

Influence of tool pin in friction stir welding on activated carbon reinforced aluminium metal matrix composite

G.DijuSamuel^a, J.Edwin Raja Dhas^b

^aResearch Scholar , Department of Aeronautical Engineering, Noorul Islam University,
Kumaracoil, 629180, India

^bProfessor and Head, Department of Automobile Engineering, Noorul Islam University, Kumaracoil, 629180, India

Corresponding author: dijusams@gmail.com , +919994441656

Abstract: This paper focus on impact of tool pin in friction stir welding on activated carbon reinforced aluminium metal matrix composite. For fabrication of metal matrix composite AA6061 is used as matrix and activated carbon is used as reinforcement and it is casted using modified stir casting technique. After casting metal matrix composite has undergone various microstructure tests like SEM, EDAX and XRD. FSW is carried out in this metal matrix composite by choosing various tool pin profile like square, round, Threaded round, hexagon and taper. The quality of welded plates is measured in terms of ultimate tensile strength and hardness.

Keywords: AA6061, SEM, EDAX, XRD, FSW, Hardness, Tensile Strength.

1. INTRODUCTION

Metal matrix composites (MMCs) are being an unavoidable metal in aviation field because of the benefit of low weight to quality proportion. MMCs are one of the most important class of composites for structural, thermal and kinetic applications. Aluminium based hybrid composites have good strength, low weight, good weldability and corrosion resistance. It is widely used in industries like aerospace, automobile, marine etc [1]&[2].

Stir casting procedure is a fluid state technique for the creation of metal matrix composites in which clay particles (reinforcement) are blended with a liquid metal(matrix) by methods for mechanical mixing [3-5]. In that observation aluminium fly ash composite have improved their mechanical properties by adding some suitable percentage of reinforcement.[6]. In some other literature there will be changes in mechanical properties by mixing reinforcements like SiC, Ti, Albite, graphite etc. Tensile and compressive property was improved by adding AA6061 with different weight percentage of albite and graphite[7].

AMC can be used in this welding since in this process rotating tool moves along joint interface, produces warmth and brings about recycling stream of plasticized material close to the tool surface. This mellowed material is subjected to expulsion by the tool pin rotational and navigate developments prompting arrangement of friction stir processing zone [8].



During this welding, a special shaped FSW tool is rotated, plunged and then traversed along the joint to form weld [9] FSW has been used to weld the monolithic materials such as aluminum, magnesium, steel. Recently, several studies have reported that the FSW produces a high quality weld joint in aluminum based composites [10]. The advantage of friction stir welding is it will eliminate all types fusion problem during welding. From literature [11-15] it is understood there will be influence in tool pin profile used in friction stir welding in literature pin profile like square, hexagon, taper, round, threaded round, Threaded Taper, Triangle are used from this four influential profile is used in this research work. In this paper the welded composite plates mechanical properties are measured.

2. Experimentation:

2.1 Friction Stir Casting :

The materials used to fabricate metal matrix composite are AA6061 rod and powdered activated carbon. The matrix for the composite is chosen as AA6061 cylindrical rods and activated carbon is used as reinforcement. Aluminum bars were put in a graphite cauldron and were covered to dodge pollution and warmed utilizing an electrical furnace. The AA6061 rods were melted at a temperature of 900°C utilizing an electric heater. The liquid compound is mixed utilizing mechanical stirrer to frame a fine vortex. The Preheated activated carbon powder at a temperature of 600°C for a hour were then included at a consistent bolster rate into the liquid aluminum. 1 wt. % of magnesium particles was used as wetting agent. The composite is prepared by adding 6% of reinforcement, 93% of matrix and 1% wetting agent. From literature it is evident there will be no proper mixing of reinforcement beyond 6% of activated carbon. The composite obtained after casting is shown in figure.1



Figure.1 AA6061/activated carbon metal matrix composite

2.2 Microstructure test:

The fabricated metal matrix composites will undergo microstructure test to confirm the proper mixing of matrix and reinforcement. The presence of reinforcement also confirmed by EDAX and XRD tests.

2.3 SEM TEST

The Fig 2 a represents the microstructure of AA 6061/activated carbon metal matrix composite. The figures obviously uncovers the homogeneous circulation of the enacted carbon in the Al compound matrix and there is no confirmation of porosity and splits in the castings. The presence of matrix and reinforcement is highlighted in the figure.2

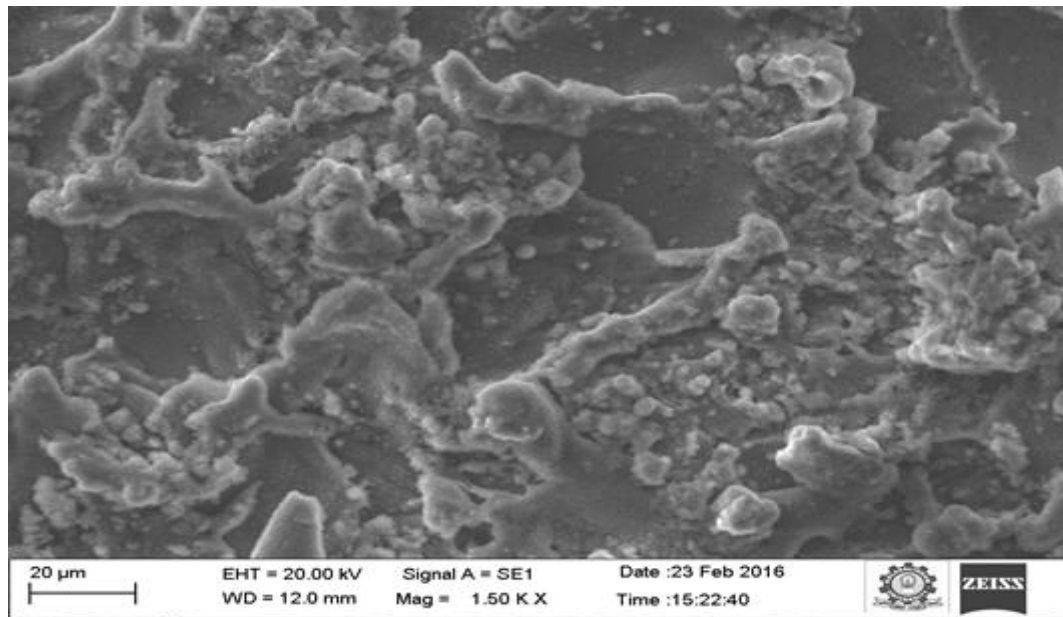


Figure.2 SEM image AA6061/activated carbon metal matrix composite

2.4 EDAX TEST

From fig 3EDS spectrum shows both the occurrence of Al alloy and activated carbon in the fabricated compound. The micro graph also shows that there is no agglomeration of the aluminum and activated carbon particles in the mixture. It is seen from this, that the exchange and mechanical blending of materials have occurred between two sliding surfaces, prompting the arrangement of a mechanically blended layer on the ragged surfaces.

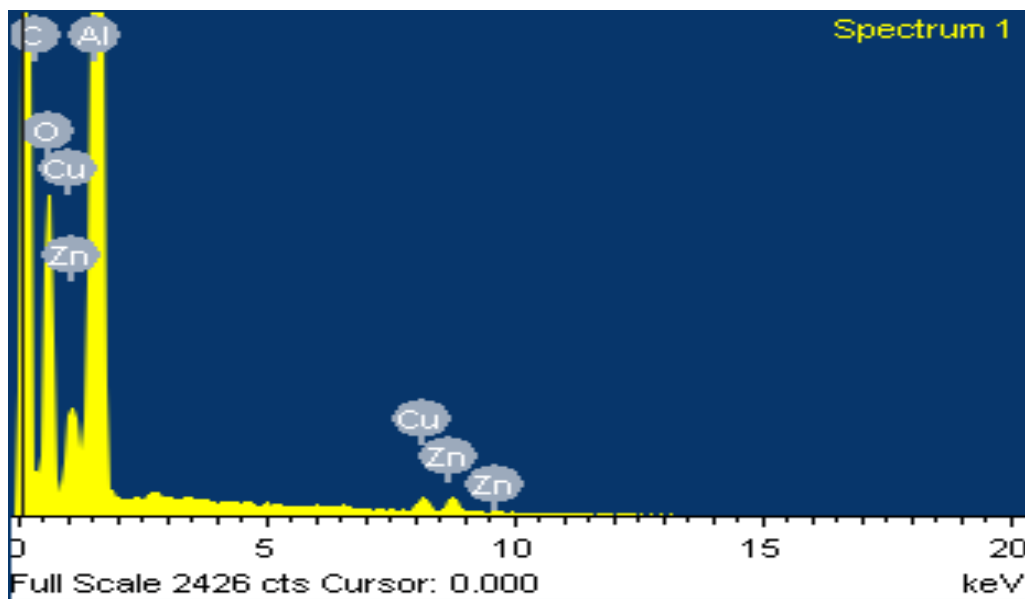


Figure.3 EDAX of AA6061/activated carbon metal matrix composite

2.5 XRD TEST

X- Ray Diffraction (XRD) of fabricated AA6061 and activated carbon metal matrix composite is shown in figure 4. It is observed that, peaks corresponding to aluminium and activated are present in all the three materials, whereas activated carbon peaks were present in AA6061/ activated carbon composites and no other reaction product peaks are seen. xrd results shows there is no formation other compound and also shows that it has good mixture. The results specifies the occurrence of aluminum in the major peak and the activated carbon in the second largest peak. In this an obviously noticeable activated carbon pinnacle can be seen in the AA6061 composite. The expansion in the force of the activated carbon tops with the aluminum substance of the composite is apparent.

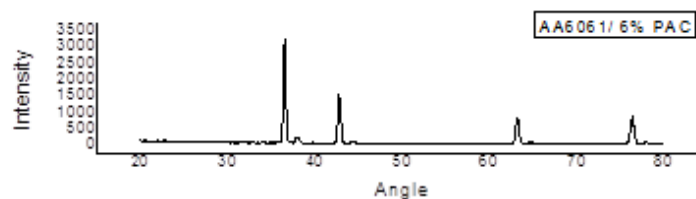


Figure.4- X-Ray Diffraction results of casted AA6061/PAC Composite

3. Friction Stir Welding:

The plate of dimensions 100mm×50×6mm are obtained in modified stir casting with various weight rate of reinforcement and different matrix materials are friction stir welded in modified vertical milling machine. The butt welding is carried out in AA6061 reinforced activated carbon composite plates. Tool selected for performing welding is High speed steel tool with four different probe shapes such as Square, Taper, Triangle, Round, hexagon and threaded round with tool length 70mm, shoulder diameter 16mm and probe length of

5.8mm. From literature the parameters for friction stir welding are spindle speed, axial load, tilt angle and tool profile. Among these four parameters tool profile will be varied other three parameters are kept constant. The values chosen are spindle speed 1200rpm, tilt angle zero and axial load 10KN. The process parameter for friction stir welding is shown in table.1. The specimen after welding were taken to tensile and hardness test as per ASTM standards. The figure 5 shows the five different types tools used for welding. Figure 6 shows friction stir welded composite plates by using different tool profile.

Table.1 Process parameters for friction stir welding

Sl.No	Parameter	Range
1.	Spindle speed	1200rpm
2.	Axial load	10KN
3.	Tilt angle	zero
4.	Tool pin profile	Round, T. Round, Taper, Square Hexagon

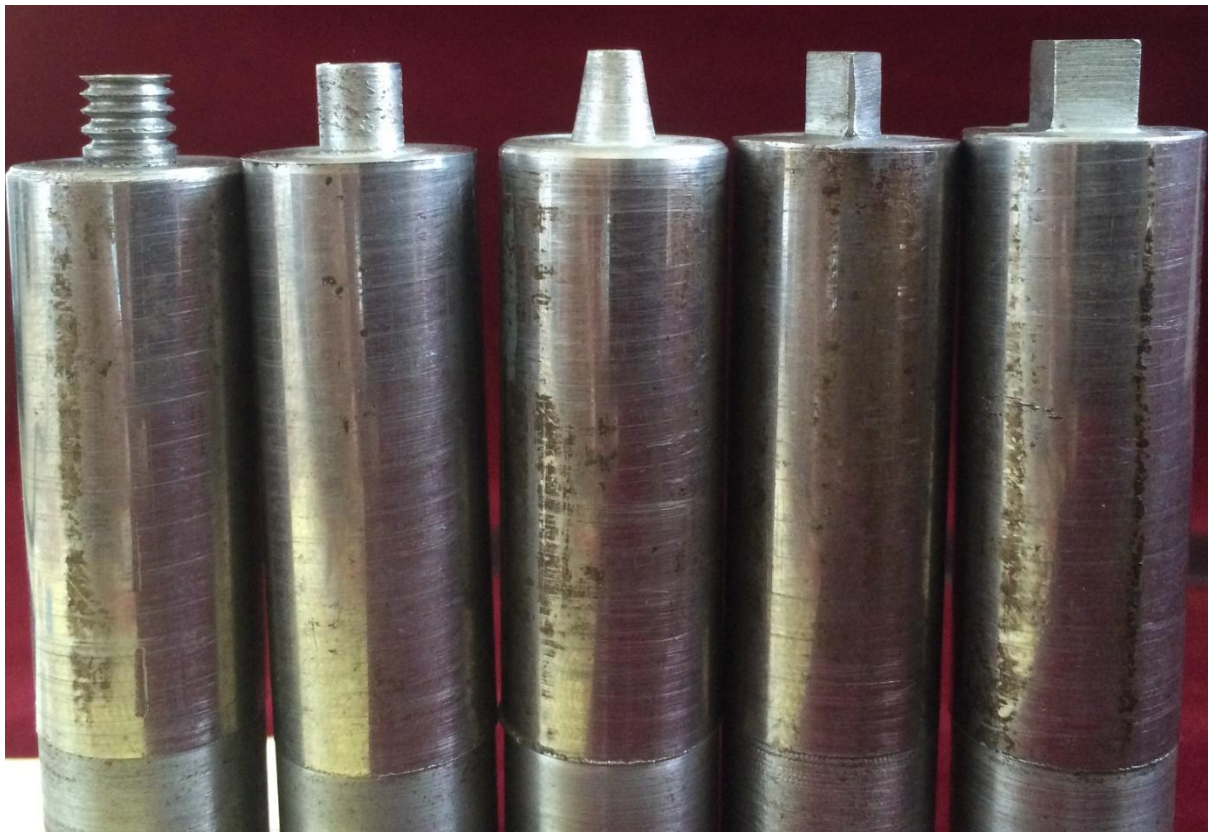


Figure 5 Five different tools for friction stir welding

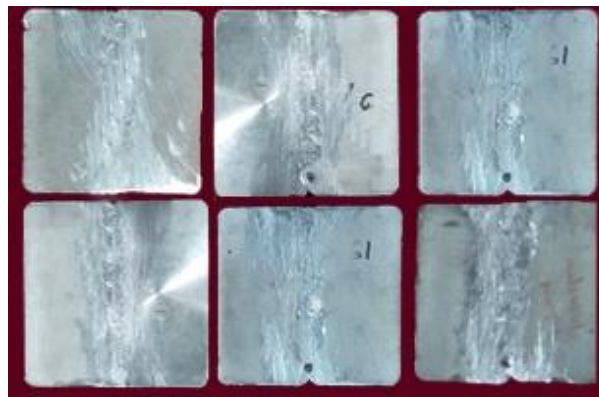


Figure 6 Friction stir welded composite plates

4. Results and Discussions

The friction stir welded composite plates are tested as per ASTM standards for ultimate tensile strength and hardness. The specimen taken for ultimate tensile strength is shown in figure 7. The values obtained after testing is narrated in table 2.

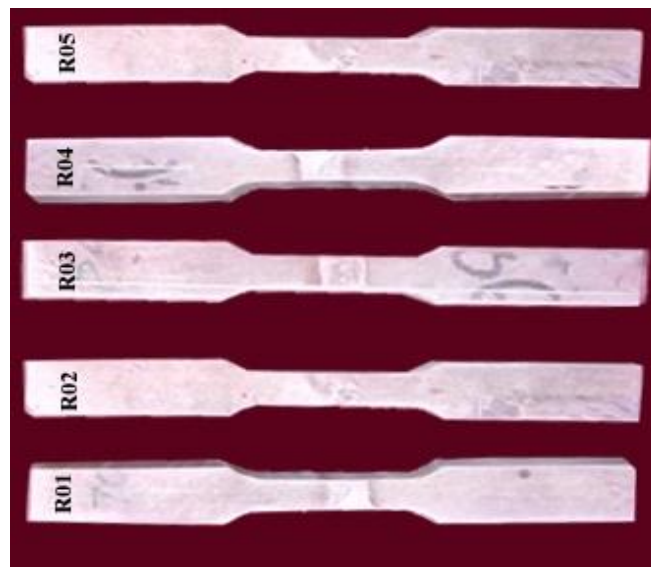


Figure 7 Specimen for ultimate tensile strength

Table 2 Ultimate tensile strength and hardness results for welded composites

Sl.No	Tool Pin Profile	Ultimate tensile strength	Hardness
1.	Square	228	56
2.	Hexagon	198	42
3.	Taper	206	46
4.	Round	212	48
5.	Threaded round	214	52

The above results show the square shaped tool gives the best result in hardness and ultimate tensile strength. The hexagon will produce least among the five types of tools used for

welding and there will be minor difference between the round shaped tool and threaded round tool. Taper shape pin profile results the moderate among all the five tools used in this research work.

References:

- [1] Mohsen hajizamani,,HamidrezaBaharvandi,“Fabrication and Studying the Mechanical Properties of A356 Alloy Reinforced With Al₂O₃-10% Vol.ZrO₂ Nanoparticles through Stir Casting”, Advances in Material Physics and Chemistry, pp 26-30 ,2011
- [2] Yashpal,Sumankant,C.S. Jawalkar“Fabrication of aluminium metal matrix composites using particulate reinforcement”,Materials today proceedings, vol-4,pp 2927-2936, 2017
- [3] Rajeshkumar Gangaram Bhandre, Parshuram M. Sonawane “Preparation of Aluminium Matrix Composite by Using Stir Casting Method”, International Journal of Engineering and Advanced Technology (IJEAT), vol-2,2013.
- [4] YanpeiSong,ShuangxuBi, XiuqingLi“Microstructures and Properties of Recycled Composites Particle Reinforced Iron Matrix Functionally Graded Materials Fabricated by Centrifugal casting”, pp360-366,Engineering,2010.
- [5] Sourabh Gargatte* , Rahul R. Upadhye, Venkatesh S. Dandagi, Srikanth R. Desai, Bhimappa S. Waghmode, “Preparation & Characterization of Al-5083 Alloy Composites”, Journal of Minerals and Materials Characterization and Engineering, pp 8-14, 2013
- [6] Inampudi Narasimha Murthy, “Comparative Studies on Microstructure and Mechanical Properties of Granulated Blast Furnace Slag and Fly Ash reinforced AA2014 Composites”, Journal of Minerals and Material Characterization and Engineering, pp8-16 , 2014.
- [7] A. Ramesh, J. N. Prakash, A. S. Shiva Shankare Gowda and Sonnappa Appaiah “Comparison of the Mechanical Properties of AL6061/Albite and AL6061/Graphite Metal Matrix Composites”, Journal of Minerals & Materials Characterization & Engineering, Vol. 8, No.2, pp 93-106, 2009.
- [8] Yu Li, Qiu-lin, Fabrication and characterization of stir casting AA6061-31%B₄C composite Structural and mechanical properties of aluminium based composites,Transactions of non ferrous metals society of china, vol 26,2304-2312,2016.
- [9] Issac dinakaran,kumaravel kalaiselvan,Influence of rice husk ash particles on microstructure and tensile behavior of AA6061 aluminium matrix composites produces using friction stir processing. Composites communications, vol 3:42–46,2017.
- [10] Rajakumar.S,Muralidharan.C , Balasubramanian.V, Influence of friction stir welding process and tool parameters on strengthproperties of AA7075-T6 aluminium alloy joints.Materials and Design, vo 132;535-549,2011.
- [11] Arun kumar kadian,Pankaj biswas, Effect of tool pin profile on the material flow characteristics of AA6061,Materials today proceedings, vol-26 pp 382-392, 2017.
- [12] Vijay ShivajiGadakh, Kumar Adepu,Heat generation model for taper cylindrical pin profile in FSW, j mater res technol vol2(4): 370–375,2013.
- [13] Kumar A, Raju LS. Influence of tool pin profiles on friction stir welding of copper. Material Manufacturing ,vol 27(12):1414–18,2012.
- [14] Sued M.K,Pons.D, Lavroff.D,Wong.E.H, Design features for bobbin friction stir welding tools: Development of a conceptual model linking the underlying physics to the production process,Materials and Design,2014, vol54 :632–643.
- [15] Srinivasa Rao.M.S, Ravikumar.B.V.R, Experimental study on the effect of welding parameters and tool pin profiles on the IS:65032 aluminium alloy FSW jointsMaterials today proceedings, vol-4,pp 1394-1404, 2017