NIET Journal of Engineering & Technology
Volume 10, Issue 2, 2019 ISSN: 2229-5828 (Print)

# Mechanical Characterization of Composites Fabricated via Friction Stir Processing

**Kartik Sharma[1], Randhir Kumar Mishra[1], Ravi Kumar Maddhesiya[1], Vishal**

[1]Departmen of Mechanical Engineering, Noida Institute of Engineering and Technology,
Greater, Noida 201306, India.

**Abstract:** ***Friction stir processing is a technique for improving the characteristics of metals by causing local, severe plastic deformation. This deformation is achieved by forcing a non-consumable tool into the workpiece and rotating it in a stirring action while being pushed laterally through it. The primary goal of this experiment is to investigate Friction Stir processing parameters, surface composite production using friction stirs, and material mechanical characteristics. The various ceramic particles, such as SiC and Al2O3, were used as reinforcement particles. The parameter for this experiment is considered as the traveling speed, tool rotation speed, and tilt angles. The main effect of the reinforcement is to improve mechanical properties, such as hardness, impact strength, and strength.***

**Keywords:** Friction stir processing; Microstructure; Parameters; Aluminium alloys

## 1. INTRODUCTION

Surface composites play a vital role in most industries, including automobiles, aero-planes, and shipbuilding, improving strength, hardness, and microstructure [1]. Friction Stir Processing is a surface engineering and solid-state surface alteration technology used to generate Metal Matrix Composite surfaces. It enables surface modification, microstructure control, wear improvement, and mechanical property enhancement. This technique was first used to enhance the mechanical properties of Al-based alloys, but it has since been extended to the manufacture of other alloys such as Mg, Ti, Cu, and others.

Aluminum alloys can take on super-plastic properties through friction stir processing. When ideally implemented, this process mixes the material without changing the phase and creates a microstructure with refined, equiaxed grains. It also enhances the tensile strength and fatigue strength of metals.

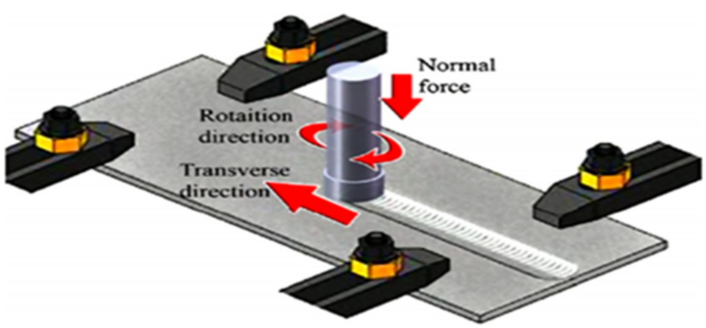



**Fig. 1.** Schematic illustration of FSP process [2]



Publisher: Noida Institute of Engineering & Technology,
19, Knowledge Park-II, Institutional Area, Greater Noida (UP), India.

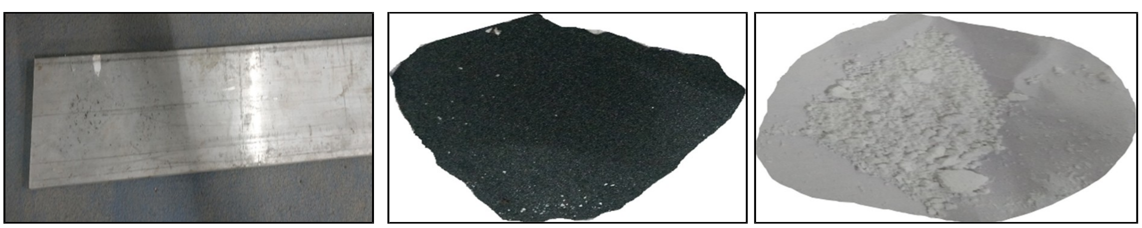
Friction stir processing is a particularly successful way of improving the mechanical properties of semi-solid metal aluminium alloys. Friction stir processing had a hardness of 64.55 HV, higher than the primary metal (40.58 HV). The rotation speed of 1750 rpm and travel speed of 160 mm/min was the best processing parameters [3]. A. Thangarasu et al. [4] found that the TiC particles substantially impacted the TiC particle distribution and sliding wear behavior of the AA6082/TiC AMCs. This work also discusses the impact of TiC particles on worn surfaces.

The Friction Stir Processing of SSM356 Aluminum Alloy was studied by Chainarong s. et al. [5]. Friction stir processing, a solid-state technology for microstructural modification that uses heat from friction and stirring, was used to improve the mechanical properties of SSM 356 aluminium alloys. Friction stir processing is a highly successful approach for improving the mechanical properties of semi-solid metal aluminium alloys.
L. Suvarna Raju et al. [6] studied the impact of three parameters on the mechanical characteristics of CueAl2O3 surface composites manufactured via friction stir processing was investigated, including volume percentage of reinforcement particles (i.e., $Al_2O_3$), tool tilt angle, and concave angle of the shoulder. It is due to the insertion of reinforcement particles, which raise the recrystallization temperature by anchoring the grain boundaries of the copper matrix and preventing dislocation mobility. The mechanical parameters measured are linked to microstructure and fracture characteristics.
It has been found that only a few researchers have worked on friction stir processing based on the above literature review. Thus, this study will focus on improving the metallurgical features of the material using friction stir processing. In this study, stir processing has been used to investigate the friction parameter.

## 2. EXPERIMENTAL STUDY AND METHODOLOGY

### 2.1 Selection of Material

All the selected materials are shown in Figure 2. Aluminium comprises about 8% of the Earth's crust; it is the third most abundant element after oxygen and silicon. It has a different field of application.
Silicon carbide is a semiconductor that contains both silicon and carbon. Since 1893, synthetic SiC powder has been mass-produced as an abrasive. SiC is a semiconductor material utilized in semiconductor electronics devices that operate at high temperatures or voltages. Silicon carbide is a semiconductor that contains both silicon and carbon. Since 1893, synthetic SiC powder has been mass-produced as an abrasive. SiC is a semiconductor material utilized in semiconductor electronics devices that operate at high temperatures or voltages.



(a) Aluminium (b) Silicon Carbide (SiC) (c) Aluminum Oxide ($Al2O_3$)

**Fig. 2.** Selected materials

Aluminium oxide (IUPAC name) or aluminium oxide (American English) is an aluminium and oxygen chemical compound called Al2O3. It forms the precious gemstone's ruby and sapphire in its native crystalline polymorphic phase as the mineral corundum. The resistance of metallic aluminium against weathering is due to aluminium oxide. As the mineral corundum, it occurs naturally in its crystalline polymorphic phase. Because of its hardness, Al2O3 is essential in producing aluminium metal as an abrasive.

### 2.2 Procedure

The selected materials were utilized in the machining process, as shown in Figure 3. The base material was cut as per the required size (100×50×10mm. The drilling operation was performed on the surface of a material size of



Publisher: Noida Institute of Engineering & Technology,
19, Knowledge Park-II, Institutional Area, Greater Noida (UP), India.

3mm. The holes were filled with a mixture of Silicon Carbide, Aluminium Oxide. The setting of mixture materials was performed vertical milling machine. The three parameters were varied speed, tilt angle, and mixture. The selected process parameters for the study are shown in Table 1.

(a) Specimen of base metal (b) Friction Stir Processing (c) Processed work piece

**Fig. 3.** Experimental procedure

Table 1. Process parameters

| S. No. | Specimen Composition | Tool speed (rpm) | Tilt angle (degree) |
|---|---|---|---|
| 1 | Al+SiC | 1500 | 0 |
| 2 | Al+SiC | 1500 | 1 |
| 3 | Al+SiC | 1500 | 2 |
| 4 | $Al+Al_2O_3$ | 1500 | 0 |
| 5 | $Al+Al_2O_3$ | 1500 | 1 |
| 6 | $Al+Al_2O_3$ | 1500 | 2 |
| 7 | $Al+SiC+Al_2O_3$ | 1500 | 0 |
| 8 | $Al+SiC+Al_2O_3$ | 1500 | 1 |
| 9 | $Al+SiC+Al_2O_3$ | 1500 | 2 |

### 2.3 Mechanical Testing

The ASTM-based samples were used for the impact strength and hardness tests. The Charpy impact test 55×10×10, mm with 2 mm depth v-notch specimen were used, as shown in Figure 4. The notch of the specimen was placed on the support in the opposite direction of the hammer's blow. The specimen was tested on an impact testing machine up to 300 J. The specimen did not absorb the total applied energy, and it continued to swing to its topmost position after breaking the specimen. The indicator stops making while the pendulum falls back. The readings of the indicator were noted. The remaining test pieces were removed from the vice so that the machine could be ready for further test.



Publisher: Noida Institute of Engineering & Technology,
19, Knowledge Park-II, Institutional Area, Greater Noida (UP), India.

NIET Journal of Engineering & Technology
Volume 10, Issue 2, 2019 ISSN: 2229-5828 (Print)

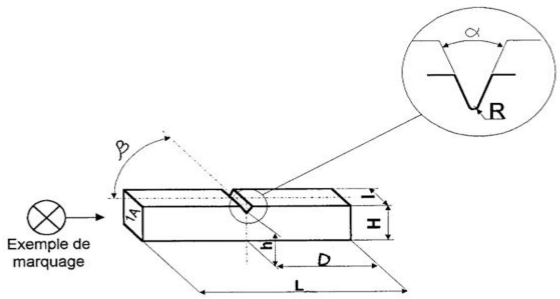


**Fig. 4**. Standard geometry of Charpy impact specimen

Through the scale of penetration of the indenter loaded on a material test piece, the Brinell scale characterizes the indentation hardness of materials. In a typical test, a steel ball with a diameter of 10 mm (0.39 in) is indented with a force of 3,000 kgf. Figure 5 depicts the specimens that were tested. The hardness of the indentation was computed once it was measured.

**Fig. 5.** Specimen for hardness test with hardness testing machine

## 3. RESULTS AND DISCUSSION

The energy comparison results of the different test pieces of different compositions are shown in Table 2. In the Charpy test, different reinforcements were utilized. The minimum impact strength is observed when Al2O3 is used as reinforcement at the revolving speed of 1500 rpm, and the tilt angle is 0°, whereas maximum impact strength is observed when Al2O3 is used as reinforcement at a revolving speed of 1500 rpm and tilt angle was 0°.



Publisher: Noida Institute of Engineering & Technology,
19, Knowledge Park-II, Institutional Area, Greater Noida (UP), India.

Volume 10, Issue 2, 2019 ISSN: 2229-5828 (Print)

Table 2. Experimental test results; impact strength and hardness

| S. No. | Specimen Composition | Tool speed (rpm) | Tilt angle (degree) | Impact Strength (J) | Hardness Test | |
|---|---|---|---|---|---|---|
| | | | | | Diameter (mm) | BHN |
| 1 | Al+SiC | 1500 | 0 | 63 | 1.3 | 59.303 |
| 2 | Al+SiC | 1500 | 1 | 65 | 1.2 | 73.165 |
| 3 | Al+SiC | 1500 | 2 | 64 | 1.3 | 59.303 |
| 4 | Al+$Al_2O_3$ | 1500 | 0 | 46 | 1.2 | 73.165 |
| 5 | Al+$Al_2O_3$ | 1500 | 1 | 75 | 1.3 | 59.303 |
| 6 | Al+$Al_2O_3$ | 1500 | 2 | 112 | 1.3 | 59.303 |
| 7 | Al+SiC+$Al_2O_3$ | 1500 | 0 | 97 | 1.4 | 47.811 |
| 8 | Al+SiC+$Al_2O_3$ | 1500 | 1 | 57 | 1.2 | 73.165 |
| 9 | Al+SiC+$Al_2O_3$ | 1500 | 2 | 77 | 1.3 | 59.303 |

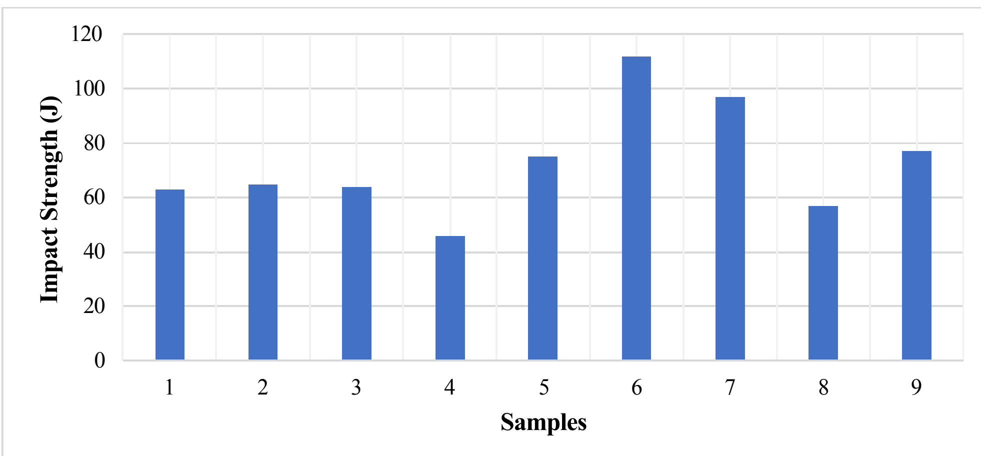



**Fig. 6**. Charpy impact strength test results.

The Brinell hardness number test (refer Fig. 7), the Minimum hardness is observed when SiC+ Al2O3 was used as reinforcement at revolving speed of 1500 rpm, and tilt angle was 0°, whereas maximum impact strength is observed when SiC is used as reinforcement at revolving speed of 1500 rpm and tilt angle was 1°.



Publisher: Noida Institute of Engineering & Technology,
19, Knowledge Park-II, Institutional Area, Greater Noida (UP), India.

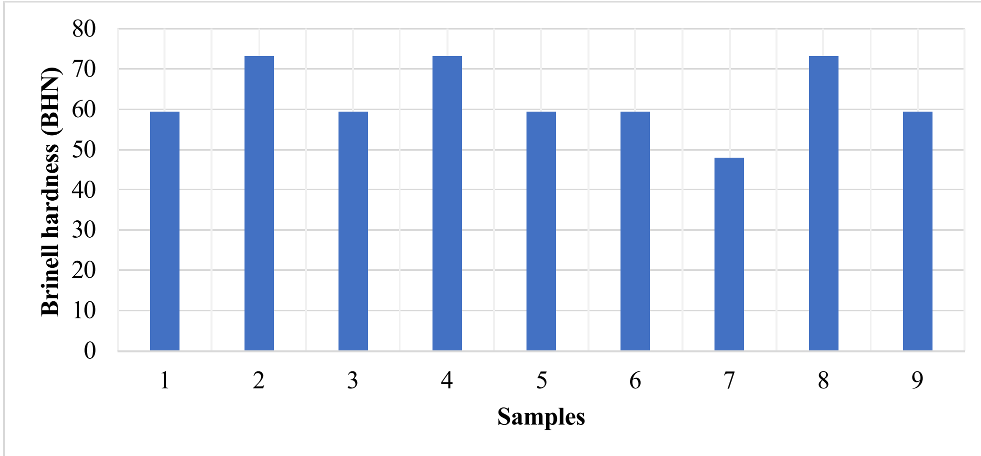



**Fig. 7.** Hardness test results.

## 4. Conclusion

In this study, friction stir processing on the aluminum using a vertical milling machine has been performed. FSP is a solid-state technique to improve properties at the microstructural level. The various ceramic particles, such as SiC, Al2O3, were used as s reinforcement particles. The hardness and impact of friction stir processing are increased compared to the parent metal. The optimal parameter is speed 1500 and tilts angle 10 for the composition of Al+ Sic. Consequently, friction stir processing is a very efficacious method to improve the surface property.
With the low value of costs and highly efficient processes like FSP is regarded as a good option of design for future challenges, and also aircraft industries replace the conventional joining technologies.

## References

[1] S. Prakrathi, M. Ravikumar, K. R. Udupa, K. Udaya Bhat, Fabrication of Hybrid Surface Composite through Friction Stir Processing and Its Impression Creep Behaviour, ISRN Materials Science, 2013, 541762,
[2] H. Sarmadi, A.H. Kokabi, S.M. Seyed Reihani, Friction and wear performance of copper–graphite surface composites fabricated by friction stir processing (FSP), International Journal on the Science and Technology of Friction, Lubrication and Wear, 23, 2013, 336-441.
[3] S. Chainarong, P. Muangjunburee, S. Suthummanon, Friction Stir Processing of SSM356 Aluminium Alloy, Procedia Engineering, 97, 2014, 732-740.
[4] A. Thangarasua, N. Muruganb, I. Dinaharan, Production and wear characterization of AA6082 -TiC surface composites by friction stir processing. International journal of Procedia Engineering, 97(12), 2014, 590-597.
[5] S. Chainarong, P. Muangjunburee b, S. Suthummanon, Friction Stir Processing of SSM356 Aluminum Alloy, Procedia Engineering, 97(12), 2014, 732-740.
[6] L. Suvarna Raju, A. Kumar, Influence of Al2O3 particles on the microstructure and mechanical properties of copper surface composites fabricated by friction stir processing, International journal of defence technology, 10 (23), 2014, 375-383.
[7] Samidha Garg, S.N.Singh; 'Performance Comparison Of High Frequency Single Phase PWM Inverters Using PSpice',Volume No.1,Issue No.1,2013,PP.001-008,ISSN :2229-5828
[8] Satyendra Sharma, Dr.Brahmjit Singh; 'Planning and Optimization of UMTS Network Radio Link with Limited Interference',Volume No.2,Issue No.1,2013,PP.009-012,ISSN :2229-5828
[9] L.NavinkumarRao, S Gairola; 'Steady -State and Dynamic Performance of the Static Var Compensator (SVC) Phasor Model',Volume No.2,Issue No.1,2013,PP.013-016,ISSN :2229-5828
[10] Rishi Singhal, S.P. Singh and Dr V. K. Pandey; 'Design of Phase Compen-sation Circuits For Multistage OP-AMP',Volume No.2,Issue No.1,2013,PP.017-019,ISSN :2229-5828
[11] Mohd Yunus Khan, Saroj Kumar Padhi and R.K. Singh; 'Extraction ,Characterization And Engine Performance of Jatropha Curcas Oil',Volume No.2,Issue No.1,2013,PP.021-028,ISSN :2229-5828
[12] Srivastav, Vivek; 'Analytical Study of Traffic Behaviour in a Network on Chip Architecture',Volume No.2,Issue No.1,2013,PP.029-032,ISSN :2229-5828



Publisher: Noida Institute of Engineering & Technology,
19, Knowledge Park-II, Institutional Area, Greater Noida (UP), India.