INTERNATIONAL JOURNAL FOR TRENDS IN ENGINEERING & TECHNOLOGY
VOLUME 5 ISSUE 2 – MAY 2015 - ISSN: 2349 - 9303

Study on Microstructure and machining characteristics of 7% B_4C_p reinforced in Aluminium6061 MMC produced by stir casting method

Sachin Kumar
UG Student, R & D Centre,
Department of Mechanical Engineering,
Siddaganga Institute of Technology,
Tumkur-572103, Karnataka INDIA
Email: sstarnalli21@gmail.com

P S Ranjan
UG Student, R & D Centre,
Department of Mechanical Engineering,
Siddaganga Institute of Technology,
Tumkur-572103, Karnataka INDIA
Email: psranjan06@gmail.com,

V Auradi
Associate Professor, R & D Centre,
Department of Mechanical Engineering,
Siddaganga Institute of Technology,
Tumkur-572103, Karnataka INDIA
Email: vsauradi@gmail.com

Abstract
The specimen was casted with the reinforcement B_4C_p (7wt. %) and matrix Al6061 by Stir casting method to study its microstructure and machining characteristics. The microstructure was observed by using computerized optical microscope. The machining characteristics of Al6061-B_4C_p depend on different parameters like depth of cut, feed rate and cutting speed. Therefore the effects were studied by varying one of the parameters and keeping the other two as constant. After machining, the surface was examined by using Insize digital optical microscope analyzer to know the condition of the machined surface.

Index Terms- Reinforcement, Matrix, Stir casting, Microstructure Machining, Depth of cut, feed rate, cutting speed, BUE.

1 INTRODUCTION

Composite materials are materials made from two or more constituent materials with significantly different physical or chemical properties. A metal matrix composite is composed of matrix and the reinforcement. Matrix is a monolithic material into which the reinforcement is embedded reinforcements. The new material may be preferred because they are stronger, lighter and have a low coefficient of thermal expansion; good wear resistance etc., when compared to other materials.

Among the various materials available, Aluminium and its alloys are widely used in fabrication of MMC's. Aluminium based metal matrix composites have become a very valuable addition to the field of newer materials. These composites are mainly used in Automotives, Aerospace and in Defense sector. The Aluminium based composites are mainly produced by using the stir casting method and powder metallurgy process. In this experiment an attempt is made to produce the Aluminium composite using stir casting method and study the microstructure.

In present work, an attempt will be made to study the microstructure and the machining characteristics of Al6061 reinforced with 7% B_4C_p particulates.

Machining is process in which a piece of raw material, that can be cut into desired shape and size by controlled removal of material from work or work piece. The Machining characteristic of Al6061- B_4C_p depends on different parameters like depth of cut, feed rate and cutting speed. Therefore the effects were studied by varying one of the parameters and keeping the other two as constant.
Although machined surfaces appear smooth to the naked eye, they are quite rough at the microscopic levels. Hence, knowing the surface roughness plays an important role.

The surface finish produced is strongly dependent on the cutting speed. The surface roughness for low speed is very high and much less surface roughness is obtained at higher cutting speed. It is found to be good at lower feed and getting worst as feed the increases. As feed the increases contact between tool and work piece also the increases.

Aluminium60661-Boron Carbide Composites

It is a metal matrix composite in which Aluminium-6061 is a matrix and Boron Carbide ($B4C$) is the reinforcement.

Composite is produced by stir casting method.

Properties of Al6061-$B4Cp$:-

- Good toughness.
- Good surface finish.
- Excellent corrosion resistance to atmospheric conditions.

- Good weldability.
- Good workability.
- Corrosion resistance to the sea water.

Also the reinforcement B_4C_P is one of the hardest materials known, ranking third behind diamond and the cubic boron carbide. B_4C_P is produced by reacting carbon with B_2O_3 in electric arc furnace, through carbon -thermal reduction or by gas phase reactions.

Mechanical Properties of Aluminium-6061

Density	2.7
Elastic modulus(GPa)	70-80
Poisson's Ratio	0.33
Brinell Hardness number	95-97
Thermal Conductivity (W/mK) at 25^{0}C	173
Melting Temperature (C)	580^0

Mechanical Properties of Boron Carbide

Density (g/cc)	2.5
Elastic Modulus (GPa)	460
Poisson's Ratio	0.17
Hardness (kg/mm^2)	3200
Fracture Toughness	2.5
Flexural Strength	410
Thermal Conductivity (W/mK) at 25^{0}C	90
Melting Temperature (C)	2445

2. EXPERIMENTAL PROCEDURE

Stir casting method

Calculated amount of 6061Al alloy was charged into the SiC crucible, and is heated to a temperature of 750^{0}c in an electrical resistance furnace. Flux is added which decreases the contact angle and surface tension forces and improve the wettability of B_4C_p particles at lower temperatures. B_4C_p were pre- heated to a temperature of 200^{0}C in an oven to remove the absorbed gases from the particle surface. The Melt is agitated with the help of a Zirconia coated stainless steel stirrer to form a fine vertex. A stirring speed of 200 rpm and stirring time of 1 minute were adopted. Preheated B_4C_p was added along with stirring as shown in figure 2.1.

Fig 2.1 Addition of B_4C into the melt

Fig 2.2 Pouring of molten metal into permanent mold

After holding the melt for a period of 5 minutes, the melt was poured from 750^{0}c in to a preheated metallic mold having dimensions of 170mm x 33mm diameter as shown in figure 2.1 and 2.2. The finally obtained casted product Al6061-B4Cp is as shown in figure 2.3.

Fig 2.3 obtained Cast product.

Microstructural analysis

Microstructural study gives a clear picture of distribution of reinforcement in the matrix and arrangement too.

Steps Involved in microstructure analysis

- **Grinding-** Defined as rapid removal of material from a sample either to reduce it to a suitable size or to remove irregularities from the surface.
- **Lapping-** It is removal of material to produce a smooth unpolished surface and used to produce a dimensionally accurate specimen to high tolerance.
- **Polishing-** It is material removal process to produce a scratch free surface using fine abrasive particles.
- **Etching-** It is used to enhance micro-structural features such grain size.
- The finished specimen is kept under optical microscope to obtain the images of grain Micro-structure.

MACHINABILITY

Machinability is a term indicating how the work material responds to the cutting process. In the most general case good machinability means that material is cut with good surface finish, long tool life, low force and power requirements, and low cost. A closer definition of machinability requires some quantitative judgments to be made. Several possibilities are available, but in practice so called machinability index is often quoted.

Machinability index is defined by,

$$KM=V/VR$$

Where V is cutting speed for the target material that ensures tool life,VR is the same for reference material
If KM>1, machinability of target material is better that this of the reference material and vice versa.

MACHINING PARAMETERS
The Mechanical characteristic of Al6061-B_4C_P depends on different parameters like depth of cut, feed rate and cutting speed. Therefore the effects were studied by varying one of the parameters and keeping the other two as constant.

CUTTING SPEED
It is the peripheral speed of work piece past the cutting tool per unit time. d=diameter of the work piece, n=speed of the work piece.

FEED RATE
It is the distance travelled by the tool during each revolution of the work piece. The increase in cutting force with the increase in feed rate may be attributed to the higher friction between tool and work piece.

DEPTH OF CUT

It is the perpendicular distance measured from the machined surface to the original surface of the work piece.
DOC=*D'*-*d"*
D'=original diameter of the work piece,
d"=final diameter of the work piece.

EQUIPMENTS USED FOR MACHINING OPERATION

- Lathe machine
- Lathe tool dynamometer
- PCD tool

LATHE MACHINE

SPECIFICATIONS OF LATHE MACHINE

RAV I MACHINE PRODUCT	LATHE MACHINE BANKA(35)
Bed length	5 feet to 7 feet
Centre length	175mm
Swing over bed	350mm
Spindle board	40mm
Spindle speed	48-135rpm
Width of bed	242mm

LATHE TOOL DYNAMOMETER
Lathe tool dynamometer is a multi-component dynamometer that is used to measure forces during the use of machine tool. Lathe tool dynamometers are increasingly used for the accurate measurement of forces and optimizing the machine forces. These multi-component forces are measured as an individual component force in each co-ordinate, depending on the co-ordinate system used.

Specifications of LTD

Model	UIL-15
Capacity	500kg
Tool size	$20mm^2$
Sensor type	Strain gauge based 350Ω bridge
Power	230V 50Hz
Dynamometer mounting hole	25mm diameter hole to mount sensor on tool post
Record output	Analog output for connect any recorder

PCD tool
PCD tool is a composite of diamond particles sintered together with a metallic binder. Diamond is a hardest and therefore abrasion resistant of all materials. As a cutting tool, it has good wear resistance.

Advantages of PCD tool

- Better surface finish.
- Interrupted cutting machine without any problem.
- Better ratio of surface finish to cutting forces and metal material removal rate.
- Possibility of closer dimensional tolerance.

Surface Roughness

Surface roughness plays an important role in satisfactory operation of hydrodynamic lubrication of rolling or sliding contacts. Although machined surfaces appear smooth to the naked eye, they are quite rough at the microscopic levels. The surface finish produced is strongly dependent on the cutting speed. The surface roughness for low speed is very high; much less surface roughness is obtained at higher cutting speed. It is found to be better at lower feed a getting worst as feed the increases. As feed the increases contact between tool and work piece also the increases.

3. RESULTS AND CONCLUSION

The figure 3.1 clearly shows microstructure of Aluminium 6061.

Fig 3.1 optical micrograph of Al6061

The figure 3.2 clearly shows microstructure of Boron Carbide particulates.

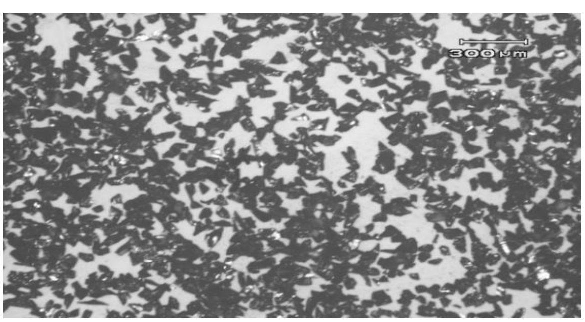

Fig 3.2 optical micrograph of B4Cp

It reveals the homogeneous distribution in the composite resulting from the reinforcement of Boron carbide (7% by weight) in Aluminium6061 matrix.

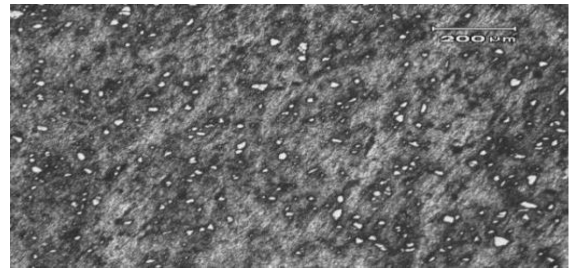

Fig 3.3 optical micrograph of Al6061+7% of B_4C_p

The cutting force during machining of composites decreases with increasing has cutting speed show in below graph
Fig 3.4 shows the variation of cutting force with cutting speed in X, Y and Z directions.

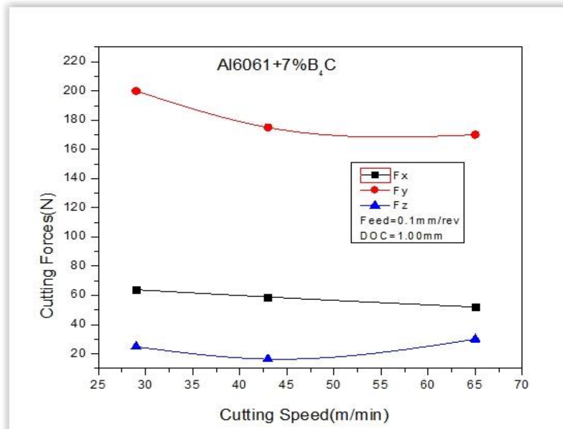

Fig 3.4 shows the variation of cutting force with cutting speed in X, Y and Z directions. From graph it is clear that during turning of Al6061-B4Cp, as cutting speed the increases cutting force decreases at constant feed rate and depth of cut.
The cutting force the increases with the increase in feed rate and depth of cut as shown in graph below.

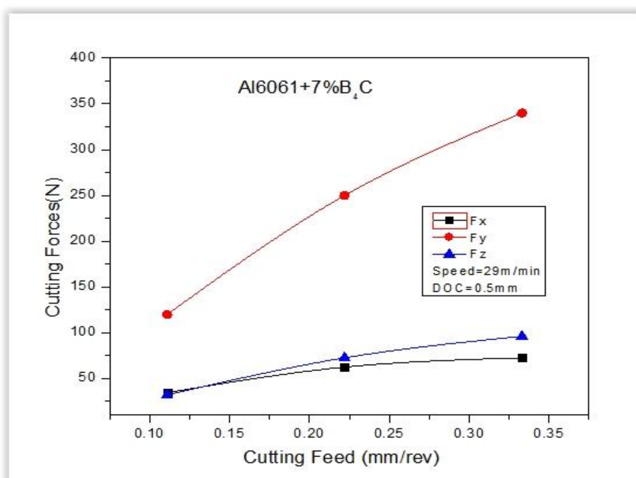

Fig 3.5 shows the effect of increasing feed rate on cutting force.

Fig 3.5 shows the effect of increasing feed rate on cutting force during turning of Al6061-B4Cp. The graph clearly reveals that as feed rate the increases the cutting force developed during turning also the increases. The increase in cutting force with the increase in feed rate may be attributed to the higher friction between tool and work piece.

The effects of cutting forces at variable depths of cut under constant speed and feed rate.

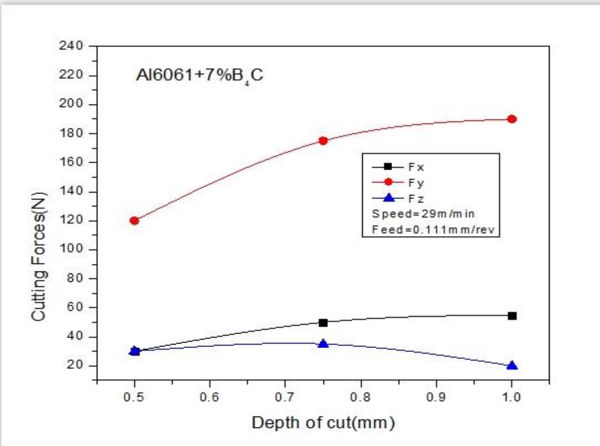

Fig 3.6 shows the influence of the depth of cut on cutting forces that are generated during turning of Al6061-B_4C_P.

Fig 3.6 shows the influence of the depth of cut on cutting forces that are generated during turning of Al6061-B_4C_P.From the graph it is clear that cutting force the increases with increasing in depth of cut. Amongst all the three forces predicted, the increase in tangential force (F_Y) is much higher when compared to other two forces.

5. Conclusion:

• The increase in cutting force with the increase in feed rate may be attributed to the higher friction between tool and work piece.

• As cutting speed the increases cutting force decreases at constant feed rate and depth of cut.

• It is clear that cutting force the increases with increasing in depth of cut.

• Formation of built-up edge was observed for all the cutting speed during the machining of Composites however, the size of BUE decreased with the increased cutting speed.

• Surface roughness of composites the increases with increasing feed rate and depth of cut, but decreases with increasing in cutting speed.

6. REFERENCES

[1] Vijaykumar Hiremath, S T Dundur, Bharat Raj L and Dr. V Auradi, Study on Mechanical and Machinability Properties of B4Cp reinforced 6061 Aluminium MMC produced via melt stirring.

[2] R. Teri, Machining of composites (page. no. 1 – 9).

[3] S. Rama Rao, G. Padmanabhan, Fabrication and Mechanical Properties of Aluminium and Boron carbide Composites.

[4] K. Rajkumar, J. Maria Antony Charles, Mechanical and Machining Characteristics of Al – B4C Metal Matrix Composites.

[5] F.Topan, A.Kilicarslan, L.Kerti, the Effect of Ti Addition on the Properties of Al – B4C Interface.

[6] S. Kennan, H.A. Kishawy, "Surface characteristics of machined Aluminium metal matrix composites". International Journal of Machine Tools & Manufacture 46 (2006) 2017–2025

[7] Thiagarajan Rajmohan, Kayaroganam Palanikumar, "Examination of wire electrical di s charge m ach i n i n g of Al_2O_3p/ Al6061 co mpos i t e s". International Journal of Machine Tools & Manufacture 45 (2005) 251– 259

[8] Y. Zhu, H.A. Kishawy "Influence of alumina particles on the mechanics of machining metal matrix composites". International Journal of Machine Tools & Manufacture *45 (2005) 389–398*

[9] *Y.Z. Li, Q.Z. Wang, B.L. Xiao, Z.Y.* "Fabrication and Welding of Aluminium Matrix Composite Reinforced with WC and B4C Particles". *Measurement 46 (2013) 1470–1481*

[10] S. Rama Rao, G. Padmanabhan. Fabrication and mechanical Properties of Aluminium-boron carbide composites.

Author Profile:

• Pradeep.V.Badiger is currently pursuing master's degree program in Manufacturing Science and Engineering in SIT, Tumkur,
Phone-+91-9980556720. E-mail: pvb.badiger@gmail.com

• Vijaykumar Hiremath is currently Assistant Professor in SIT Tumkur .
E-mail: hiremath.vijaykumar@gmail.com