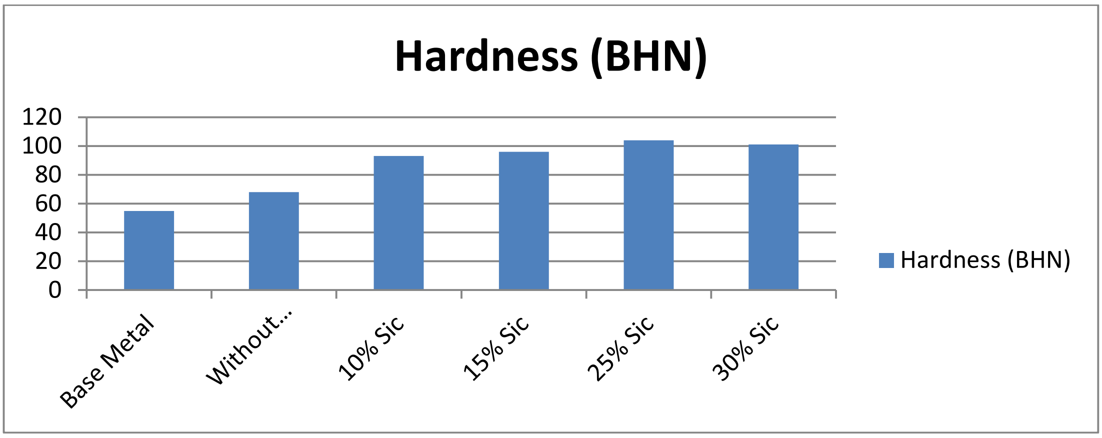
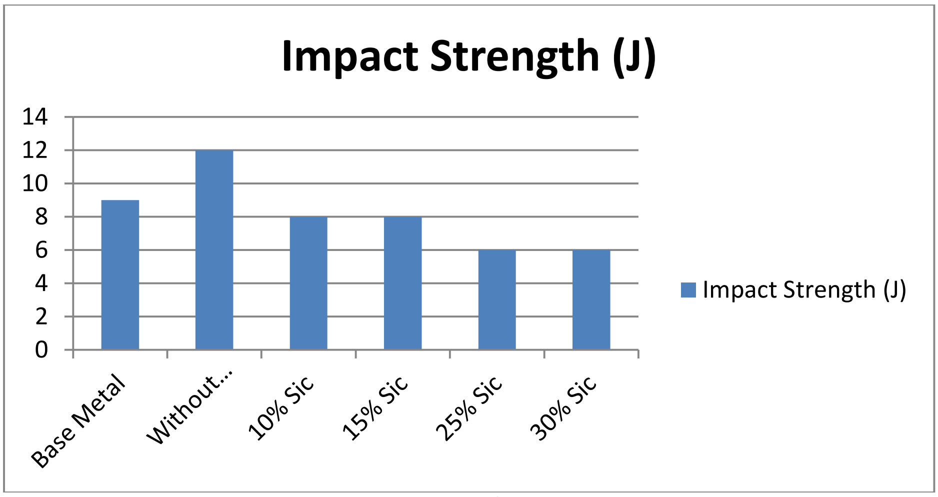


Graph 4: comparison of Hardness

3.4 HARDNESS:

From graph (4) the hardness value of friction stir welded joint increase as the volume percentage of SiC at weld interface increases from 10% to 25% at the joint and decreases from 25% to 30%. The hardness of friction stir welded joint increased about 19% at weld portion without adding reinforces particulates. As the reinforcement at weld interface from 10% to 25 % and 25% to 30% hardness increases about 47% and 45.5% respectively. This is due an increase in the percentage of the hard and brittle phase of the ceramic particulates in the joint.



Graph 5: comparison of Impact Strength

3.5 IMPACT ENERGY:

Graph (5) is a graph showing the effect of reinforcement content on the impact energy of Friction stir welded Joint of AA6061. It can be seen that as the Silicon carbide content increase, the impact energy of the welded joint decreases. Quantitatively as SiC content is increased from 10 to 30 Volume percentages, is a reduction in impact energy 33.33%. The brittle nature of the reinforcing materials (SiC) plays a significant role in degrading the impact energy of the friction stir welded joint, since the unreinforced friction stir welded joint have the highest impact energy compare to parent material and reinforced friction stir welded joint, indicating that it is the toughest of them all.

CONCLUSION

Mechanical properties of reinforced friction stir welded joint were good compare to unreinforced friction stir welded joint of aluminium alloy 6061.

Mechanical properties of a friction stir welded joint of Aluminium alloy 6061 was enhanced by addition of Silicon Carbide particulates at weld interface with volume proportions 10% to 25%. But when the volume proportion was 25% to 30% mechanical properties were decreased. In all volume proportions percentage of elongation was decreased.

Friction Stir welded joint without reinforcement having less mechanical properties compare to parent metal and with reinforcement.

Due to reinforcing materials which was added at weld interface the material behavior changes from ductile to brittle.

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REFERENCES

[1] J. Gilbert Kaufman, “Properties of Aluminum Alloys Tensile, Creep, and Fatigue Data at High and Low Temperatures”, ASM International 2002.
[2] Farhad Gharavi, Khamirul Amin Matori, Robiah Yunus, Norinsan Kamil Othman, Firouz Fadaeifard. “Corrosion behaviors of Al6061 alloy weldment produced by friction stir welding process”. Journal of Materials Research and Technology, 2015, P.P 314-322.
[3] Prashant Prakash, Sanjay Kumar Jha, Shree Prakash Lal, “A Study of Process Parameters of Friction Stir Welded AA 6061Aluminum Alloy”, International Journal of Innovative Research in Science, Engineering and Technology, Vol. 2, Issue 6, June 2013, P.P 2304-2309.
[4] Abbas MK, “Effect of friction stir welding on the microstructure and corrosion behavior of aluminum alloy AA6061-T651”.In Proceedings of the 2nd regional conference for engineering and sciences. 2010
[5] El-Menshawy K, El-Sayed A, El-Bedawy ME, Ahmed HA,El-Raghy SM. “Effect of aging time at low aging temperatures on the corrosion of aluminium alloy 6061”. Corrosion Science, 2012, 54:167–73.
[6] Zhang D, Li J, Joo HG, Lee KY. “Corrosion properties of Nd:YAG Laser–GMA hybrid welded AA6061 Al alloy and its microstructure”. Corrosion Science 2009; 51:13991404.
[7] Nikseresht Z, Karimzadeh F, Golozar MA, Heidarbeigy M. “Effect of heat treatment on microstructure and corrosion behavior of Al6061 alloy weldment”. Materials and Design, 2010; 31:2643–8.
[8] M. Kok, “Production and mechanical properties of Al2O3 particle-reinforced 2024 aluminum alloy composites”, Journal of Materials Processing Technology, 161 (2005), P.P 381–387.
[9] G.B. Veeresh Kumar, “Studies on Al6061-SiC and Al7075-Al2O3 Metal Matrix Composites”, Journal of Minerals & Materials Characterization & Engineering, 9(1), PP.43-55, 2010.