INVESTIGATION ON SURFACE FINISH AND TOOL CONDITION WHILE TURNING AL20 Mg_2Si METAL MATRIX COMPOSITE

[1]MOHSEN MARANI, [2]VICTOR SONGMENE, [3]IBRAHEM MAHER

[a]Aluminium Research Centre-REGAL, École de technologie supérieure, Montreal, Canada
[b]Department of Mechanical Engineering, Kafrelsheikh University, Kafrelsheikh, Egypt
E-mail: marani.mohsen@gmail.com, victor.songmene@etsmtl.ca, ibrahemmaher@eng.kfs.edu.eg

Abstract— Surface roughness is a key measure that defines machined surface integrity. In this current work, an experimental investigation was conducted to determine the effects of cutting conditions on surface roughness when turning the Al20%Mg_2Si metal matrix composite and Bi-treated Al20%Mg_2Si composite. The results showed that surface roughness value improved with cutting speed increment. In addition, Bi treated workpiece showed better surface finish results compared to base composite

Keyword- Surface roughness, Built up edge, Metal Matrix Composite

I. INTRODUCTION

Mechanical properties of light metal matrix composites such as superior strength, stiffness and better wear resistance indicate that metal matrix composites (MMC) play an important role in application for engineering components [1]. In fact, these properties, coupled with low density, and the ability to operate at elevated temperatures, has made these materials suitable for using in the manufacture of a range of components, from engine parts to sports goods [2].

Al-based composite reinforced by in-situ Al20%Mg_2Si particles is one of the combinations of MMC's, which is more atractive in the areas of aerospace and automotive engineering components. In addition, Al%20 Mg_2Si in situ metal matrix composites (MMCs) have the potential to replace the commonly used Al–Si alloys [3]. Despite the fact that Mg_2Si intermetallic particles exhibit some advantages, their coarse morphology in the Al-matrix has been thought to lead to the low ductility observed in these materials. Therefore, there is a need to improve mechanical properties of these composites. One of the most common and effective methods for improving the morphology of workpiece is modification of the microstructure [4].

It has been reported that the addition of some elements such as Ce, Li, Sr and Bi to the melts of Al20% Mg_2Si composites can effectively refine the size of primary Mg_2Si and change its morphology [5]. In fact, it is expected that the mechanical properties of composite can be improved by addition of optimum modification and the microstructure of material can be changed by modification that affects the machinability of the composite.

The major issue of MMCs is the poor machinability which occurs due to the ceramic reinforcements (whiskers, particles and fibers) in the soft metal matrix [6]. These issues of machining MMCs have been addressed from various aspects. It has been found that the morphology, distribution and the matrix properties are all factors that affect the overall cutting process [7].

Barzani et al investigated the machinability of Al–Si–Cu cast alloy containing bismuth and antimony using coated carbide insert. They have found that type of Si shape (flake or lamellar shape) has a major effect but cutting speed slightly affects chip shape. It is also found that addition of antimony lead to change flake–like eutectic silicon into the refined lamellar structure and increased surface roughness value and machinability of alloy[8] . Another investigation was done on surface roughness when machining Al-Si alloy. They have found that surface roughness increased with increasing feed rate from 0.05 to 0.15 mm/rev while increasing cutting speed from 70 to 250 m/min improved surface roughness value after machining [9].

It is known that some parameters such as cutting speed, feed rate, depth of cut and geometry of insert play a vital role in machinability of composites. In fact, these parameters have direct effect on the cost of manufacturing products. Therefore, having optimum cutting condition is necessary to have the best surface roughness in machining process. The aim of this study is to investigate the effect of cutting parameters on surface roughness during turning of %20AlMg_2Si metal matrix composite

II. METHODOLOGY AND EXPERIMENTAL PROCEDURE

An induction furnace was used to melt the materials. The melt temperature was maintained at 750-760°C for a period long enough to allow for complete melt homogenization. Bismuth (Bi) in the form of metallic granules was added in certain concentration. In order to have a complete homogenization melt, the melted materials were stirred and it was then poured at a temperature of 730 ± 5°C into the permanent mold. Two workpieces, namely Al20% Mg_2Si metal matrix composite and 0.4 wt.% Bi treated Al20% Mg_2Si

metal matrix were cast. Tables 1 is given the details of the workpieces.

A CNC turning machine with 8.3 kw power and 6000 rpm was used. Three cutting speeds 70, 180, 250 m/min and feed rates 0.1, 0.15, 0.2 mm/rev have been employed respectively. Kennametal inserts with grade K10, was mounted on the holder designated by SVJBL-1616H11. Table 2 is given the details of tools. A Mitutoyo-Formtracer 5000 was used to measure surface roughness after machining process and average surface roughness of recorded values was calculated.

Table1. Details of cutting tool

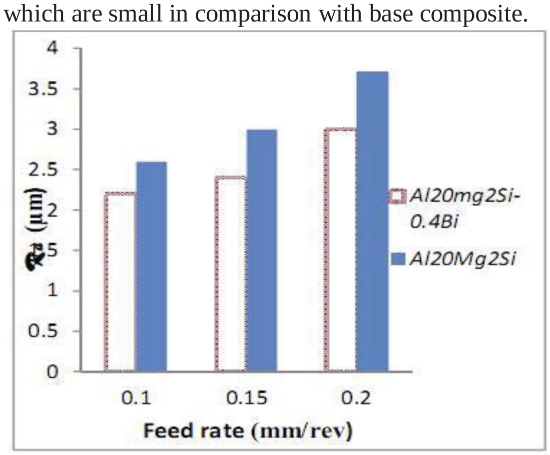
nose radius	relief angle	rake angle
0.2 mm	5°	0°

Table 2. Chemical composition of Al20% Mg_2Si metal matrix composite

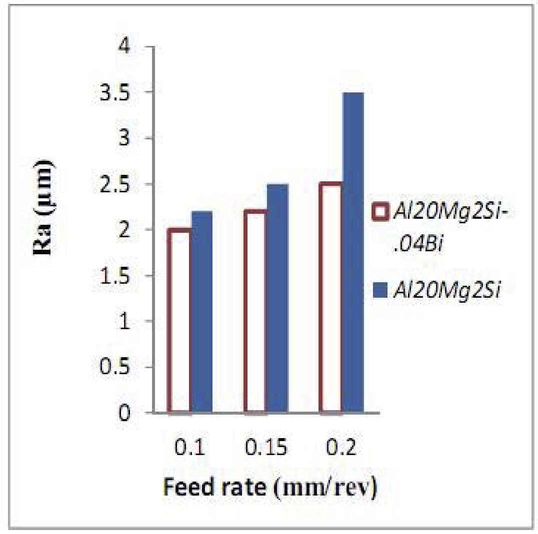
Al	Si	Fe	Cu	Mn	Mg	Cr	Zn
Bal	7.05	0.62	2.050	0.218	12.720	0.035	0.610

III. RESULT AND DISCUSSION

Figure 1 (a,b and c) shows that the surface roughness increased with increasing feed rate from 0.1 to 0.2 mm/rev. As it can see in figure 1 (a), the highest surface roughness value is just below 4µm at highest feed rate (0.2 mm/rev) which is related to base composite Al20% Mg_2Si metal matrix while Figure 1 (c) revealed that lowest surface is about 2 µm for Bi-treated Al20% Mg_2Si composite. In addition, it is clear that Al20% Mg_2Si -0.4Bi metal matrix composite shows lowest surface roughness for all machining conditions compared to base composite. This can be related to the size of Mg_2Si particles which are small in comparison with base composite.



(a)



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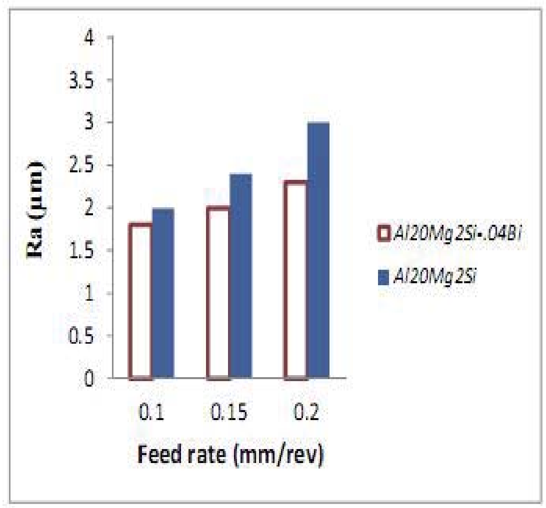
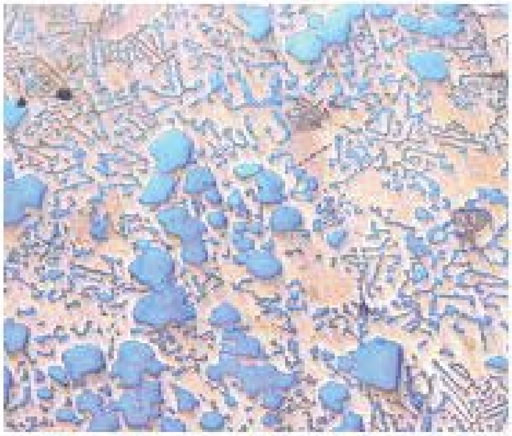


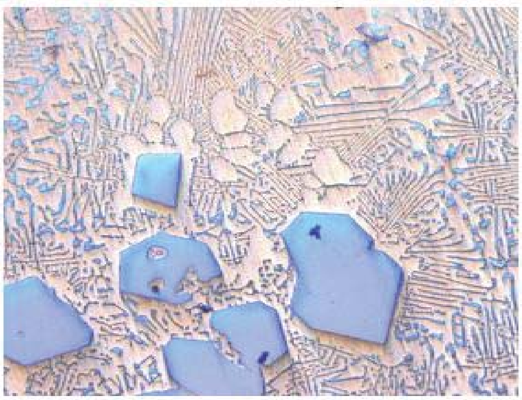
(c)

Figure1 Surface finish for Al20% Mg_2Si MMC and Bi treated Al20% Mg_2Si MMC at cutting speed of (a) 90 m/min, (b) 180 m/min, (c) 270 m/min.

As it can be seen in figure 2, the size of Mg_2Si particles changed from 22 µm to around 11 µm by addition of optimum amount of Bi. The changing of size of Mg_2Si particles has direct effect on value of surface roughness during machining process. In fact, there is no tendency to build-up edge formation (Figure3) due to quick breakage of it from tool and low melting point of Bi, thereby decreasing the friction between tool edge and chip leads to have less tool wear and finally a smooth machined surface. It has also been found that Bi acts as lubricant during machining process and it can improve machinability of the composite.



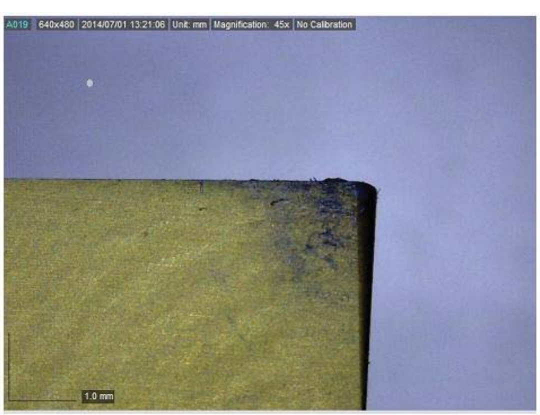
(a)



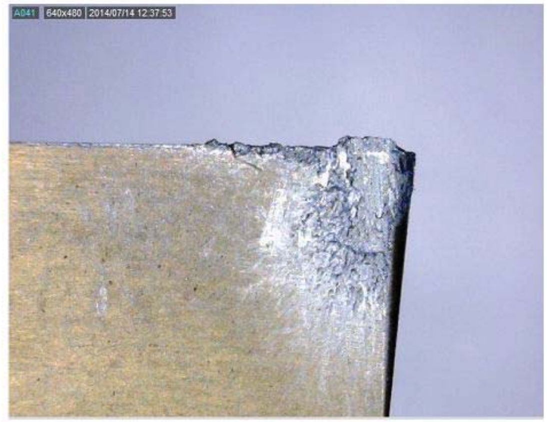
(b)

Figure 2 Optical micrographs showing different size of Mg_2Si particles indifferent conditions (a) base composite (b) Bi-treated composite

Figure 3 (a and b) shows the amount of build-up edge on the flank and rake of insert. As it can be seen in figure 3b, there is massive amount of build-up edge (BUE) on the insert when turning Al20% Mg_2Si composite as base composite at highest cutting speed and highest feed rate while there no tendency to make BUE for Bi treated composite during machining process[9].



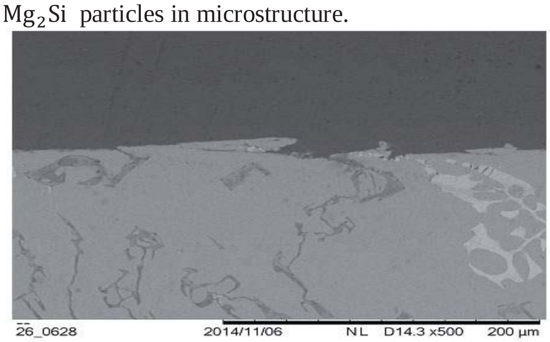
(a)



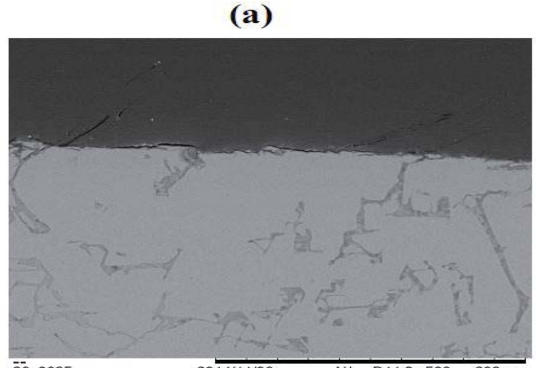
(b)

Figure 3. Build-up edge formation during machining (a) Bi-treated Al20% Mg_2Si composite and (b) Al20% Mg_2Si metal matrix composite.

Figure 4 (a and b) shows machined surface for base composite and Bi-treated composite respectively. From figure 4 a, it is noticeable that there is surface tearing after machining which could be related to big size of Mg_2Si particles for Al20% Mg_2Si metal matrix composite as base composite, while there is a smooth surface after machining Bi-treated composite which may be attributed to the role of Bi as lubricant during machining and distributed small size of Mg_2Si particles in microstructure.



(a)



(b)

Figure 4. Image of machined subsurface of (a) Al20% Mg_2Si MMC and (b) Bi-treated composite.

CONCLUSION

The following conclusions from the current study in dry turning of Al20%Mg_2Si metal matrix composite as base composite and Al20% Mg_2Si -.04Bi can be drawn: surface roughness improved with increasing of cutting speed. Bi-treated Al20% Mg_2Si showed better surface finish due to low tendency of build-up edge formation during machining process. It is also found that the changes in topography and surface roughness are associated to the size changes of the Mg_2Si particles in the microstructure.

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REFERENCES

[1] 1. Emamy, M., N. Nemati, and A. Heidarzadeh, The influence of Cu rich intermetallic phases on the microstructure, hardness and tensile properties of Al–15% Mg 2 Si composite. Materials Science and Engineering: A, 2010. 527(12): p. 2998-3004.

[2] 2. Qin, Q., et al., Strontium modification and formation of cubic primary Mg 2 Si crystals in Mg 2 Si/Al composite. Journal of Alloys and Compounds, 2008. 454(1): p. 142-146.

[3] 3. Farahany, S., M. Bozorg, and N.A. Nordin, Study the Effect of Strontium Addition on Microstructure, Impact Toughness and Corrosion Behaviour of Al-Mg2Si In-situ Composite.

[4] 4. Koch, S. and H. Antrekowitsch, Free-cutting aluminium alloys with tin as substitution for lead. BHM Berg-und Hüttenmännische Monatshefte, 2008. 153(7): p. 278-281.

[5] 5. Hadian, R., M. Emamy, and J. Campbell, Modification of cast Al-Mg2Si metal matrix composite by Li. Metallurgical and Materials Transactions B, 2009. 40(6): p. 822.

[6] 6. Cheung, C., et al., Effect of reinforcement in ultra-precision machining of Al6061/SiC metal matrix composites. Scripta Materialia, 2002. 47(2): p. 77-82.

[7] 7. Siva, S.V., et al., Machinability of aluminum metal matrix composite reinforced with in-situ ceramic composite developed from mines waste colliery shale. Materials and Manufacturing Processes, 2013. 28(10): p. 1082-1089.

[8] 8. Barzani, M.M., et al., The influence of bismuth, antimony, and strontium on microstructure, thermal, and machinability of aluminum-silicon alloy. Materials and Manufacturing Processes, 2013. 28(11): p. 1184-1190.

[9] 9. Barzani, M.M., et al., Fuzzy logic based model for predicting surface roughness of machined Al–Si–Cu–Fe die casting alloy using different additives-turning. Measurement, 2015. 61: p. 150-161.

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