EFFECT OF STRONTIUM ON SURFACE ROUGHNESS AND CHIP MORPHOLOGY WHEN TURNING AL-SI CAST ALLOY USING CARBIDE TOOL INSERT

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Abstract— Surface roughness and chip morphology are important output in manufacturing product. In this paper, an experimental investigation was conducted to determine the effects of various cutting speeds and feed rates on surface roughness and chip morphology in turning the Al-Si cast alloy and Sr-containing. Experimental trials carried out using coated carbide inserts. Experiments accomplished under oblique dry cutting when various cutting speeds 70, 130 and 250 m/min and feed rates of 0.05, 0.1 and 0.15 mm/rev were used, whereas depth of cut kept constant at 0.05 mm. The results showed that Sr-containing Al-Si alloy have poor surface roughness in comparison to Al-Si alloy (base alloy). The surface roughness values reduce with cutting speed increment from 70 to 250 m/min. the size of chip changed with changing silicon shape in Al matrix. Also, the surface finish deteriorated with increase in feed rate from 0.5 mm/rev to 0.15 mm/rev.

Keywords—turning, surface roughness, chip morphology, strontium

I. INTRODUCTION

Aluminium alloys have been extremely used in aerospace and automobile industries due to their superior properties such as higher strength to weight ratio, excellent low-temperature performance and chemical inertness to commonly used cutting tools [1]. Due to its low density and excellent recycling potential, the demand for aluminum in the transportation industry is increasing [2, 3].

Various Studies have been performed on the turning of Al-Si alloy. For instance, effect of ceramic particle on surface roughness and chip morphology was investigated and it is revealed that at low feeds, the surface roughness of the MMC was controlled by particle fracture or pull-out but at higher feeds, it was controlled by the feed [1]. They have found that Chip breakability was found to improve due to the presence of the reinforcement particles in the MMC.

Short chips were formed under almost all conditions. With the non-reinforced alloy chips of almost similar shape (long and unbroken) were formed for all cutting conditions [4]. Another investigation was done on chip and built-up edge formation on in situ AL4Cl3-Al composite [5]. The authors claimed that homogeneous microstructure and high hardness reduces the formation of BUE especially at high cutting speeds which lead to improve the quality of machined surface. Mohsen et al have studied on the effect of some additives on machinability of Al-Si cast alloy [6].

They have found that additions of some free machining element only affected the morphology of the hard silicon phase. The cutting force, feed force, and surface roughness achieved during turning depend on the shape of the eutectic silicon phase in the form of flake, lamellar, or fibrous[7].

Adhesion of aluminum to the face of the cutting tool increases the BUE changes the tool geometry, and increases the roughness of the new surface. Currently, researchers have begun studies on some free machining elements to improve mechanical properties of materials and improve machinability when compared to similar unmodified structures [8].

However, in turning there is limited literature available on the effect of modifiers on surface roughness and chip morphology of near eutectic Al-11%Si alloy. The purpose of this research is to evaluate machinability of untreated and strontium - treated Al-11%Si alloys in terms of surface roughness and chip morphology while turning at various cutting speeds and feed rates.

II. EXPERIMENT APPROACH

A. Cutting tool and workpiece material Turning investigation was carried out on an untreated Al-11%Si base alloy with 80-90 HV hardness, , and 130-160 MPa ultimate tensile strength (UTS). Another material investigated is the 0.04wt.% Sr treated Al-11%Si alloy. Details of the workpieces are given in Tables 1. A Kennametal physical vapor deposition (PVD) insert (ISO catalogue number VBGT110302F) with a TiN-coated, a radius of 0.2 mm, a relief angle of 5° and a rake angle of γ= 0°, and Grade KU10 was mounted on a holder designated by SVJBL-1616H1.

element	Al	Si	Fe	Cu
Wt%	Bal	10.68	0.67	1.67
element	Mn	Mg	Zn	Ni
Wt%	0.253	0.235	0.738	0.049

III. EXPERIMENTAL PROCEDURE

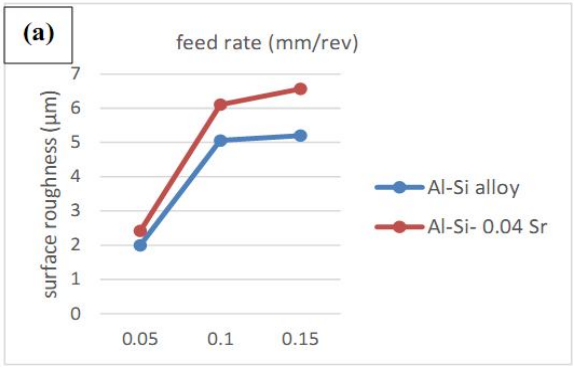
The melted materials were prepared by using an induction furnace. The melt temperature was maintained at 750-760°C for a period long enough to allow for complete melt homogenization. Strontium (Sr) in the form of metallic granules was wrapped in aluminum foil and added in certain concentration (0.04 wt. %) and the melted materials were stirred to allow for complete homogenization. The molten alloy was then poured at a temperature of 730 ± 5°C into the permanent mold.

Turning tests carried out on a with CNC turning machine ALPHA 1350S 8.3 kw power drive and 6000 rpm maximum spindle speed. Three cutting speeds of 70, 130, 250 m/min and feed rates of 0.05, 0.1, 0.15 mm/rev have been employed, respectively. Depth of cut was fixed at 0.5 mm. In the all experiments Surface roughness was measured using a Mitutoyo-Formtracer CS 5000 and accuracy of ±0.01µm. Also cut of length was 0.8 mm at different positions Units on circumference of workpiece and average surface roughness of recorded values was calculated. An optical microscope was used to observe chip morphology.

IV. RESULT AND DISCUSSION

Surface roughness plays a key role in machining operation. These years, researchers are focusing on this item to improve product quality such as piston, shaft or engine block. According to our investigation on machining of Al-11%Si cast alloy and modified alloy, surface roughness increased with increasing feed rate from 0.5 to 0.2 mm/rev for both workpieces.

It can be seen that surface roughness decreased when cutting speed increased from 70 to 250 m/min. It is due to change temperature in cutting zone which lead to decrease buildup edge (BUE). Al-Si cast alloy (base alloy) shows better surface roughness in all cutting conditions in comparison with Al-Si 0.04 Sr (modified workpiece. There is no doubt that higher BUE formation tendency with increase in ductility of Sr-containing workpiece than the base alloy may be related to increase in surface roughness.



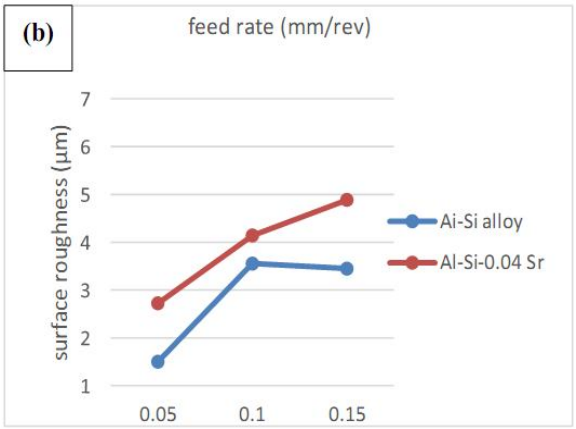
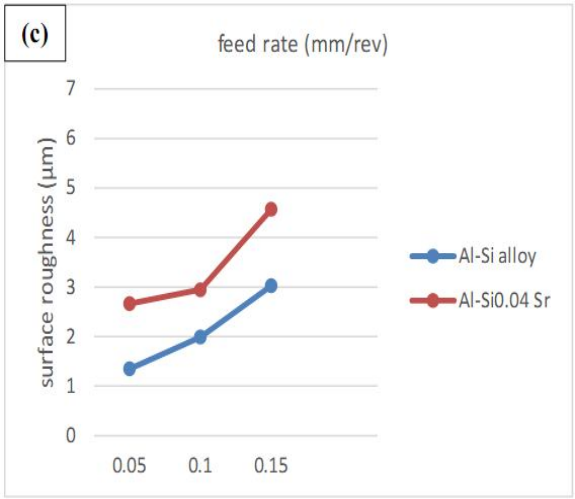


Fig 1. Value of surface roughness for Al-Si cast alloy and Al-Si 0.04 Sr (a) cutting speed of 70 m/min (b) 130 m/min and (c) 250 m/min.



Optical workpiece microstructures are illustrated in Fig.2. Coarse, plate-like Si formations was observed in the aluminum matrix of the base alloy (Fig. 2a). Coarse, plate-like Si formations are considered to be harmful for elongation and fatigue and they represent a potential site for cracks. Therefore, authors have tried to use modifier by adding only small amounts of 0.04 Sr element. According to microstructure in fig 2b, the addition of Sr had a significant effect on Si morphology as the coarse plate-like Si formations were convert to a fine fibrous form which increase surface roughness due to increase ductility and increase size of chip during machining g process.

Therefore, it is clear that the changes in the topography and surface roughness are related to the change in hard phase morphology [9, 10].

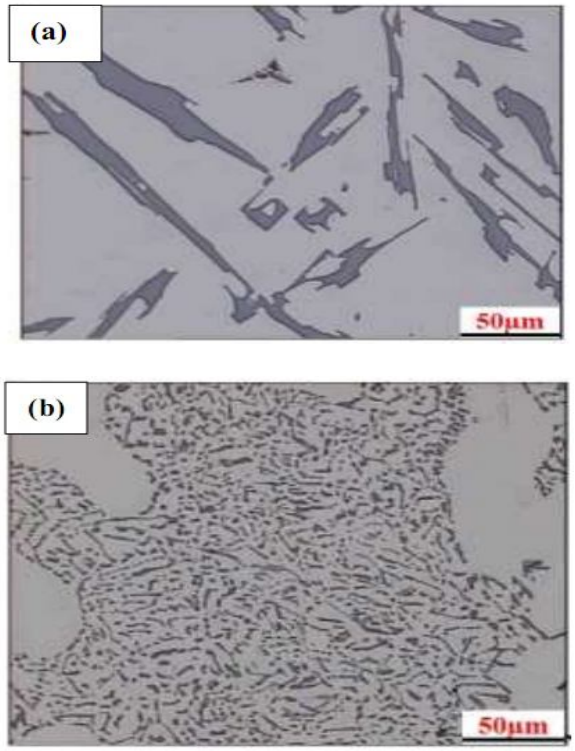


Fig 2. Microstructure of workpieces (a) Al-Si cast alloy and (b) Al-Si 0.04 Sr

Fig 3 shows the chip morphology for Al-Si cast alloy and Al-Si 0.04 Sr (modified alloy) during turning process. It can be seen that base alloy (fig 3 a) produced small size chips at cutting speed of 250 m/min and feed rate of 0.15 mm/rev. In fact, silicon particles (plate-like) come to surface of workpiece and make small size chip after turning process which lead to improve surface roughness. Fig 4 shows the built-up edge on flank face of insert during machining. It can be seen that there is no tendency to adhere material (base alloy with plate like silicon) to insert tool (fig 4a). On the other hand, the size of chips are large when 0.04 Sr is added as modifier and it can increase ductility of workpiece, adhere strongly to common tool materials and also built-up edge (BUE) formation (fig 4b) consequently increase value of surface roughness [11].

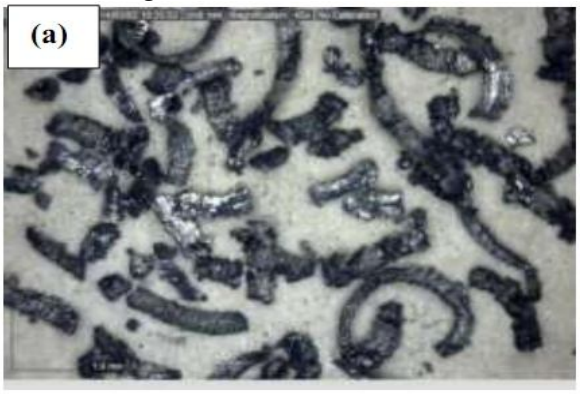
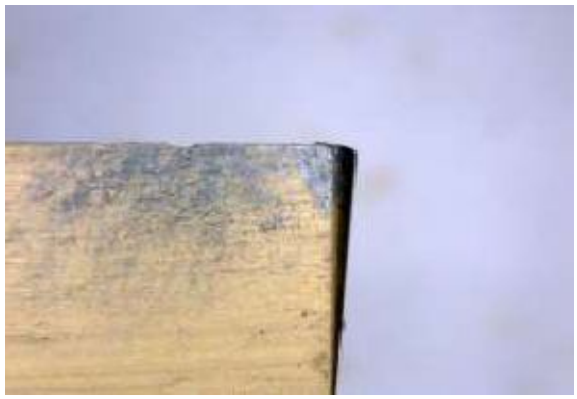




Fig3. Chip morphology (a) Al-Si cast alloy (b) Al-Si0.04 Sr



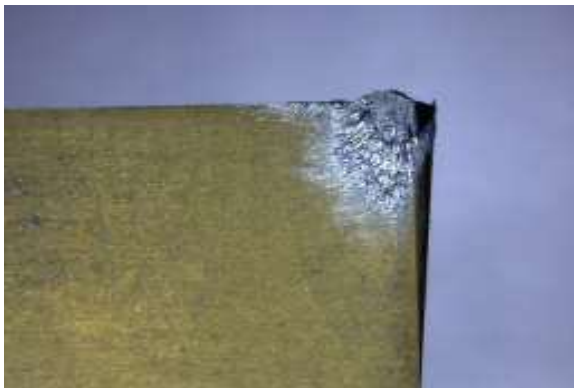


Fig4. Build-up edge formation during turning process at cutting speed of 250 m/min and feed rate of 0.2 mm/rev (a) base alloy, (b) Sr-containing

CONCLUSION

The following conclusions from the current study in dry turning of untreated and Sr-treated Al- rSi with 0.04wt.% Sr with various cutting speeds and feed rates can be drawn: Different surfaceroughness are observed in both of workpieces on the dissimilar cutting condition. It was found that surface finish improved with increasing cutting speed due to decrease in the BUE formation and quick breakage of it from tool during machining workpieces. The chip formation changed with changing silicon shape from plate-lake to fibrous shape due to Sr element. Also surface roughness increased with feed rate in both

workpieces material due to the domination of feed mark. The result shows that Sr-treated Al-Si have poor surface roughness compared to untreated condition in the all of cutting conditions. The authors would like to acknowledge university of Malaya (Grant Vo. PRO11D-13AET) for providing financial resources.

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