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Experimental Exploration of Hybrid Metal Matrix Composite using Abrasive Water Jet Machining

Barath M, Rajesh S, Duraimurugan P

Abstract: *The abrasive mixed waterjet was with success utilized to chop several materials together with steel, metal and glass for a spread of business applications. This work focuses on surface roughness of hybrid metal matrix composite (AA6061, Al2O3, B4C). Machining was applied by AWJM (Abrasive Waterjet Cutting) at completely different parameters Water pressure, Traverse speed, Abrasive flow and stand-off distance. The reinforced composite was analyzed exploitation FE SEM (Field Emission Scanning lepton Microscope) and distribution of reinforced was studied by AFM (Atomic Force Microscopy). For optimum results surface roughness was calculated.*

Keywords: *Surface roughness, Analysis of FESEM, Analysis of AFM, Al6061, B4C, Al2O3.*

I. INTRODUCTION

AA6061 blostered with Boron Carbide /Aluminium Oxide forms a metal matrix composite material by stir casting techniques and machined by abrasive water jet machining Abrasive Water Jet (AWJ) technology has exemplified a remarkable mass-producing modus operandi for automotive constituent and distinct machine capable of aviation because of precise merit by machining composite materials [1]. The laminated metal matrix composite material posses many challenges, it needs to develop a technique. So, in AWJ machine the Parametres are adapted in every sort of material which is able to permit trimming operations on composite materials. The Parametres are transverse speed, abrasive rate and standoff distance. Abrasive waterjet parameters posses' standard of cut to investigate the surface roughness of the AA6061/B4C/Al2O3 composite material [2].

Surfaces roughness is measured by associated degree with Optical profilometer and consequently assessed the standardized amplitude parameters to execute the profile of Surface roughness by Ra, Rz and Rq. The standard of a cutting surface and the cutting speed is determined by machinability process to explicit the metal alloy to strengthen the composite material [3].

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* Correspondence Author
Mr. Barath M, Pursuing Bachelor Degree, Department of Mechnical Engineering, R.M.K. Engineering College, Chennai, India. Email: barath15897@gmail.com
Mr. Rajesh S*, Assistant Professor, Department of Mechanical Engineering, R.M.K. Engineering College, Chennai, India. Email: rjs.mech@rmkec.ac.in
Mr. Durai Murugan P, Assistant Professor, Department of Mechanical Engineering, R.M.K. Engineering College, Chennai, India. Email: pdm.mech@rmkec.ac.in

The thickness, traverse speed and abrasive mass flow rate of abrasive water jet cutting on surface roughness is investigated. GMT garnet used as a abrasive material with 80 mesh. Surface roughness is measured across the depth of cut. The collision between the traverse speed of the surface roughness and the bottom of the cut has a good impact. [4].The elements of inorganic compound and limitations of mechanical properties are considerably reduced when aluminium is added [5].

The morphology and microstructure of AA6061/B4C/Al2O3 metal matrix composite analysed in scanning electron microscopy and Atomic force microscopy. When observing the cut surface of the composite material in SEM image it possesses scooping action or ploughing action and has increased in roughness at the cut surface. The AFM is use to observe the three dimensional texture of the machined surface with respect to to peak and valley present in the given image, which shows the surface roughness of the composite material [6].

II. METHODOLOGY

A. Aluminium Alloy:

AA6061 it's a silvery-white, soft, nonmagnetic and ductile metal within the chemical element cluster. By mass, component |metal makes up regarding V-E Day of the layer it's the third most abounding element when O and Si and therefore the most abounding metal within the crust.

B. Aluminium Oxide:

Aluminium oxide may be a chemical compound of aluminum and O with the statement Al2O3, it's the foremost ordinarily occurring of many aluminum oxides, and specifically known as aluminum (III) compound.

C. Boron Carbide:

The ability of Boron carbide to soak up nucleons while not forming long radionuclides makes it enticing as associate degree absorbent for particulate radiation arising in atomic power plants and from anti-personnel neutron bombs.

D. Stir Casting:

Stir casting is a liquid state methodology of material fabrications, which a phase is mixed with a liquefied metal matrix by mechanical stirring. In stir Casting most of the values are effective in liquid state fabrication.

E. Pre-Heating:

The gravity method inagurate by preheating the emboss to 150–200 °C (300–400°F) to soothe the ozze and cut back Scorching harm to the bung. Liquefied metal is then spew into the etch. When curing emboss is opened therefore the bung axe to cut back possibilities balmy dart.

The Boron Carbide is preheated at 340^{0}C to avoid porosity. During this method the Pattern or die is additionally preheated to avoid slag.

F. Abrasive Water jet Machining:

Abrasive water jet cutting is employed in region the of automotive and physical science industries. In region industries, components like metallic element bodies for military aircrafts, engine elements (aluminium, titanium, and warmth resistant alloys), aluminium body components and interior cabin components square measure created victimization abrasive water jet cutting. The cutter is often connected to a high pump wherever the water is then disemboguing from the nozzle, snippet through the fabric by douche it with the jet of expeditious water. Abrasive jet machining, additionally referred as abrasive blasting machining method-(abrasive micro-blasting, pencil blasting and micro- abrasive blasting) that uses abrasives degree to precipitate by expeditious gas to erode material from the piece of work.

G. Surface Roughness:

Surface roughness typically shortened to roughness, could be a part of surface texture, it's quantified the deviations within the direction of the conventional vector of a true surface to from its ideal kind. If these deviations square measure giant, the surface is rough if they're tiny, the surface is swish. In surface scientific discipline, roughness is often thought of to be the high-frequency, short-wavelength part of a measured surface. However, in apply it's typically necessary to understand each the amplitude and frequency to confirm that a surface is fit a purpose.

H. Scanning Electron Microscope:

Scanning microscope (SEM) is a kind of microscope that produces typify images by scanning the surface with a targeted beam of electrons. The electrons move with atoms within the typify, manufacturing numerous gesture that concerning the surface topography and composition of the typify. The electromagnetic radiation is scanned in every formation of pattern and therefore the position of the beam is combined with the detected gesture to supply delineation.

III. RESULTS AND DISCUSSION

The composite mixing ratio of Aluminium AA6061, aluminium oxide and Boron carbide are mixed in a weight of 1.5kg of AA6061, 50g of Al2O3, 100g of B4C respectively to form a composite plate of Al-B4C. The gravity method inaugurate by preheating the emboss to 150–200 °C to soothe the ozze and cut back scorching harm to the bung. The Boron carbide preheated at 340OC to avoid Porosity. During this method the Pattern or die is also preheated to avoid Slag.

Figure 1: stir casted Composite Plate

Figure 2: AA6061-B_4C-$A_{l2}O_3$ Composite after AWJM

Table 1: Machining Parameters in AWJM Process

S.NO	SOD	Abrasive Flow rate (g/minute)	Transverse Speed (mm/minute)
1	1	200	132
2	1	200	132
3	1	200	132
4	2	300	166
5	2	300	166
6	2	300	166
7	3	150	99
8	3	150	99
9	3	150	99

TABLE 2: Experimental Parameters

S.NO	SOD	Abrasive flow rate (g/min)	Transverse speed (mm/min)
1	3	150	99
2	1	200	132
3	2	300	166

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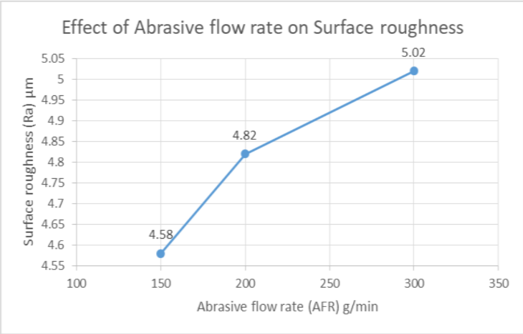

Figure 3: Surface Roughness (Ra) Vs Abrasive Flow Rate (AFR) Plot

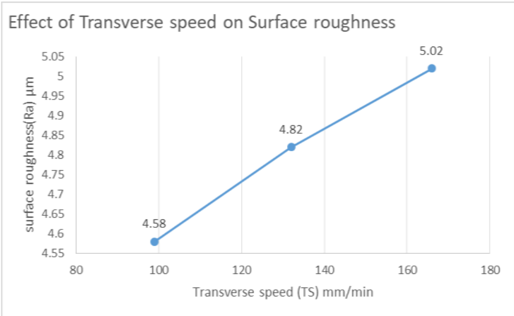

Figure 4: Surface Roughness (Ra) Vs Abrasive Flow Rate (AFR) Plot Transverse Speed (TS) Plot

The result of Surface roughness was analyzed with reference to Transverse speed and Abrasive flow rate through Mitutoyo Surf test SJ – 301 on the machined surface. From the plot, Ra (Vs) TS the transversal speed will increase from 99 (mm/min) to 166 (mm/min) the surface roughness value also increases from 4.58, 4.82, 5.02 (µm) gradually with the constant pressure of 160 (MPa) and a standoff distance of 1 (mm). However an increase in transverse speed causes the embedment of more garnet particles into the aluminium matrix craters and waviness is expelled out during machining, which results in increase in the surface roughness value.

The plot Ra (Vs) AFR shown higher than conclude because the abrasive rate will increase from 150(g/min) to 300(g/min) the surface roughness gradually increase from 4.58, 4.52, 5.02 (µm) with identical constant pressure of one hundred sixty (MPa) and standoff distance of 1(mm). Since, rise in abrasive rate causes the numerous role in influencing the surface roughness. During this work increase in abrasive rate creates sizable amount of craters on the machined surface because of higher energy done between the abrasive and at the surface.

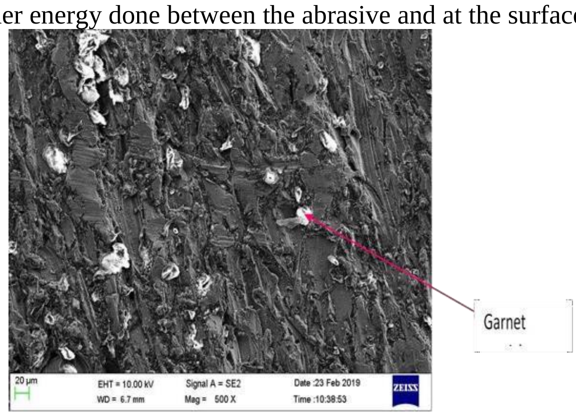

Figure: 5 Microscopic Views of Granet Particles.

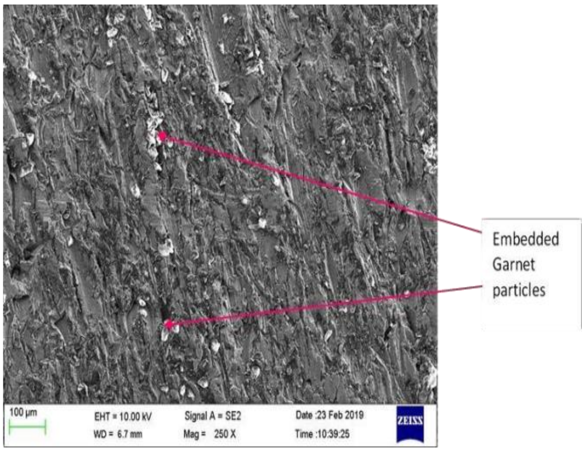

Figure: 6 Microscopic Views of Embedded Granet Particles.

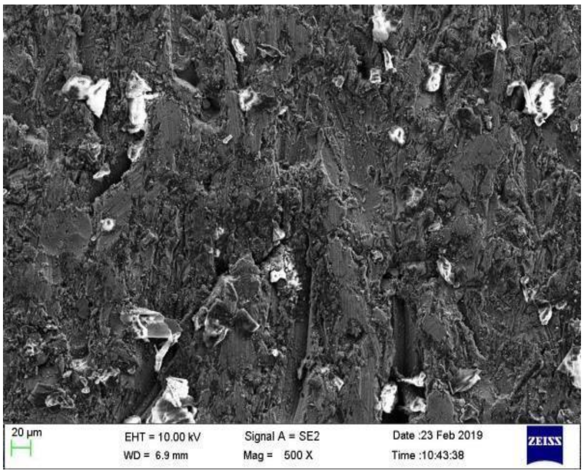

Figure: 7

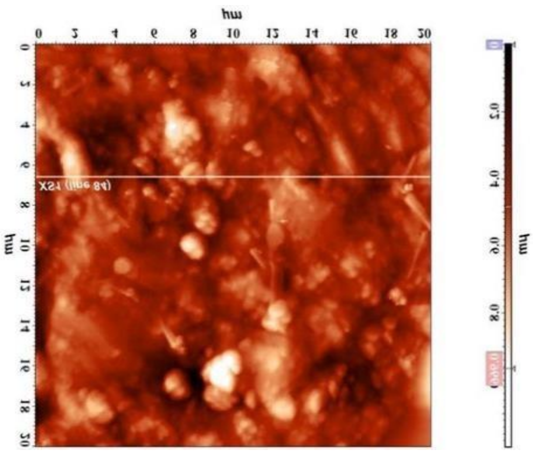

Figure: 8 2D Surface texture of machined AFM image

The phenomenon involved in the breakage during AWJ machining was either transgranular or intergranular fracture are observed in the cut surface morphology. In the SEM image the abrasive scooping action or ploughing action of particles was identified and roughness increased in the cut surface. This accumulates the relevancy of rise in crosswise speed and abrasive flow.

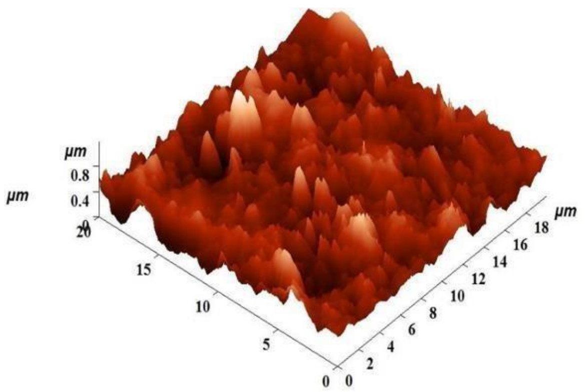

Figure: 9 3D Surface texture of machined AFM image

Atomic force microscopy and scanning force microscopy is a inordinately expeditious resolution type of scanning probe microscopy with exemplify resolution on the order of fractions of a nanometer more than 1000 times better than the optical diffraction limit. Atomic force microscopy is used to perceive three dimensional texture of the machined surface. The white peaks observed in the AFM image shows the maximum surface roughness value. The red peaks and valley observed in the AFM image shows the minimum surface roughness value. The surface roughness value obtained from the AFM test is 0.8µm.

IV. CONCLUSION

$Al6061/Al_2O_3/B_4C$ metal matrix composite material was made by stir casting technique and machined by Abrasive Water Jet Machining with abrasive garnet material 80mesh. It is analyzed with relevance in varied transverse speed, abrasive rate and maintaining continuous water pressure and standoff distance. Instant rise within the abrasive rate and transverse speed affects the cut surface. Moving towards steadily the is roughness worth. Using the Scanning Electron Microscopic the cut surface samples morphology was analyzed with respect to the varying fracture and ploughing action. By using Atomic force microscope (AFM) three dimensional texture of the machined surface is analyzed with respect to peak and valleys present in the image, which inference the surface roughness of the composite material.

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AUTHORS PROFILE

Barath M, pursuing his bachelor in mechanical engineering under annauniversity, chennai. His areas of Interest is materials science and hopes to pursue masters degree in the field. Barath also holds technical skills in dealing with composite and nanomaterilas

Rajesh S, M.E (Manufacturing Engineering), has secured university gold medal for post graduate study, published 15 papers in reputed journals and attended more than 10 international conferences and life time member in ISTE and ASME, his areas of research is additive Manufacturing, composites, welding and Composites.Recieved grants from state and central government organizations.

Duraimurugan.P has completed M.E (Computer Integrated Manufacturing) at College of Engineering,Guindy and currently pursing Ph.D in the area of Composites at Anna University. Published papers in reputed journals and attended more than 10 International Conferences and Workshops. He has received best paper Award during Research Conclave 2018@IIT Guwahati. A vast experience in teaching around 20 years in reputed University and Engineering Colleges. Received funds from State Government organization to carry out projects. Life time Member in ISTE and SAE. He has specialized in the areas of composites, Robotics, Finite Element Analysis to carryout research activities.