Surface Roughness Optimization in Turning of Hypereutectic A390 Al-Si Alloy Under Dry Machining

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ABSTRACT: Surface roughness is one of the most important measurements of surface quality during the machining process. The parameters like speed, feed rate, and depth of cut are mostly the factors that affect the surface roughness. As is known, hypereutectic A390 Al-Si alloy is an extremely hard and abrasive material and it is often used in the manufacture of internal engine parts. In most cases, machining this material will be resulting an excessive heat generated at the cutting zone and caused a variety of problems during machining such as rapid tool wear and damage on machined surface. This paper is to study about the effect of cutting parameters on surface roughness during machining hypereutectic A390 Al-Si alloy under cutting speed of 300 to 900 rpm, feed rate of 0.1 to 0.3 mm/rev and depth of cut of 0.1mm. The experiment was conducted using a full factorial design. From this investigation, it was found that feed rate and cutting speed were the dominant factors that affecting the surface roughness. The optimum cutting condition for machining hypereutectic A390 Al-Si alloy is at cutting speed of 900 rpm, feed rate of 0.1 mm/rev and depth of cut at 0.1 mm. At this cutting parameters, 0.2 µm surface roughness can be obtained which is the range value of surface roughness that need to be obtained for internal engine parts.

Keywords: *Turning operation; Hypereutectic Al-Si alloys, Dry machining*

1. INTRODUCTION

Hypereutectic silicon-aluminum alloys such as A390 Al-Si alloy has a great ability in the automotive industry, mostly for engine components due to its great corrosion resistance, high wear resistance, low density, and good thermal stability. It has become the main choice for various automotive parts such as pistons, liner-less engine blocks, and pumps [1]. However, the high silicon content in this alloy is between 17-18% which are extremely hard and abrasive, and have a considerable impact on machinability. Previous researches show that only few studies have been carried out to study the effect of machining parameters on surface roughness (Ra) of hypereutectic A390 Al-Si alloy under dry cutting condition.

In this paper, the focus is on Ra performance during machining A390 Al-Si alloy under dry cutting condition. For this purpose, CNC turning machine has been used. From the results, the optimum cutting condition to obtain better Ra will be suggested.

2. METHODOLOGY

The A390 Al-Si alloy in a form of a bar with dimension 100 mm diameter and 150 mm long to be turned down for 100 mm tool travel for every cycle. The cutting parameters during the turning are presented in Table 1. The experiment was conducted using a full factorial design with 9 runs of experiment (2 factors, 3 levels) since depth of cut is fixed.

Table 1. Cutting parameters

Parameters	Value
Cutting speed	300, 600, 900 rpm
Feed rate	0.1, 0.2, 0.3 mm/rev
Depth of cut	1 mm

The turning operations was performed with a chemical vapour disposition (CVD) with Titanium Nitrate (TiN) coated, the coating insert on grade NC3030 KORLOY (DNMG150608-GM) by using a multilock system 2525-M15. The tool insert included angle is 55° angular with 0.8 mm nose radius. CVD TiN coated has superior toughness, thermal shock and wear resistance abilities.

The apparatus used to measure on the Ra value of the machined surface is ACCRETECH Surface touch 50. During the experiment, the Ra measurement was taken three times for each run and the average values were recorded for further analysis. The measurements were made at the beginning of the cut in order to eliminate the tool wear effect. The chemical composition and mechanical properties of A390 Al-Si alloy are listed in Tables 2 and 3, as indicated [2], [3].

Table 2 Chemical composition of work material of A390

Chemical composition (%)							
Al	**Si**	**Cu**	**Mg**	**Mn**	**Fe**	**Zn**	**Ti**
Bal.	16-18	4-5	0.45-0.65	<0.1	< 0.5	<0.1	<0.2

Table 3 Mechanical properties of A390

Ultimate Strength σ (MPa)	Elongation (%)	Hardness (HB hardness)
214	0.2	90

3. RESULTS

From the surface plot in Figure 1, it is observed that the Ra is increase when the feed rate is increased and Ra is decrease when cutting speed is increased. Aluminium silicon alloys is a great material to be used in automotive and aerospace applications [4], the Hypereutectic A390 Al-Si alloy is mostly used for engine parts like cylinder block, piston, crankshaft etc. The National system for surface roughness NBSIR 75-927 stated that the optimum range Ra for engine parts are from 0.102 to 2.794 µm) Therefore, lower feed rate at 0.1 mm/rev and the cutting speed at 900 rpm with fixed 1 mm depth of cut is selected for the best output condition. The cutting condition and chip formation can be observed in Figure 2 and Figure 3 where the flank wear is formed with 0.215 µm and the chip formation is continuous which can produce better surface finish to the ductile material.

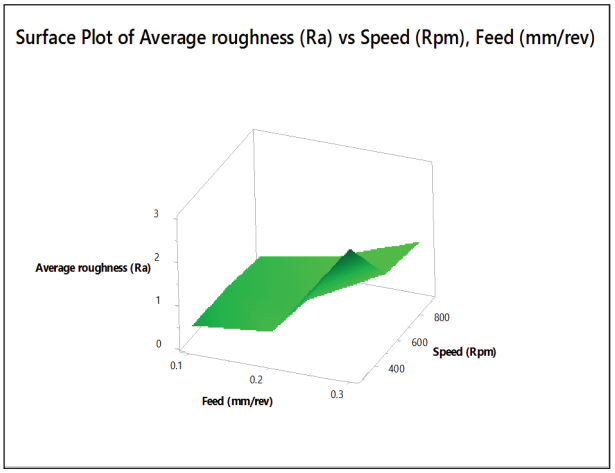

Figure 1 3D surface plot of surface roughness (µm) with feed rate and cutting speed

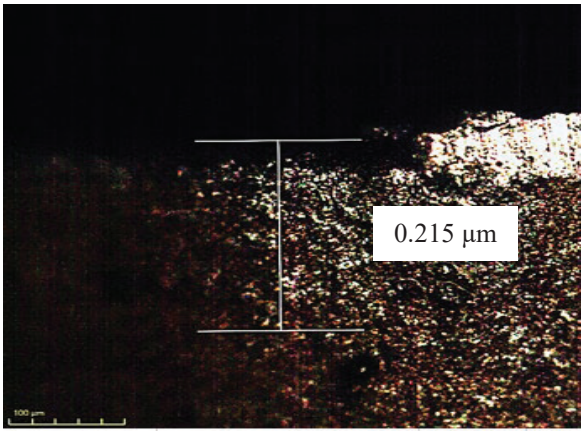

Figure 2 Flank wear formation

Figure 3 Continuous chip formation

4. CONCLUSION

The influence of the high-speed machining cutting parameter on the surface roughness value of hypereutectic A390 Al-Si alloy as indicated below:

- Optimum surface finish condition of 0.2 µm can be achieved at cutting speed of 900 rpm with feed rate of 0.1 mm/rev.
- Ra is increase when the feed rate is increased.
- Ra is decrease when cutting speed is increased.

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