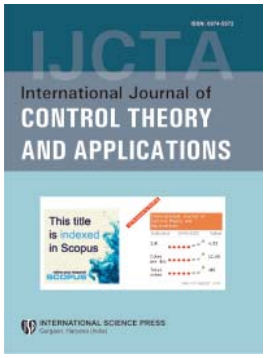

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Effect of Process Parameters on the Microstructure and Mechanical Properties of Al6061/Powdered Activated Carbon Metal Matrix Composite

Diju Samuel G[a] and Edwin Raja Dhas J[b]

[a]*Department of Aeronautical Engineering, Noorul Islam University, Kumaracoil, 629180, India*

[b]*Department of Automobile Engineering, Noorul Islam University , Kumaracoil, 629180, India*

Abstract: The aim of this work is to produce an aluminium metal matrix composite with high strength, low weight and good weldability.For preparing metal matrix composite AA6061 is used as matrix and activated carbon is used as reinforcement and it is casted using modified stir casting technique. The reinforcement activated carbon is added in various ratio 2% to 8% weight of AA6061 alloy. The casted metal matrix composites are taken as per ASTM standard by using wire cut process. A series of tests with ASTM standards are carried on the casted composite. Mechanical tests like tensile, hardness and microstructure test like SEM, EDAX, XRD and conformatory test like FTIR and thermogravity tests were taken.After finding the test results, it is noted that increase in percentage of activated carbon upto 6%, a significant increase is occurred in ultimate tensile strength, impact strength, young's modulus and hardness.

Keywords: *Aluminium alloys; composites; activated carbon; stir casting; SEM; EDAX;XRD.*

1. INTRODUCTION

Metal matrix composites (MMC) are being an unavoidable metal in aerospace field due the advantage of low weight to strength ratio. Metal matrix composites (MMCs) are one of the most important class of composites for structural, thermal and kinetic applications. Especially Aluminium based composites (AMC) have good strength, low weight, high electrical conductivity and corrosion resisitance. It is widely used in industries like aerospace, automobile, marine etc [1],[2]. Among the various reinforcement used activated carbon is very cheap and readily available. For activated carbon, due to its high degree of micro porosity, its activation level sufficient for useful application may be attained solely from high surface area; *i.e.* it has very good adsorption properties.

Stir-casting process is a liquid-state method for the fabrication of metal matrix composites,in which ceramic particles (reinforcement) are mixed with a molten metal(matrix) by means of mechanical stirring [2]. In that observation aluminium fly ash composite have improved their mechanical properties by adding some suitable percentage of reinforcement.[8]. In some other literature there will be changes in mechanical properties by mixing reinforcements like SiC, Ti, Albite, graphite etc[11]. Tensile and compressive property was improved by adding AA6061 with different weight percentage of albite and graphite[21].

Activated carbon is a form of carbon processed to have small, low-volume pores that increase the surface area available for adsorption. Just one gram of activated carbon has a surface area in excess of 500m^2. The density of activated carbon is 2100kg/m^3.Compare to all reinforcement added with AA6061 activated carbon have some distinct advantages like readily available,cheap and good adsorption.

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In the present work an attempt has been made to fabricate AA6061+ activated carbon hybrid composite. The literature from previous work in the area of AA6061 metal matrix composite there is limited work is carried out by using activated carbon as reinforcement with AA6061.so this paper mainly focuses on mechanical test like tensile,hardness, microstructure test like SEM, EDAX and XRD and conformative tests like FTIR and thermogravity tests were carried out.

2. EXPERIMENTATION

The materials used to fabricate metal matrix composite are Al6061 rod and powdered activated carbon. The matrix for the composite is chosen as AA6061cylindrical rods(containing 0.4 percent Mg and 0.75 percent Si). Activated carbon in powdered form is used as reinforcement .

The chemical composition of AA 6061is shown in Table 1. AA6061 rods of 1500g were placed in a graphite crucible and the crucible was coated to avoid contamination and heated using an electrical furnace. The AA6061 rods was melted at a temperature of 900°C using an electric furnace shown in Fig. 3.The molten alloy is stirred using mechanical stirrer to form a fine vortex. The Preheated activated carbon powder at atemperature of 600°C for 60 minutes were then added at a constant feed rate into the molten aluminum. 1 wt.% of magnesium particles was used as wetting agent. Casting carried out with different parameters are shown in Table 2. The composite is prepared by adding different weight percentage of activated carbon like 2% 4% 6% and 8%. From this experiment it is evident there will be no proper mixing of reinforcement beyond 6% of activated carbon.

Figure 1: AA6061 Rod

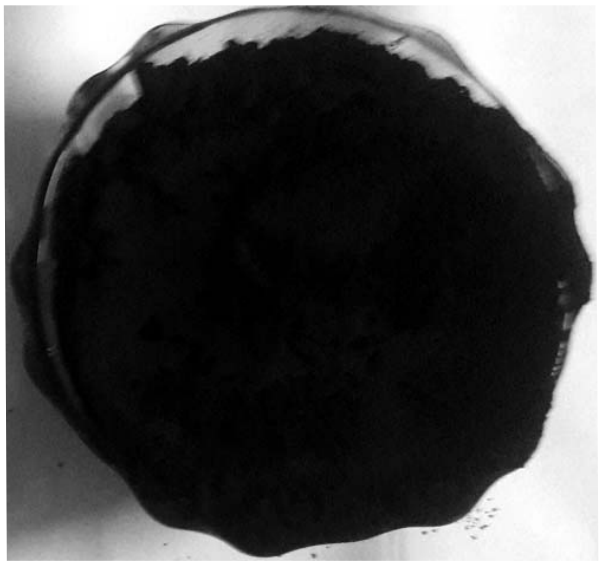

Figure 2: Activated Carbon Powder

Table 1
Chemical composition of the Al6061 alloy

Sl.No	*Component*	*Weight*
1.	Magnesium	0.8-1.2
2.	Silicon	0.4 – 0.8
3.	Iron	Max. 0.7
4.	Copper	0.15-0.40
5.	Zinc	Max. 0.25
6.	Titanium	Max. 0.15
7.	Manganese	Max. 0.15
8.	Chromium	0.04-0.35
9.	Others	0.05
10.	Aluminium	Remaining

Table 2
Process Parameters

Sl.No	*Parameters*	*Unit*	*Value*
1.	Stirring Speed	RPM	450
2.	Furnace Temperature	^{0}C	650
3.	Stirring time	Min	2-3

Figure 3: Modified Stir Casting Apparatus

3. TESTING AND RESULTS

A series of mechanical test and microstructure were carried out on the developed composites with ASTM standards.

3.1. Tensile test

Tensile test is carried out with ASTM E8/82 standard in UTM machine. The young's modulus and Ultimate Tensile Strength was measured.

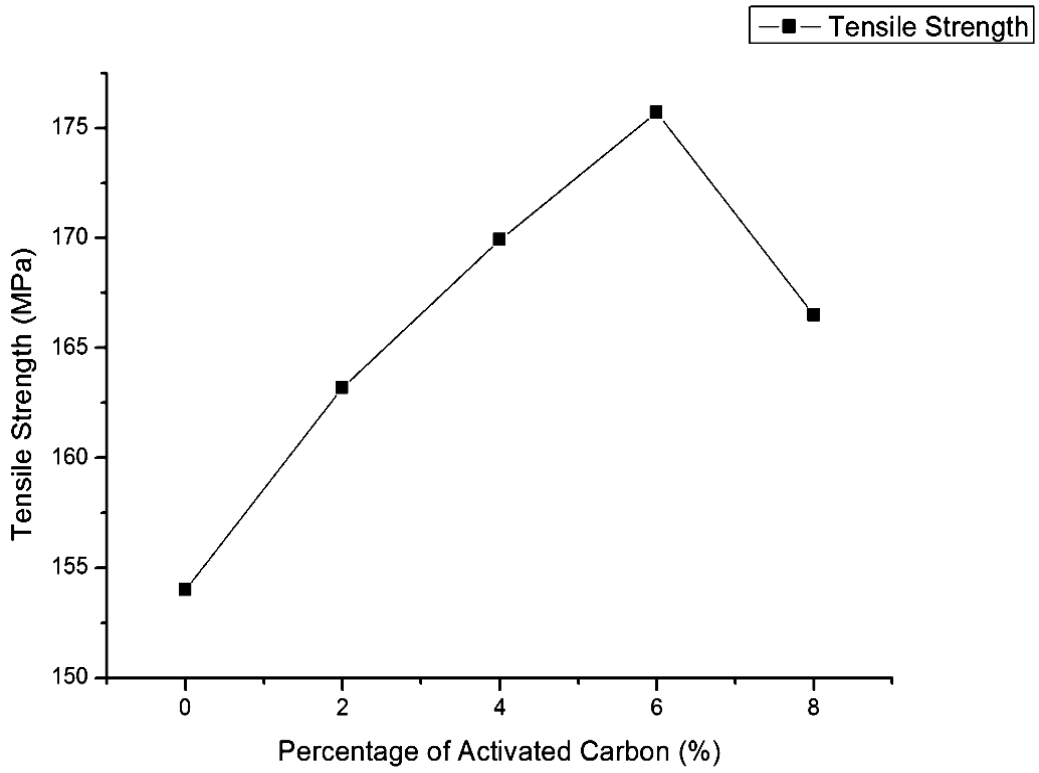

Figure 4: Effect of activated carbon content in tensile strength

Figure 4 shows the variation of Tensile stength with increase in weight percentage of activated carbon. It is noted that after addition of activated carbon beyond 8 % the tensile strength gets reduced that is due improper mixing of activated carbon with AA6061.Tensile property of fabricated composite is increased rapidly compared to aluminium matrix composites (AA 6061/B_4C) [20].

3.2. Hardness

ASTM E10 standard is used for the hardness test. Brinell hardness test is adapted for finding out the hardness of metal. Ball type intender of 10mm diameter with 100 kg load is applied.

Figure 5 shows the variation of hardness with increase in weight percentage of activated carbon. It is noted that after addition of activated carbon beyond 8 % the hardness number gets reduced that is due improper mixing of activated carbon with AA6061.

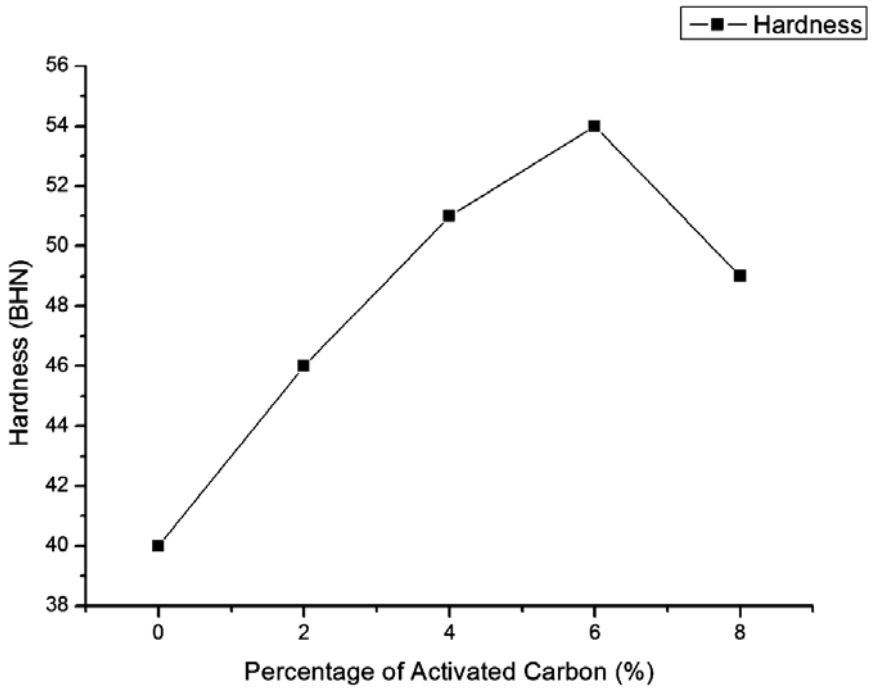

Figure 5: Effect of Activated Carbon Content in Hardness

3.3. SEM Test

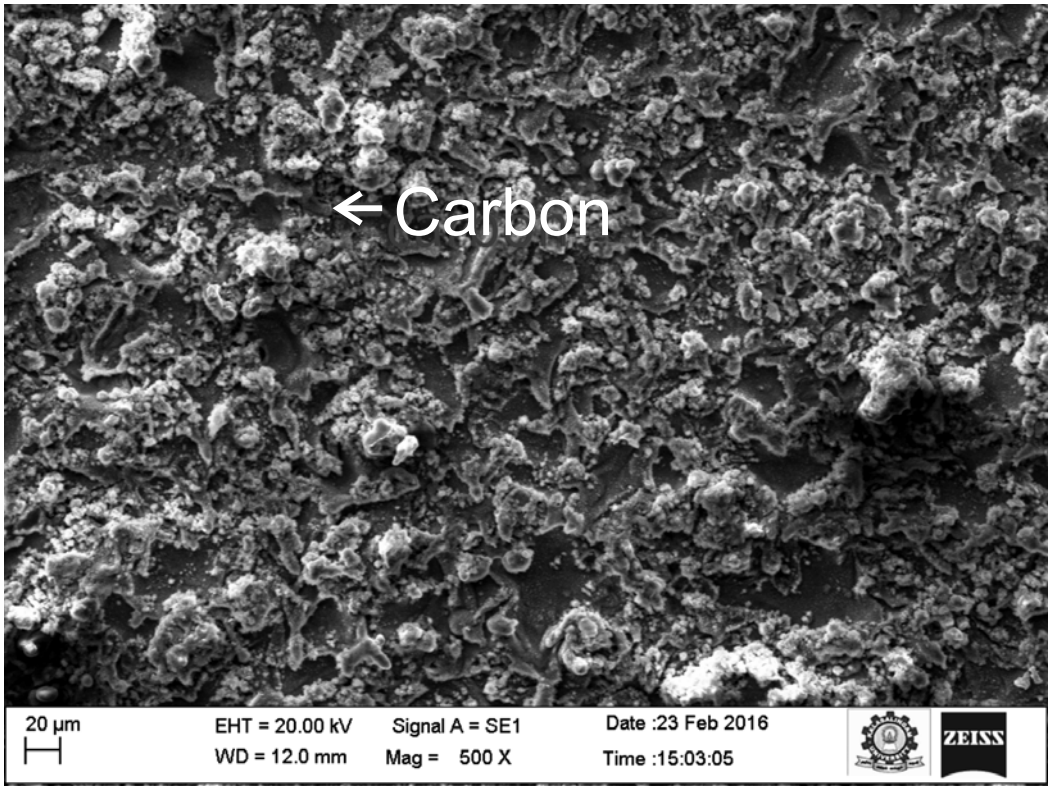

Figure 6a: Sem of Al6061 -2%PAC)

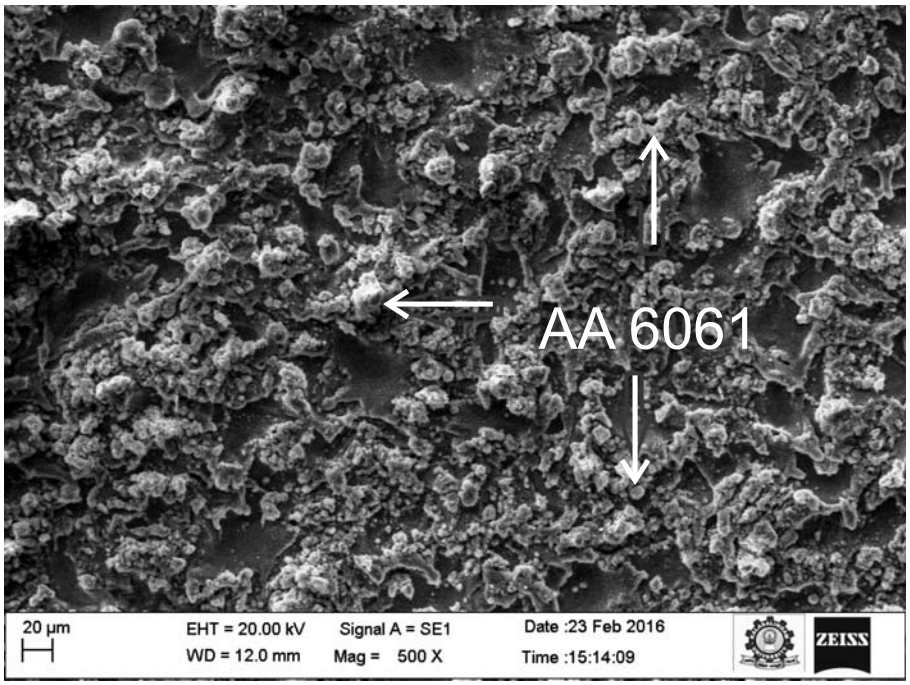

Figure 6b: Sem of Al6061 -2%PAC)

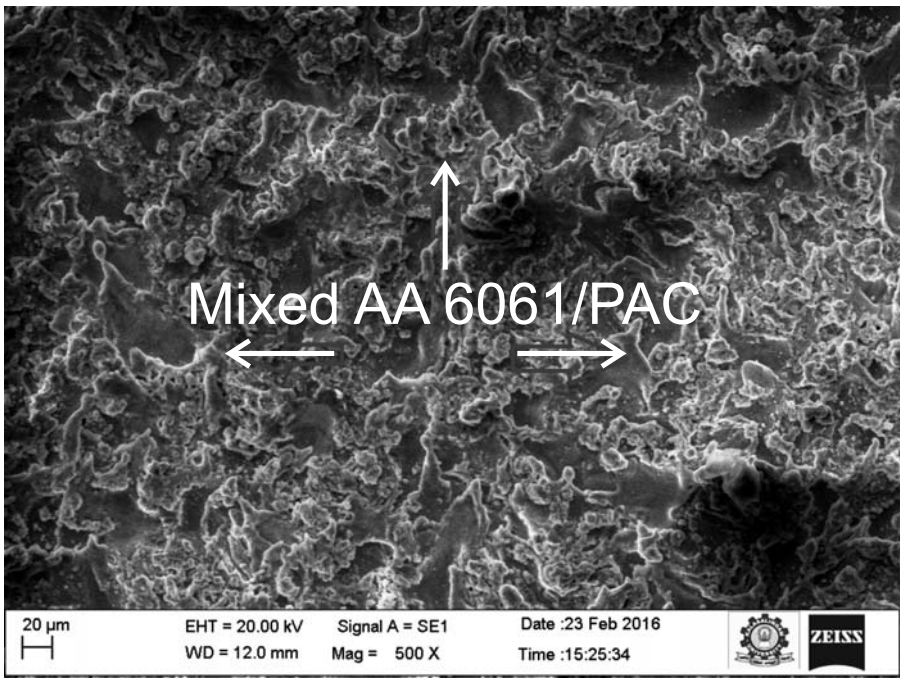

Figure 6c: Sem of Al6061 -2%PAC)

SEM image of the Al6061 composite with various percentage of activated carbon. The fig 7 *a*-c shows the microstructure of different weirht percentage of AA 6061 and activated carbon. Sem image of the composites shown in Fig. 7 *a- c* clearly reveals the homogeneous distribution of the activated carbon in the Al alloy matrix and there is no evidence of porosity and cracks in the castings. This might be related to proper process parameters employed for the production of castings.

3.4. EDAX Test

From fig 7 a-c, EDS spectrum shows both the presence of Al alloy and activated carbon in the fabricated composite. The micro graph also shows that there is no agglomeration of the aluminum and activated carbon particles in the mixture. It is observed from this, that the transfer and mechanical mixing of materials have taken place between two sliding surfaces, leading to the formation of a mechanically mixed layer on the worn surfaces.

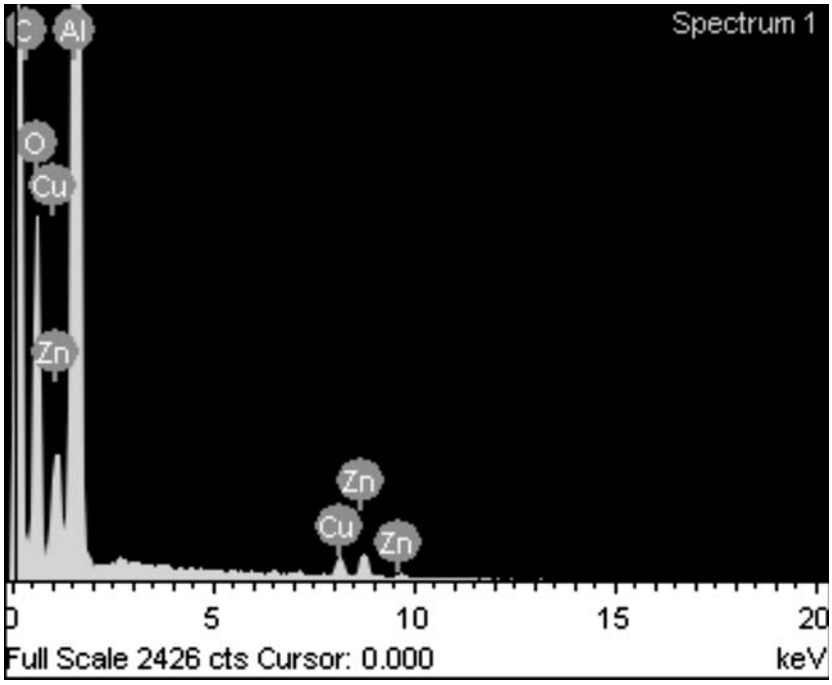

Figure 7a: EDAX Al6061 – 2%PAC

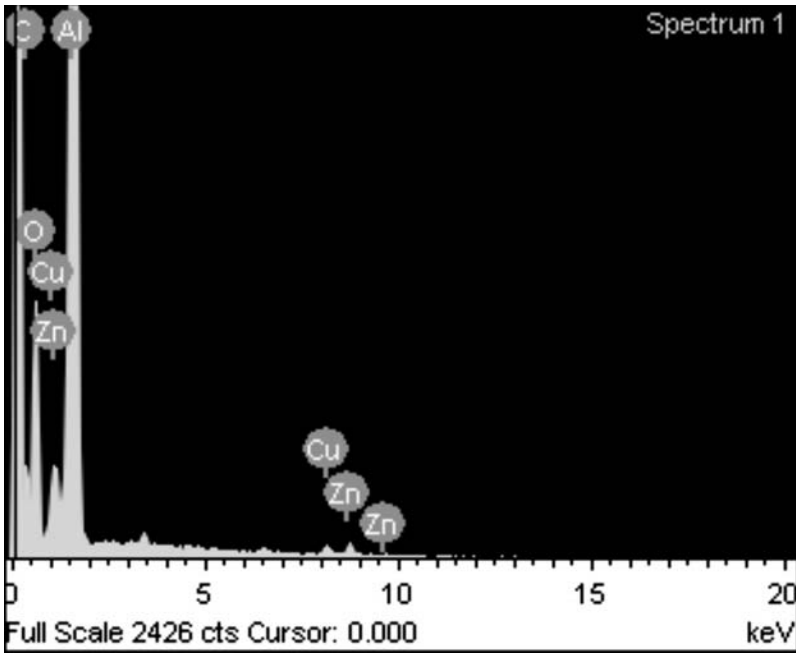

Figure 7b: EDAX Al6061 – 2%PAC

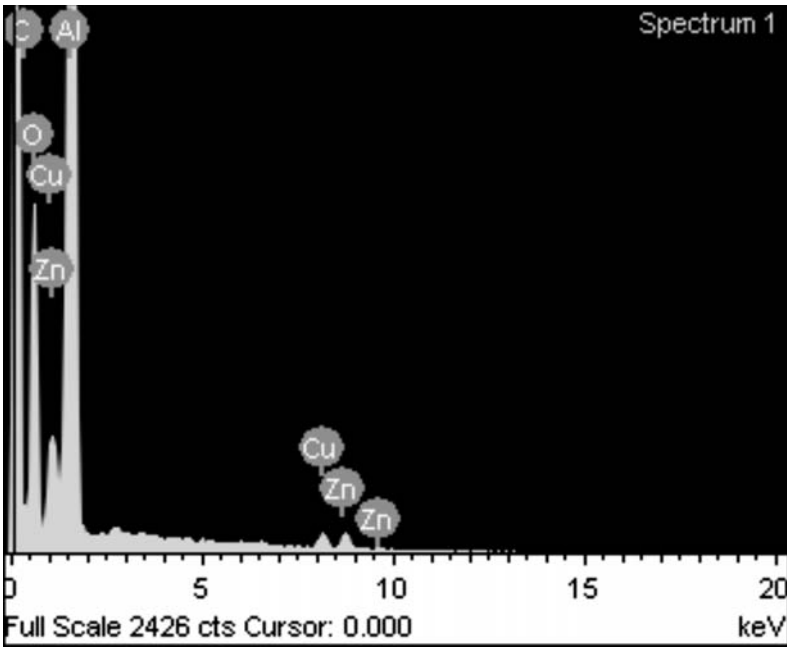

Figure 7c: EDAX Al6061 – 2%PAC

3.5. XRD Test

X- Ray Diffraction (XRD) of fabricated AA6061 and activated carbon metal matrix composite is shown in fig 8. It is observed that, peaks corresponding to aluminum are present in all the three materials, whereas activated carbon peaks were present in AA6061–6wt% activated carbon composites and no other reaction product peaks are seen. Comparing the XRD peaks of composites, it is observed that the intensity of the peaks corresponding to activated carbon is found to be higher with increased amount of activated carbon in the materials. This is foe al 6061 with 6% of activated carbon which has high gross intensity. This shows that it has good mixture**.**The results indicates the presence of aluminum in the largest peak and the activated carbon in the second largest peak.In this a clearly visible activated carbon peak can be observed in the Al6061 composite. The increase in the intensity of the activated carbon peaks with the aluminum content of the composite is evident. The Al6061 with 6% of activated carbon has only lots of peak value which has attained in the angle of 27.709^{o} to 64.469^{o} it shows in the table 3. In this Al6061 with 6% of activated carbon has the highest peak value of 278.

Table 3
XRD with 6% of activated carbon

Index	*Name*	*Scan*	*Angle*	*d value*	*Net intensity*	*Gross intensity*
0	Peak #1	Al6061 (6%).raw#1	27.769	3.21009	47.0	278
1	Peak #2	Al6061 (6%).raw#1	62.313	1.48886	29	148
2	Peak #3	Al6061 (6%).raw#1	63.106	1.47204	27.22	146
3	Peak #4	Al6061 (6%).raw#1	63.849	1.45670	26.4	144
4	Peak #5	Al6061 (6%).raw#1	64.409	1.44537	29.5	140

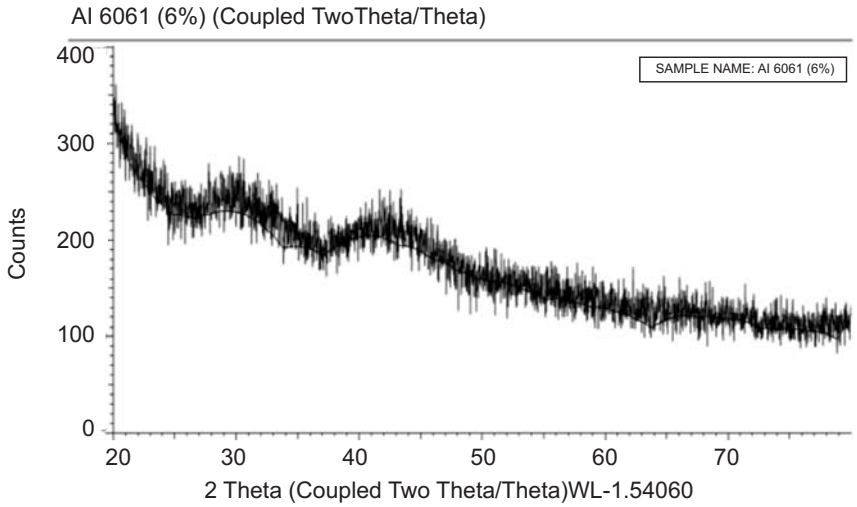

Figure 8: XRD with 6% of activated carbon

4. CONFORMATION TEST

Conformation test was taken based on above mechanical and microstructure test. From above test result it is evident AA 6061 with 6 wt% activated carbon shows good result so based on this FTIR and Thermogravity tests were carried out.

4.1. FTIR

Fourier Transform Infra – Red is a IR radiation is passed through the sample. By passing IR radiation will give a quick and qualitative indication about the change in the chemical structure. The spectra of AA6061/Activated carbon metal matrix composite is shown in fig 9. The broad adsorption band in the region around 3100cm^{-1} would be alkane residues are detected from C-H stretching and C-H deformation absorptions. C-H stretching absorption bands appear just below 3000 cm^{-1} one for symmetrical and other for asymmetrical vibrations.

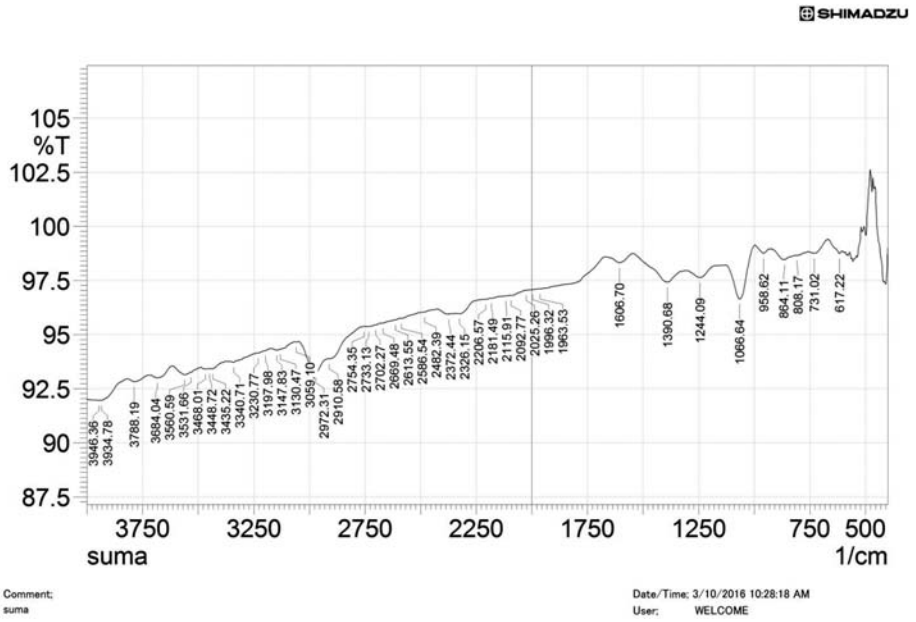

Figure 9

4.2. Thermogravimetric analysis

The thermogravimetric analysis (TGA)–DSC curves for the investigated Al-6061/ activated carbon are shown in Fig 10. These results show that the endothermic peaks originated in the range of 890–900ºC due to melting of Al-6061.It clearly shows that melting point of Al 6061 is improved rapidly by adding activated carbon as reinforcement.

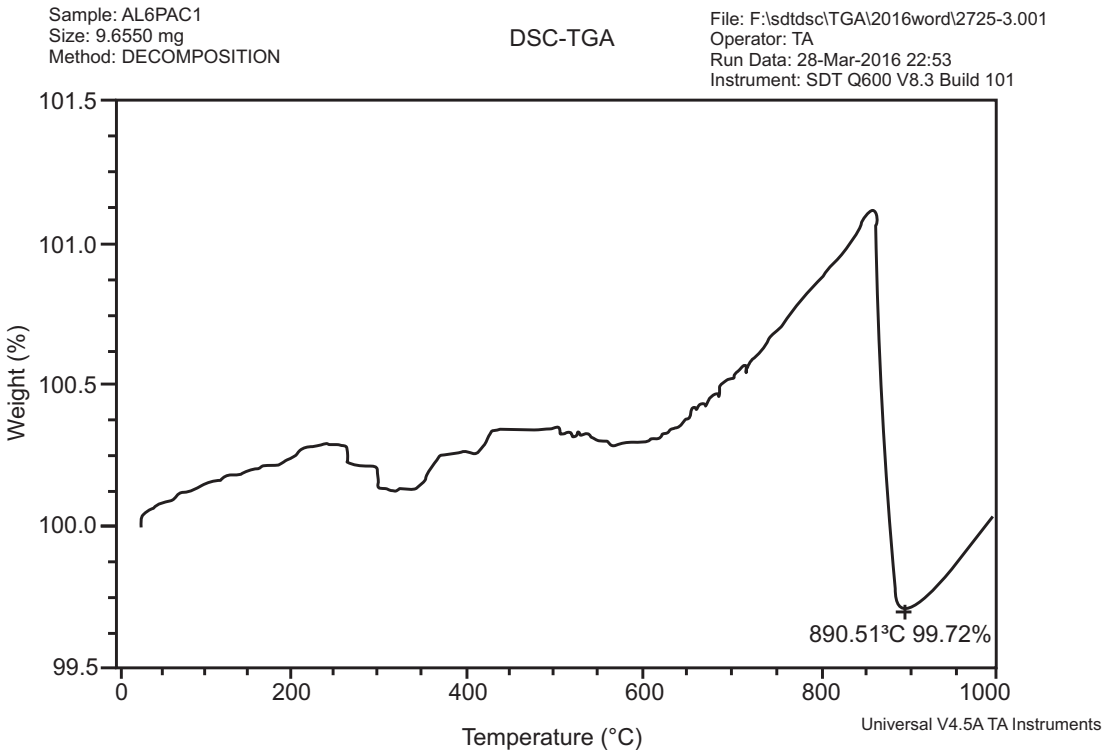

Figure 10

5. CONCLUSION

The Al 6061/ activated composites were fabricated by modified stir casting technique with different weight percentage of reinforcement from 2% to 6% and the microstructure, mechanical properties were evaluated. From this study, the following conclusions are derived.

1. The SEM micrographs shows the presence of al6061 and activated carbon particles in the composite with homogeneous dispersion.
2. The hardness of the composites were increased from 40BHN to 54 BHN with respect to addition of weight percentage activated carbon as reinforcement.
3. From EDAX test EDS spectrum shows the presence of aluminium and carbon particles in the composite.
4. The reinforcement of particles has increased the tensile property of aluminum matrix and composites from 154 MPa to 176 MPa
5. In thermogravimetric analysis the melting point of composite is improved rapidly by adding activated carbon as reinforcement.

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