

Characteristic Investigation on Impact Strength of Aluminium Based Hybrid Composite Plates Weld by FSW

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Abstract

Aluminium Alloy 2024 metal-matrix composites fortified with Silicon carbide fine greenish particulates show enhanced mechanical properties like high toughness, high flexible modulus, and good resist wear, which makes them promising auxiliary materials for automobile field and aviation enterprises. Notwithstanding, these composites likewise demonstrate poor in malleability and ductility because of reinforce of non-deformable ceramic particulates, which restrains their wide applications to a specific degree, stifle this by strengthen arbitrary spasmodic E-glass fibers and exceeds expectations structure with higher sturdiness. The Current work is meant to examine the process parameters of friction stir welding on Aluminium metal matrix composite plates of measurement 100mmx50mmx6 mm joined by the high carbon high chromium tool, rotational speed of 600rpm, 900rpm and 1200 rpm also compiled welding speed rate of 40 mm/min, 80mm/min and 120 mm/min, Followed via completed Charpy Impact test on ASTM standard samples, classify the effect quality and contrasted and that of unreinforced matrix.

Keywords: Metal Matrix, Silicon Carbide, E Glass Fiber, Friction Stir Welding, Charpy Impact Test.

1. Introduction

Friction stir welding (FSW) is a relatively new solid-state joining process especially for low melting temperature and non ferrous materials. FSW technique is a versatile pressure welding process; join the metals in their plastic stage. its bag having lot advantages over other conventional method of fabrication of non ferrous materials such as less energy utilization, no environmental issue, and mass production. In particular, it can be used to assemble low weight high strength aerospace aluminum alloy metals [1]. FSW is one of the most recent progressions that basically utilize the combination of friction and heat created by grating interface between the hard non deformable tool and work piece to produce locally diffusion of atoms in plates create joint of strong solid state systems [2]. First idea beyond joining of materials using friction and stir combination, FSW created by TWI. This strategy is even though not for the most part used because of the particular weaknesses. However, it has ended up being most capable and intense welding technique in advance and aeronautics field has been benefitted by advancement of this FSW process in strong state. here no melting temperature involve in joining its eliminates residual stress elimination concepts, FSW method is used to combine comparative or different materials by compactive development of pivot and controlled development in production of strong weld joint [3]. Works on different types of tools its influences on performance of friction stir welding and concluding the results with welding parameters [4]. [5] Some researchers attracted towards this novel joining technique and enthused about

perspectives like investigate variety of mechanical characteristic of weld joint in hardness, diffusivity, temperature segments, interface and bonding of materials [6]. In the Friction Stir Welding technique, except process parameters number of tool pass on work and the metal to be welded makes the drastic change in characteristic of properties of materials. In the meantime, the thermo mechanically plasticized zone is produced by grating between the tool and the surface of the plate and by contact of the neighbor atoms due to stir action [9-10]. due to spectacular benefits of light weight and presence of copper as major alloy The Aluminum AA 2024 compound has been altogether used as a conspicuous materials of the aviation parts and vehicle field, the segments are manufactured by FSW due to highly resists to corrosion and toughness. In current work is gone for trademark examination of the various parameters of FSW of Aluminum alloy 2024 hybrid composites. Dynamic strike on automobile, aerospace components leads severe physical damage measured through toughness behavior. An exhaustive literature review has been made in the areas of fracture toughness testing. In this work investigate the fracture toughness means impact strength of stir weld AA2024 composite plates.

2. Selection of Materials and Techniques

A. Ingredients of Hybrid Composites

The work is generally centered an around Automobile applications; hereafter it is judicious to select ingredients of composite materials having valuable characteristic for particular area of application. Perceived and prime property to be aim for assurance of materials is reduction in weight. Automobile segments looking advantages with respect to weight to strength

ratio, brings about less fuel utilization, long life. In this research 2024 aluminium alloy (AA 2024) compound as metal matrix compound and short intermittent Electrical grade glass fibers (E) 2 to 3 mm length, fine greenish Silicon Carbide of 25 micron used as reinforcement. Aluminum alloy is ductile compound having demurely Cu as the primary inclusion synthesis with remains lower hints of Mn, Mg, Cr, ferrous trace and Si. The matrix is by and large used metal in aviation segments also, Henceforth it is fitting to consider, comprehend and build up a welding technique which will simply benefit the manufacture of segments. Silicon Carbide (SiC) - (Reinforcement) is for a long while known to be a fair fortification material used as machining tool ingredient specially in grinding. these are hard ceramic particles, combined with matrix phase incorporated and promote more advances in properties enhancement . E-Glass fiber is otherwise called "Electrical grade Glass", prime advantages of fiber are "better stiffness and relatively less weight, resistance to corrosion and chemical attack, impervious to moisture absorption and electrical insulation". Following tables projects consoled ingredients of reinforce materials.

B. Stir Casting

Al 2024 is melted in graphite crucible with coke fire open heart furnace to prevent contamination in side crucible. Casting process is done for 0% of reinforcement in the initial trial and then a measured weight % of silicon carbide and E-glass fibers of 7% and 3% respectively. Preheat sic, glass fibers in separate container up to 500 degree for SiC, and 700 degree for Glass fiber. Followed by mixing the reinforcement add some amount of scum power to molten aluminium, it removes impurities in molten state form slag, due to light in nature it settle on upper surface of molten metal, then is removed. then preheated reinforcement (Sic and E-glass fibers) is added in to the molten metal with the help of mechanical stirrer stir the molten ingredients mixture with suitable speed of 700 rpm up to 2 minutes each in three slot, it helps proper distribution of the reinforcement throughout the molten. The temperature of composite is maintained around 720°c .the composite melt was poured into a preheated die to solidify. With the help of fettling and wire EDM machine weld plates are produced.

Table 1: Percentage of composition in E-glass fiber (by weight)

SiO ₂	Al ₂ O ₃	CaO	MgO	B ₂ O ₃
54.3%	15.2%	17.2%	0.6%	8.0%

Table 2: Percentage of composition in AA 2024 (by weight)

Cu	Mn	Mg	Si	Cr	Zn	Ti	Iron	Aluminium
3.8-4.9	0.30-0.90	1.20-1.80	0.50	0.10	0.25	0.15	0.5	Balance



Fig. 1: AA2024 Billet



Fig. 3: Pattern Impression



Fig. 2: Mould Preparation



Fig. 4: Melting



Fig. 5: Pouring

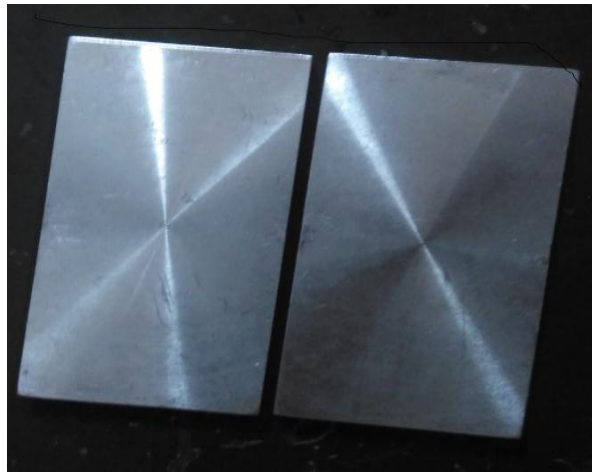


Fig. 6: Cast Plates

C. Friction Stir Welding

Fabricated specimens of standard size 100mm x50mm x 6mm dimensions are joined using Friction Stir welding in order to get butt type. The welding is finished using an indigenous ETA fabricated 3 axis Friction Stir Welding machine, the tool (pin, shoulder) diving down the contact line of the butt plates produced localized deform, friction along the travel line, create adequate measure of heat to join the samples, deliver strong bond between plates because of forged action of shoulder face on work and atomic diffusion in contiguous plates due to stirring of tool. Different types of taper pin tools used for welding process. In current work we have used high carbon high chromium Tool having a cylindrical tapered pin length. Welding is carried out using an indigenously built FSW machine with welding parameters focus on tool rotational speed and weld speed (Feed rate), Tilt Angle is zero. Weld length is 70 mm along butt surface of plate with single pass. Initially 2 composite plates are fixed firmly on support backing plate of welding machine in the vertical position and a radial compressive load has been applied over plates to prevent the split and slip formation between them with usage of alignment key. Then machine is switched on using hydraulic button, machine is operated, the parameters are employed in the program of a FSW machine, resulting a strong sound weld. Welding parameters coated as below table.

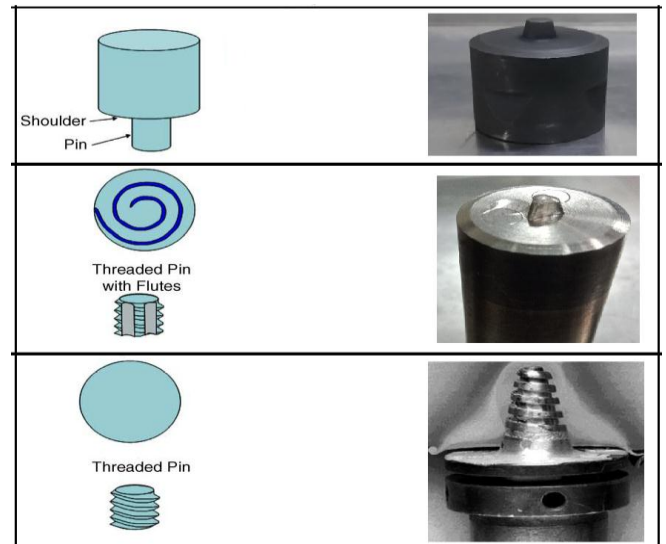


Fig. 7: Different types of taper pin tools

Table 3: Friction stir welding parameters

Sl no	Rotational speed (rpm)	Traverse speed (mm/min)	Tilt angle (degree)
1	600	40	0
2	900	80	0
3	1200	120	0



Fig. 8: ETA 3 axis Friction Stir Welding machine

After every trail the welded samples are machined with help of wire EDM along transverse direction to the weld and prepare ASTM E-23 Charpy impact test standard samples.

3. Experimental Setup

The present work goes for adequately weld the sample plates at various arrangement of parameters regarding rotational spindle speeds are 600, 900 and 1200 rpm along tool feeding rate are 40,80, 120 mm/min. Spindle Torque, Normal load and Traverse load experienced amid during welding of hybrid composite plates. Table.4 Indicates tests points of interest for Impact test directed on both weld and non weld zone tests of Base AA 2024and Composite plate samples



Fig. 9: Friction Stir Weld Plate

Table 4: Impact test samples

Specimen	Sample details	Weld parameters
1	AA 2024 +0% sic +0% E glass	-
2	AA 2024 +7% sic +3% E glass	-
3	20S1F1 (AA 2024 +0% sic +0% E glass)	600rpm and 40mm/min
4	20S1F2 (AA 2024 +0% sic +0% E glass)	600rpm and 80mm/min
5	20S1F3 (AA 2024 +0% sic +0% E glass)	600rpm and 120mm/min
6	2S1F1 (AA 2024 +7% sic +3% E glass)	600rpm and 40mm/min
7	2S2F1 (AA 2024 +7% sic +3% E glass)	900rpm and 40mm/min
8	2S3F1 (AA 2024 +7% sic +3% E glass)	1200rpm and 40mm/min

A. Characterization of Mechanical Properties

Once FSW is done, the Charpy Impact Test Specimen is machined with reference to "ASTM E-23 standard" using wire EDM. The figure below gives the schematic diagram of impact test samples of size 55mm X5mmX10mm (length X thickness X width). The Charpy test is a standard method of studying the impact strength of

a component. A rectangular beam is V notched in the center, it is then placed between two end supports of anvils and is broken by a strike the weight along pendulum against the work piece, place notch at same face of strike also measure the height of which the pendulum was dropped. Then find the total energy absorbed by the sample and tabulated.

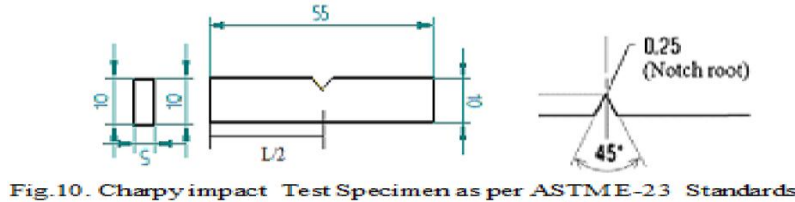


Fig.10. Charpy impact Test Specimen as per ASTM E-23 Standards

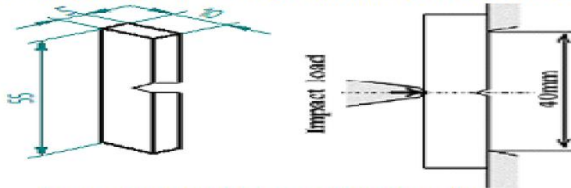


Fig.12. Method Of Strike On Work Piece



Fig.11 Charpy impact Test Specimen

Table 5: Charpy impact testing machine specification

SPECIFICATION : Machine: AIT 300 ASTM		
Sl no	Particulars	Values
1	Initial potential energy	300J
2	Pendulum drop angle	140°
3	Impact velocity	5.182 m/s
4	Effective weight of pendulum	22.35 kg
5	Angle of strike edge	30°
6	Width of strike edge tip	4mm
7	Distance between anvil	40mm
8	Angle of anvil	80°
9	Radius of support	1mm
10	Specimen size	10 mm x 5 mm x55mm

(17.5kN) at a tool rotational speed of 600 rpm and remains almost similar variation in 900and 1200rpm.

4. Outcomes of Investigation and Overview

A. characteristics of Normal load for composite plates

The graphical representation 1. clearly show the variation of normal load for Composite plates at constant feed of 40mm/min .from curve noticed that normal force exerted on work is more

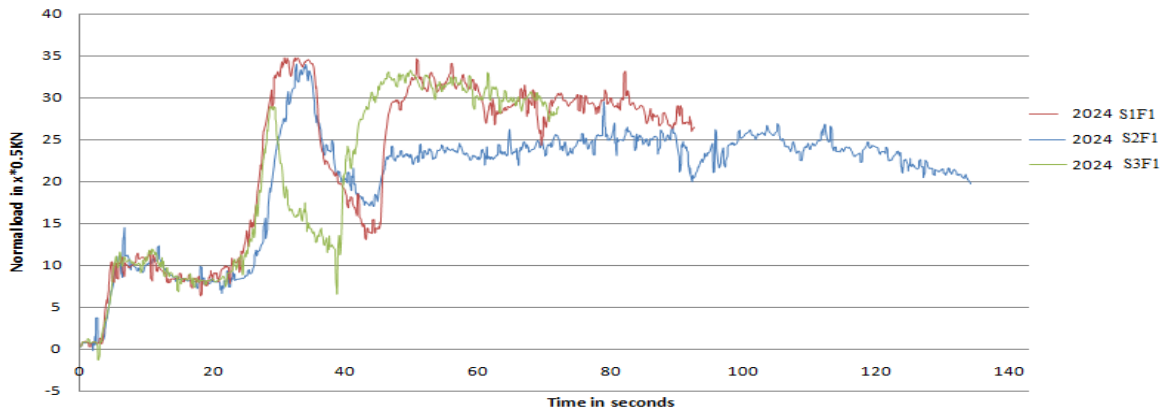
B. characteristics of Traverse load for composite plates

The graphical representation 2. clearly show the variation of traverse load for Composite plates at constant feed of 40mm/min .from curve noticed that during weld direction, traverse force

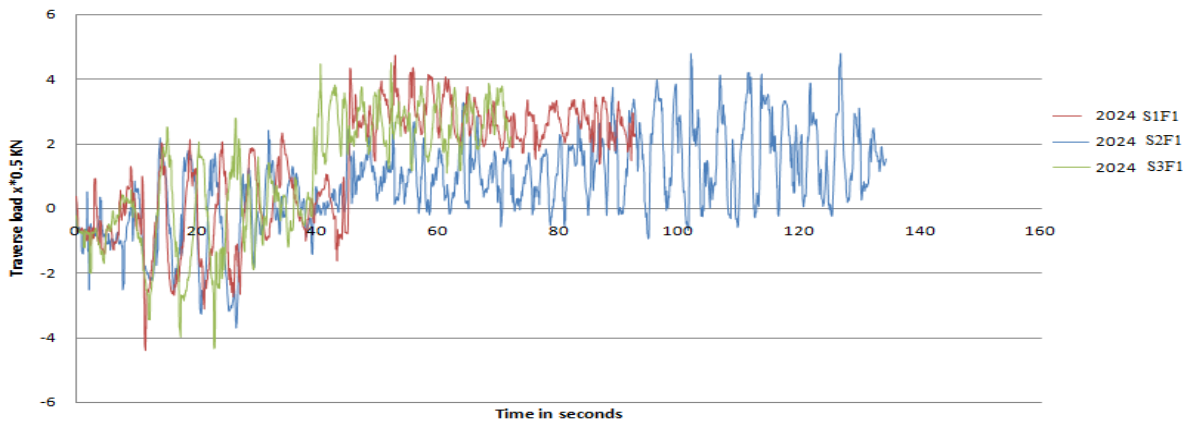
exerted on work is attain maximum(2.1KN) at a tool rotational speed of 900 rpm and remains almost similar variation in 600and 1200rpm .

The graphical representation 3. clearly show the variation of spindle torque for Composite plates at constant feed of 40mm/min .from curve noticed that during weld Torque exerted on work is almost constant value of 6.2 N/M at a tool rotational speed of 600, 900 and 1200rpm.

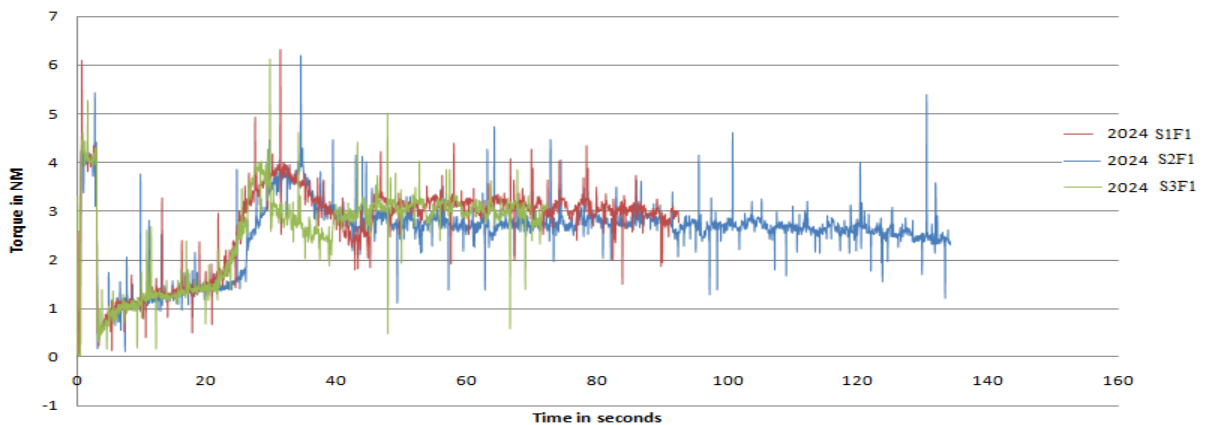
C. characteristics of spindle Torque for Composite plates



Graph. 1: Normal load (kN) vs Time (sec)



Graph. 2: Traverse load (kN) vs Time (sec)

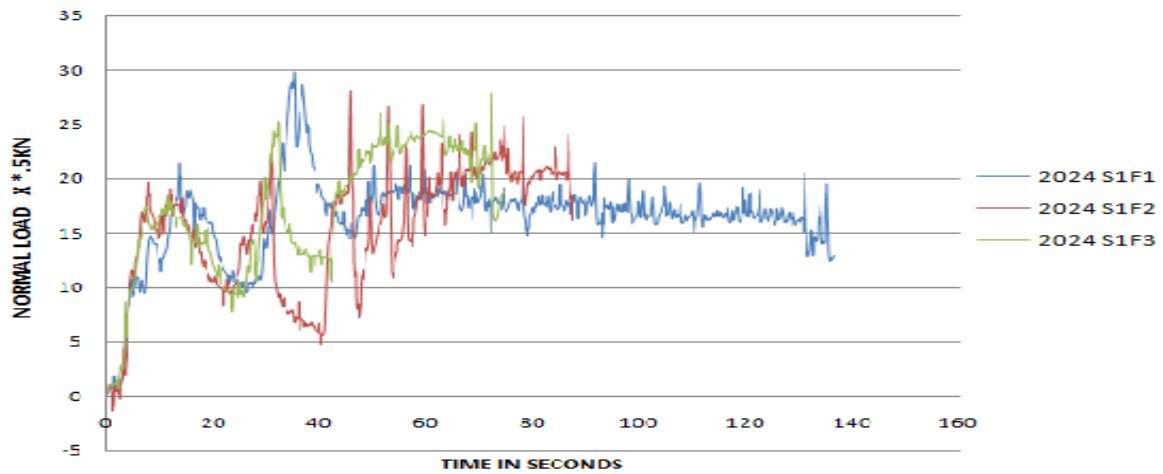


Graph. 3: Torque (N/M) vs Time (sec)

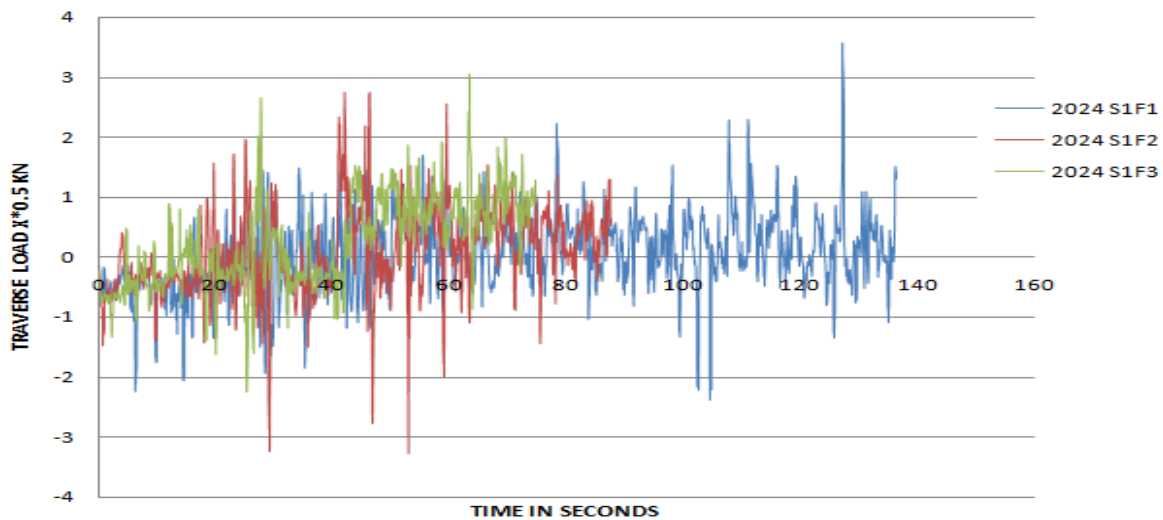
D. Characteristics of Normal, Traverse and spindle Torque for base plate

tool rotational speed of 600 rpm and different feed rate of 40,80 and 120mm/min. from curve noticed that achieved maximum value of 15 KN,1.75KN and 14N/M respective loads.

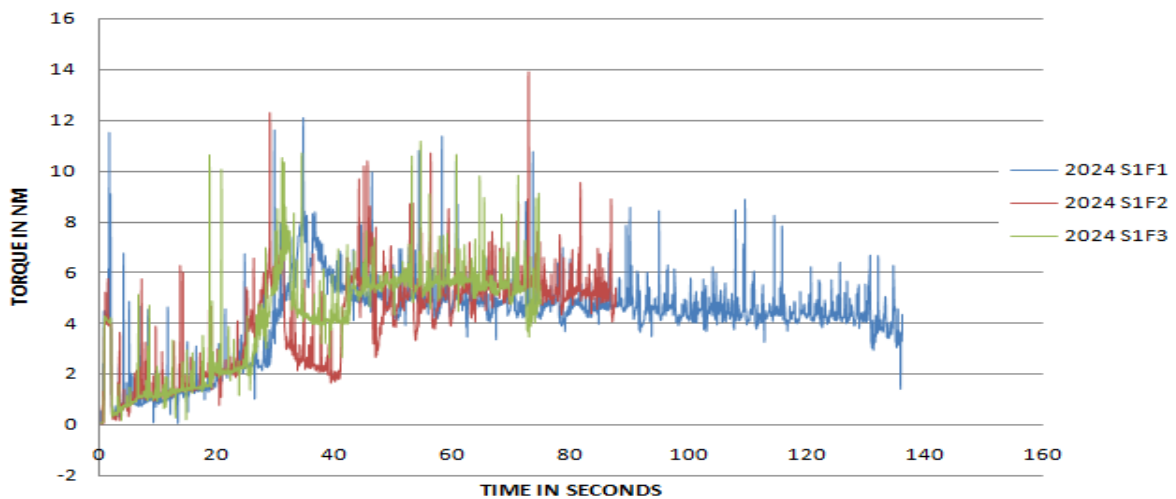
The graphical representation clearly show the variation of normal load , traverse load and spindle torque for base plates at constant



Graph. 4: Normal load (kN) vs Time (sec)



Graph. 5: Traverse load (kN) vs Time (sec)



Graph. 6: Torque (N/M) vs Time (sec)

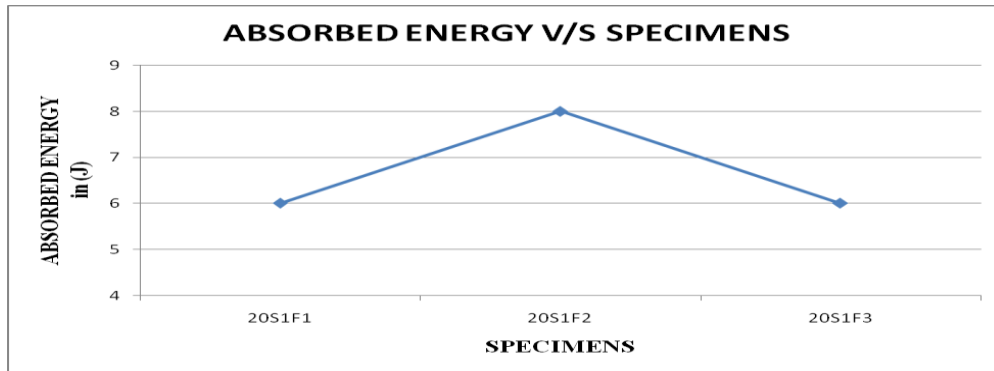
E. Test Results

The consequence result of Impact test on base metal and hybrid composite samples are resolved and classified. An outcome of impact test results gives a reasonable induction of influence of welding variables on toughness.

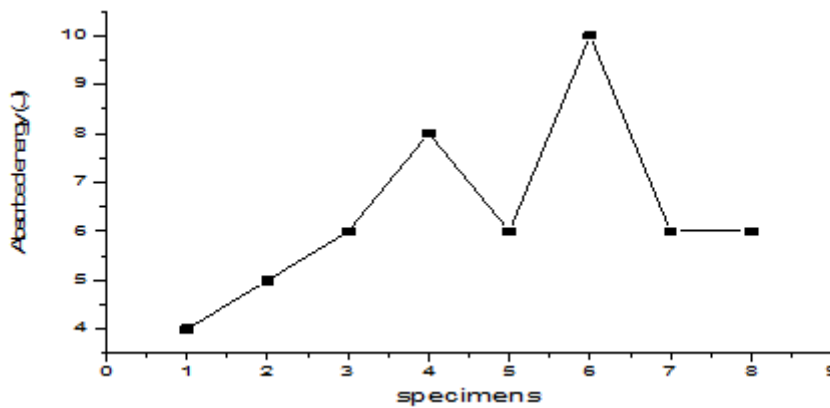
Graphs are plotted to assess the variety in the Impact quality attributes of weld and non weld zone of Aluminum 2024 base metal plates and Aluminum composite plates along various process parameters of welding.

Table 6: Charpy Impact Test Results

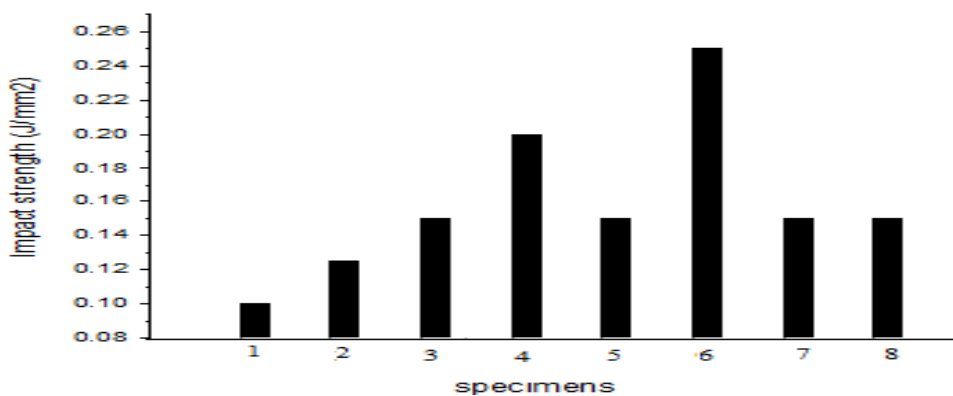
Sl.No	Sample details	Weld parameters	Position	Impact velocity m/s	Absorbed Energy(J)	Impact strength J/mm ²
1	2024 +0% sic +0% E glass	-	Base material	5.18	4	.10
2	2024 +7% sic +3% E glass	-		5.18	5	.12
3	20S1F1	600rpm and 40mm/min	Weld spot	5.18	6	.15
4	20S1F2	600rpm and 80mm/min		5.18	8	.20
5	20S1F3	600rpm and 120mm/min		5.18	6	.15
6	2S1F1	600rpm and 40mm/min		5.18	10	.25
7	2S2F1	900rpm and 40mm/min		5.18	6	.15
8	2S3F1	1200rpm and 40mm/min		5.18	6	.15



Graph. 7: Absorbed energy (J) vs AA2024



Graph. 8: Control chart of Absorbed energy (J) vs specimens



Graph. 9: Impact strength (J/mm²) vs specimens Specimens with weld zone

F. SEM, EDAX and Structural Morphology

The miniature structural morphology of the compound helps to describe, distribution of reinforcements particles, fibers of fine Silicon Carbide and chopped E glass respectively in aluminium metal matrix. The miniaturized scale structure plainly exceeds expectations of the scattering of the particles and fortifications in the lattice stage.

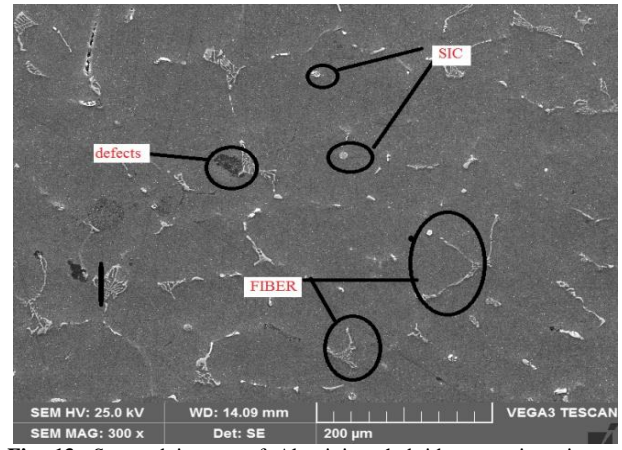
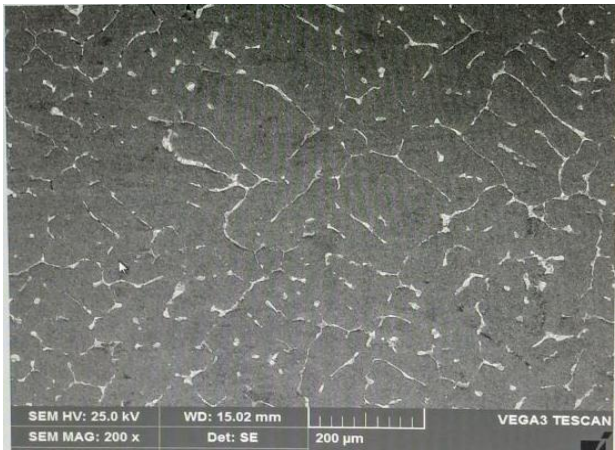


Fig. 13: Scanned images of Aluminium hybrid composite witness the reinforcement

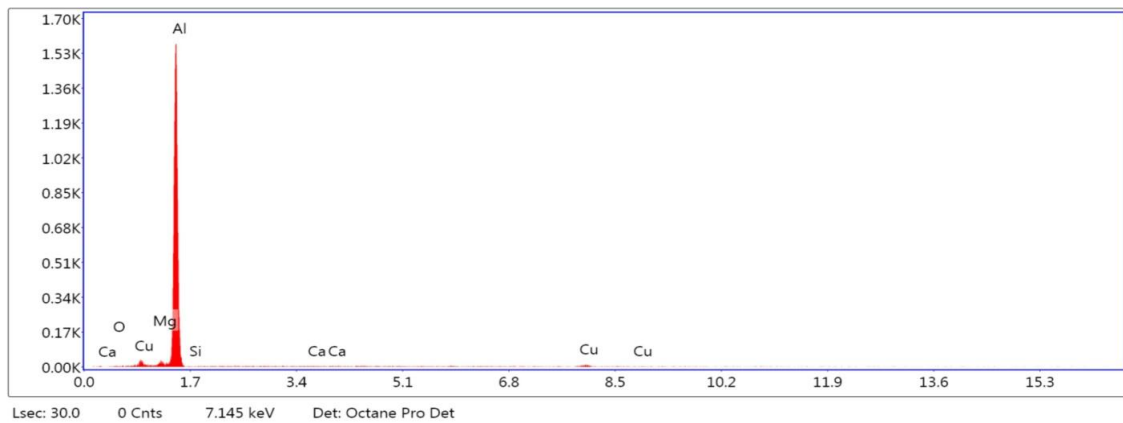


Fig. 14: EDX image obtain form AA2024 metal matrix composite weld zone

Table 7: EDX table, showcase the Ingredients of composite materials in weight percentage

Ingredients	Weight %	% Atoms	Net int.	Error %	K ratio
O.K	0.61	1.04	0.58	93.26	0.0014
MgK	1.38	1.56	10.29	20.23	0.0114
AlK	93.90	95.41	757.53	2.92	0.8112
SiK	0.27	0.27	0.63	88.26	0.0007
CaK	0.27	0.18	1.17	65.55	0.0021
CuK	3.58	1.54	7.71	26.14	0.0347

5. Conclusion

After intensive characteristic assessment of welding variables and its impact on toughness behavior of the Aluminum 2024 base and Aluminum hybrid composites are accompanying and conclusions have been drawn.

1. Stir casting process produced homogeneous distribution reinforcement in AA metal matrix and sound cast.
2. Using friction stir welding process, high quality solid butt joint of Aluminum 2024, SiC and E-glass hybrid composite plates obtained.
3. The maximum normal and traverse force exerted on work during welding of composite materials.
4. The maximum spindle torque obtained on work during welding of aluminium base materials.
5. Impact strength of composite materials show reverse characteristics with weld speed and feed rate in FSW, because insufficient heat generated during high speed and high feed rate welding.
6. Over all 60% toughness increased in composites compared to the as cast aa2024 alloy.

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