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Investigation of the Mechanical and Machinability Characteristics of Al6061 Composites Reinforced with B_4C Particles

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Abstract: Metal matrix composites especially Aluminium metal matrix has emerged as structural materials satisfying all requirements basically light weight, high strength values and high toughness values. The improved mechanical properties combined with the savings in weight have paved way for engineering applications in automotive, aerospace applications. This is due to the exhibiting superior properties compared to the base matrix. It has also replaced conventional materials when specific properties are demanded for the required applications.
In the present work, successful attempts were made to reinforce Boron carbide (B_4C – 4 to 10% in steps of 2%) additions using stir casting method with copper (CU) chill material embedded in mould. Mechanical properties such as UTS, hardness have been studied. Machinability studies has been carried out using turning tests. The influence of cutting parameters namely feed, speed and depth of cut has been studied with respect to the power consumption. Cutting forces were measured by varying spindle speed, feed and depth of cut. Results indicate the improvement in mechanical properties with addition of B_4C and the castings made in Cu chill exhibits higher values of UTS and hardness. From the machinability studies it is observed that the power required to machine composite increases with increase in the B_4C additions.
Keywords: MMC's, Chill, Hardness, Ultimate tensile strength, Cutting forces

I. INTRODUCTION

The industrial demand for new materials is a testimony for the development of MMC's (Al-MMCs). Low density, good thermal conductivity, wear resistance property has made Al -MMC to be considered as a candidate material for several structural, automotive and aerospace applications [1-6]. Among the different alloys used Al6061 is the most widely used one. This is the most widely employed heat treatable alloy used for medium to high strength requirements; exhibits good toughness values, finds its application in automotive, recreational products, fabrication of equipment's as it exhibits good corrosion resistance property [5-8]. B_4C additions has also been reported on this alloy to improve the properties, especially for wear resistance applications. Chills promoting directional solidification is one of the methods adopted for achieving good strength properties. Different chill materials with different thermal conductivity have been explored by investigators for carrying out the structure, mechanical properties correlations [4]. Machinability may be defined as an ease with which the material may be machined under specific condition. This property plays an important step in the manufacturing process. Different methods have been employed to assess the machinability property like the tool wear, cutting force measurement, surface finish etc. [10-12, 14]. Power consumed during machining is one of the methods of assessing the machinability of the material.

In the present investigation, Al6061 alloy is reinforced with varying percentages of B_4C additions. B_4C additions were carried out soon after the metal attained the molten condition and molten alloy was transferred into the mould in which chill material is embedded. Mechanical properties such as UTS and hardness and machinability property has been studied and the results are quite interesting and useful for automotive applications and foundry men worldwide [13].

II. EXPERIMENTAL PROCEDURE

Matrix material selected in the present investigation is Al6061 alloy. Al6061 alloy is a popular choice in various industrial and manufacturing applications due to its high strength, good corrosion resistance, and excellent workability [6,9].

The alloy comprises aluminum as the primary element, with magnesium, silicon, and copper added in specific proportions to enhance its mechanical and physical properties. The precise composition of the matrix material is given in the table 1.

Table 1: composition of Matrix Al6061 alloy

Elements	Cu	Mg	Si	Fe	Mn	Zn	Ti	Cr	Al
Wt. by %	0.16	0.83	0.52	0.26	0.03	0.01	0.10	0.15	remaining

For this investigation, B_4C in powder form with a mesh size of 140 was chosen as the reinforcement material. This selection was based on the favorable mechanical properties of B_4C, such as its high strength and hardness values, which make it an ideal candidate for reinforcement purposes [2,6]. Table 2 presents detailed information on the properties of B_4C, including its density, Young's modulus, Poisson's ratio, and thermal conductivity. The mesh size of 140 indicates the particle size distribution of the B_4C powder, which is essential to ensure that the reinforcement material can be effectively dispersed and integrated into the matrix material. The characteristics of the reinforcement material play a critical role in determining the overall properties of the composite material [9,12].

Table 2: Properties of reinforcement B_4C

Density(gm/cc)	2.52
Hardness (BHN)	350
Size (µm)	105
Young’s Modulus(Gpa)	450-470
Melting point(^oC)	2445

A. *Composite Preparation*

The present work aims at casting Al6061 - B_4C composite with chills embedded in the mould. Stir casting method is used to fabricate Al6061 - B_4C by varying reinforcement additions. Al6061 alloy ingot was placed inside the crucible. This was heated to a temperature of 750^0C. When the metal attained the molten state degassing using hexachloroethane was carried out [2, 6, 9]. At the temperature of 750^0C, different amounts of preheated B_4C (with varying percentages) were added into the vortex followed by mechanical stirring. Cover flux was added to the molten metal before pouring into the mould. After solidification and cooling, the castings were removed from the mould and specimen were prepared for mechanical properties and machinability tests.

B. *Mechanical Properties*

Brinell hardness test was carried out on 10mm hardened steel ball indenter. Specimen measuring 20mm height and 20mm diameter was machined from the alloy with reinforcement additions made using chill material. An average of three hardness measurements across the cross section has been considered for the analysis. UTS values were determined for the alloy with reinforcement additions. Standard tensometer specimens were machined from the above and using a tensometer UTS values were determined.

C. *Machinability Test*

In the present investigation, the machinability was evaluated by using turning operations for 10% of B_4C additions. After selecting the cutting parameters such as speed, feed and depth of cut, the tangential cutting force was measured (during turning operation) using lathe tool dynamometer on lathe machine. Power consumed during machining is determined.

III. RESULTS AND DISCUSSION

The results of the investigation carried on Al6061 alloy reinforced with B_4C additions cast using copper chill material are highlighted here under.

A. Hardness Value

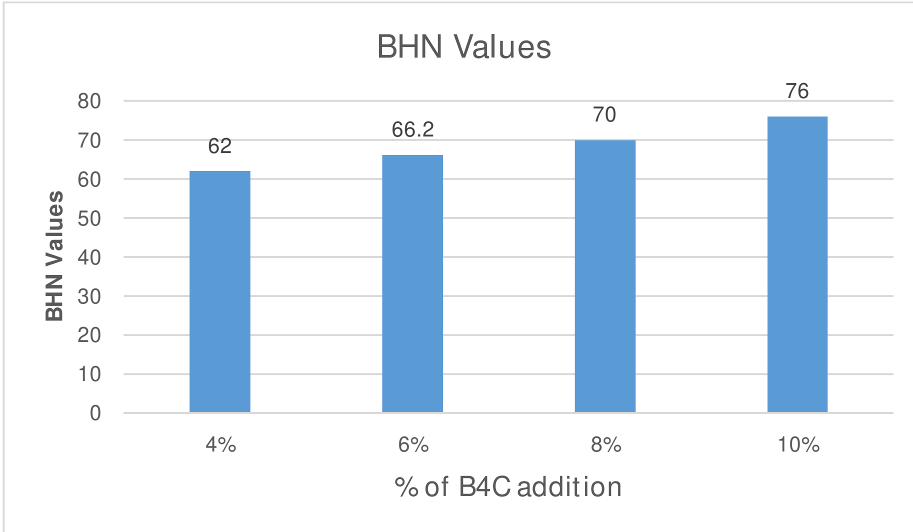

Figure 1: Histogram - BHN values for varying B_4C addition with copper chill

Figure 1 shows the histogram drawn for the hardness values obtained for the alloy with reinforcement made using copper chill. It can be observed from the figure that the alloy with higher B_4C additions exhibits higher hardness values. It is also seen that hardness values increases with increase in B_4C additions. The increase in the hardness value is attributed to the refinement in microstructure.

B. UTS Value

Figure 2 shows the histogram drawn for the UTS values obtained for the alloy with reinforcement made using copper chill. It can be observed from the figure that the alloy with higher B_4C additions exhibits higher UTS values. It is also seen that UTS values increases with increase in B_4C additions.

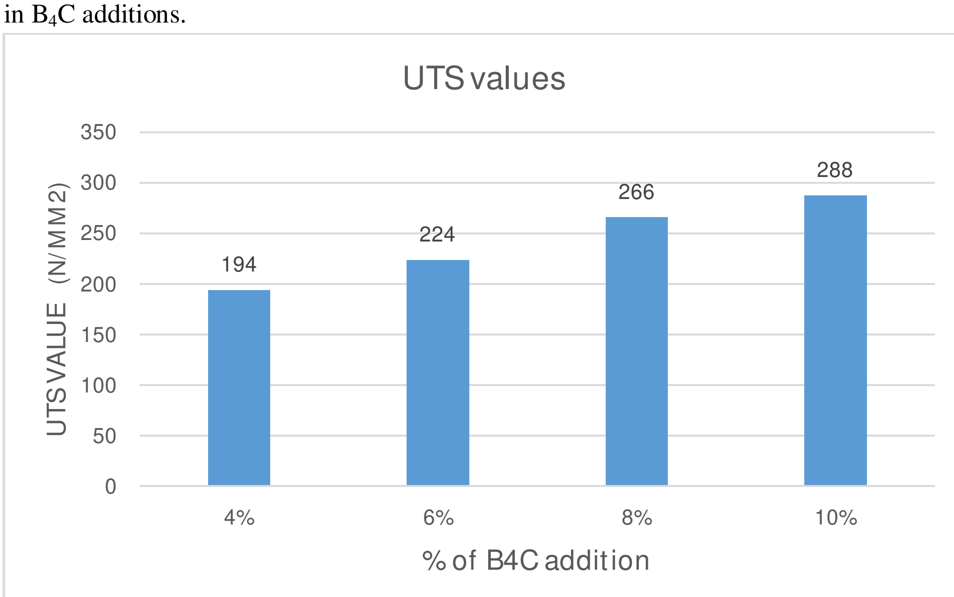

Figure 2: Histogram - UTS values for varying B_4C addition with copper chill

C. Machinability Studies

Machinability studies were carried using turning test (lathe machine is used). Cutting force measurements were made and the same has been used for the power consumption calculations. Figure 3, 4 & 5 shows the variation of power with varying cutting parameters viz depth of cut, feed, and spindle speed. It can be observed from the figure that power consumption during machining increases with increase in speed, feed, and depth of cut for 10% of B_4C addition with copper chill.

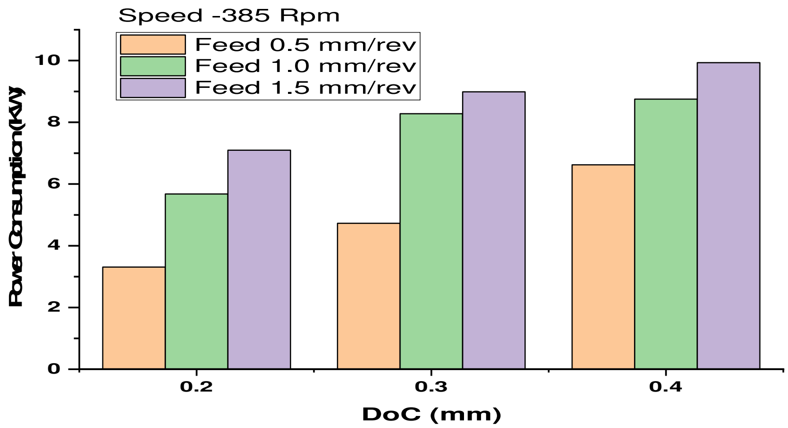

Figure 3: Histogram - power consumption value - speed 385 rpm

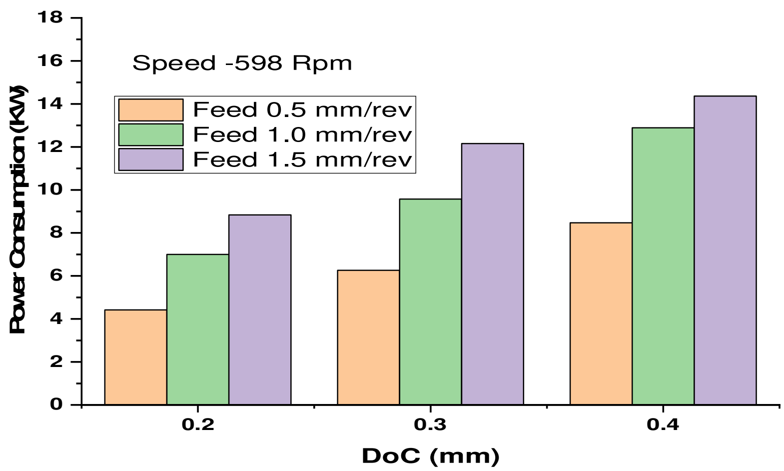

Figure 4: Histogram - power consumption value - speed 598 rpm

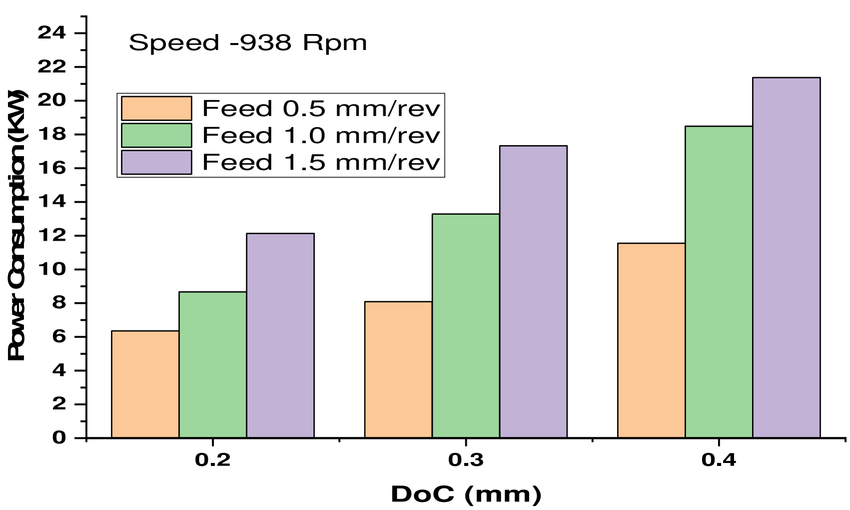

Figure 5: Histogram - power consumption value - speed 938 rpm

IV. CONCLUSION

After conducting studies on Al6061 alloy reinforced with B_4C in combination with copper chill, the following observations are made.

1) Hardness value increases with increased additions of B_4C.
2) UTS value increases with increased additions of B_4C.
3) It is observed that power required for machining higher amounts of reinforcement additions is more. Power Consumption increases with increase in speed, feed and depth of cut (DOC).

REFERENCES

[1] P. Rotagi, Advances in cast MMC's, Adv. Mater. process 2 (1990) 38-44

[2] Sanman.S, Prashanth K P, Anil K C, Venkatesha B K, Gopal Krishna U B & Yuvaraj L "Effect of percentage of reinforcement particulates on the corrosion behaviour of aluminium boron carbide composites" Journal of Mines, Metals & Fuels, Vol.69, No.12A, DECEMBER, 2021, PP- 250-254. https://doi.org/10.18311/jmmf/2021/30111

[3] Siddappa P. N, B.P. Shivakumar, Yogesha K.B, Mruthunjaya M & Hanamantraya gowda M.B, Machinability study of Al-TiC metal matrix composite, MATEC Web of conferences, 144, 03001(2018)

[4] K.C. Anil, J. Kumaraswamy, Akash, S. Sanman, "Experimental arrangement for estimation of metal-mold boundary heat flux during gravity chill casting", Materials Today: Proceedings, Volume 72, Part 4, 2023, Pages 2013-2020, ISSN 2214-7853, https://doi.org/10.1016/j.matpr.2022.07.399.

[5] A.D. Bagawade, P.G Ramdasi, Effect of cutting parameters on material removal rate and cutting power during hard Turning of AISI 52100 steel

[6] Leela B.N., Dr. N.D. Prasanna, Dr. Balasubramanya H.S, Influence of chill material on microstructure and mechanical properties of Al6061-B4C composite, IJSR, ISSN: 2319-7064, Vol 12, Issue 2 (2023)

[7] Anil, K. C., Sachin Gadge, Rishabh Kumar Srivastva, and K. V. Sreenivas Rao. "Three-body abrasive wear behavior of Al-8011 alloy reinforced with graphite and red mud particulates." Int. J. of Science, Engineering and Management (IJSEM) 2, no. 2 (2017).

[8] J. Kumaraswamy, K.C. Anil, Vidyasagar Shetty, Development of Ni-Cu based alloy hybrid composites through induction furnace casting, Materials Today: Proceedings, Volume 72, Part 4, 2023, Pages 2268-2274, ISSN 2214-7853, https://doi.org/10.1016/j.matpr.2022.09.215.

[9] Leela B.N., Dr. N.D. Prasanna, Dr. Balasubramanya H.S, Mechanical and Wear behavior of Al6061 aluminum alloy composites subjected to B4C particulates produced using stir casting, IJERT, ISSN:2278-0181, Vol 8, Issue 14, 2020

[10] Harishchandra, R.S. Kadadevaramath and K.C. Anil, "Effect of tool material on machinability of TiCp reinforced Al-1100 composite" IOP Conf. Series: Materials Science and Engineering 149 (2016) 012026. DOI:10.1088/1757-899X/149/1/012026

[11] Richard Geo, Jose Sheril D'Cotha, Effect of turning parameters on power consumption in EN24 alloy steel using different cutting tools, IJERGS, Vol 2, Issue 6, ISSN: 2091-2730, Nov (2014).

[12] Srivathsan. A, Srinivasa Perumal R. & Vignesh. A., Machinability studies on Turning Al6061 alloy with 10% reinforcement of B4C on MMC, , MATEC Web of conferences, 40, 01002(2016)

[13] K.V. Sreenivas Rao, K.C. Anil, Akash, K.G. Girisha, Effect of Particle Size on Mechanical Properties of Al-RMp Metal Matrix Composites, Materials Today: Proceedings, Volume 4, Issue 10, 2017, Pages 11154-11157, ISSN 2214-7853, https://doi.org/10.1016/j.matpr.2017.08.080

[14] D Srinivasa and G V Naveen Prakash, Machinability studies on Hybrid Aluminum metal matrix composites, IOP Conf. series; Mater.Sci.Eng.,1258(2022) 012023.