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Chip Formation and Surface Roughness in Dry Machining of Aluminium Alloys

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This paper presents an analysis of the chip characteristics and surface roughness in dry machining of aluminium alloys. The experiments carried out consisted of different cutting condition models based on combination of cutting speed, feed rate and depth of cut as the parameters of cutting process. The design of cutting parameters models was base on design of experiment response surface methodology use of Minitab Software. The results show that, the chips produced in turning of LM6 and AA7050 aluminium alloy was found different chip shape for the similar of cutting condition model. Surface roughness values of AA7050 alloy was found to be lower as compared to surface roughness values of LM6 alloy in the similar of cutting condition model. The values of surface roughness also has affected by combination of cutting parameter when machining of aluminium alloys. The good quality of surface roughness was found in the cutting model no. 1 ($v = 100$ m min^{-1}, $f = 0.05$ mm rev^{-1} and $a_p = 1$ mm) when turning of AA7050 aluminium alloys, and at the cutting model no. 6 ($v = 250$ m min^{-1}, $f = 0.125$ mm rev^{-1} and $a_p = 0.5$ mm) when turning of LM6 aluminium alloys.

Keywords: Dry Turning, Chip Form, Surface Roughness, Aluminium Alloys.

1. INTRODUCTION

Majority of the components of aerospace and automotive vehicles need different machining operations during their manufacturing process, mainly for the assembly requirements. Generally, the components have to present both a high dimensional precision and a high surface quality. These factors are required in order to obtain an adequate performance of the overall device. The mentioned components are usually made of light materials, such as aluminium or titanium. This is due to their very good relationship between their weight and their mechanical properties.

In machining process, friction between tool and workpiece generates heat which affect the dimensional accuracy, surface finish, chip flow and hence will determined the quality of finish product. Cutting fluids are used in machining process to remove the heat, reducing fiction, reduce cutting force and power requirements, improve dimensional, and improve surface finish. Meanwhile, the used of cutting fluids can be dangerous to health workers and the environment. Besides, the great social preoccupation about the environmental conservation has made necessary to develop cleaner production technologies. The *dry machining* is a simplest method consists on eliminating the cutting fluids. However, the total suppression of these cutting fluids involved to work under very aggressive conditions.[1–6]

In turning operations, where the tool is continuously removing metal for a long period, a continuous chip can became entangled with the tool and the workpiece. The continuous type of chip can be hazardous to the worker and, unless controlled properly, it can affect to the quality of finish product and the tool. Then, the monitoring and control of the chip form is required because it can be affect to surface finish, dimensional accuracy and tool life.[7,8]

Thus, such situation makes necessary a design of cutting model for combinations of cutting parameters and types of tools that optimize the machining process to obtaining machined parts with a good dimensional precision and a high quality surface, with a cost as low as possible and, of course, under secure conditions for workers and equipments.

In this work, the relationship between each cutting parameters model and the types of chip form and surface roughness (R_a) in dry turning process of LM6 and AA7050 aluminium alloys will be analyzed.[9–11]

2. EXPERIMENTAL SETUP

The material LM6 and AA7050 aluminium alloys were used in the experiment. Their compositions in percentage of mass have been included in Tables I and II, respectively. The machining was done on CNC lathe machine and cutting tool insert uncoated carbide VCGT 160408 FL K10 with tool holder SVJCR was used

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Table I. Chemical composition (wt.%) of alloy LM6.

Si	Fe	Cu	Mn	Mg	Ni	Zn	Sn	Ti	Other	Al
10–13	0.6	0.1	0.5	0.1	0.1	0.1	0.15	0.2	0.15	Rest

Table II. Chemical composition (wt.%) of alloy AA7050.

Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti	Other	Al
0.12	0.15	2.0–2.6	0.10	1.9–2.6	0.04	5.7–6.7	0.06	0.15	Rest

Table III. The factors and levels used in the experiment.

Factor	Unit	Low	Levels medium	High
Cutting speed (v)	m min^{-1}	100	175	250
Feed rate (f)	mm rev^{-1}	0.05	0.125	0.2
Depth of cut (a_p)	mm	0.5	1.0	1.5

in the experiment. The surface roughness was measured using portable MarSurf PS1 to measure of average surface roughness (R_a). The models combination of parameters: cutting speed (v), feed rate (f) and depth of cut (a_p) were selected as the cutting parameters. The design of cutting parameters models was based on design of experiment response surface methodology use of Minitab Software. The factors and levels each parameter was set as shown in Table III. Fifteen cutting condition models represent Box-Behnken design to carry out the experiment.[12]

3. RESULTS AND DISCUSSION

3.1. Chip Characteristics

Chips form produced in turning of LM6 and AA7050 aluminium alloy at various of cutting models are shown in Figures 1 and 2, respectively. Figure 3 is the types of chip form produced in turning operations according to the standard ISO 3685.[13] Chip obtained from the test carried out on the LM6 and AA7050 aluminium alloy has been classified according to that standard as shown Table IV. From the table, they were clearly seen that turning of LM6 and AA7050 aluminium under similar of cutting condition model was found different of chip form, this is due to different of the properties and the structure of the material. Chips produced at various cutting condition model between LM6 and AA7050 aluminium are not the same shape, therefore, the selection of cutting parameter can be effecting on the chip form.

The chip characteristics produced in turning of LM6 and AA7050 aluminium alloy was found continuous chip (e.g., similar 1.3, 2.3, 4.3 or 5.3) and noncontinuous chip. Continuous chip is unfavourable for the worker as well as the products and the tools.

3.2. Surface Roughness

The recorded surface roughness values when machining of LM6 and AA7050 aluminium alloys with uncoated carbide tool under dry turning process at various cutting condition model are shown in Figure 4. From the figure, they were clearly seen that surface roughness values of LM6 alloy higher than surface roughness values of AA7050 alloy in the similar of cutting condition model, it due to affected by the properties and the structure of the material. The values of surface roughness also has affected

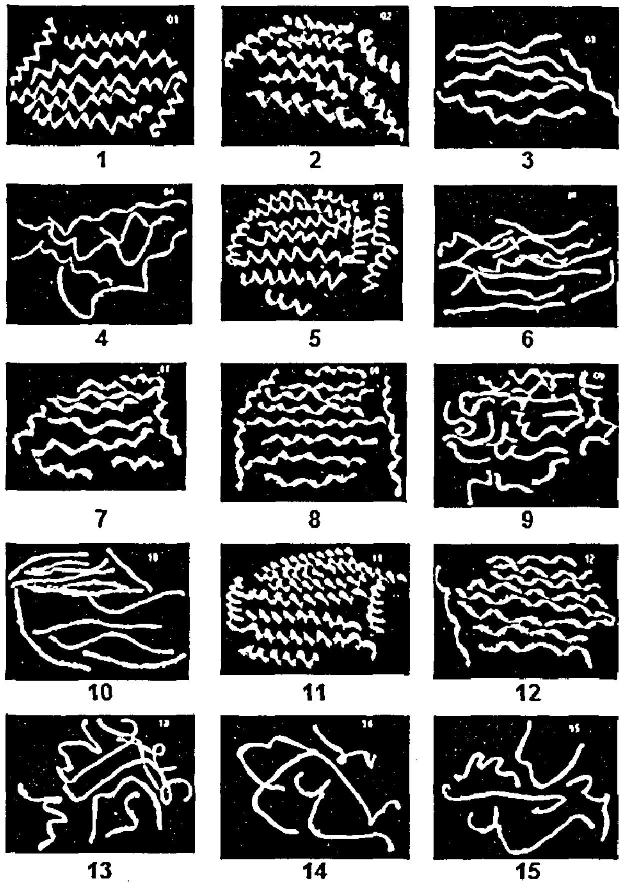

Fig. 1. Chip form of LM6 aluminium alloys.

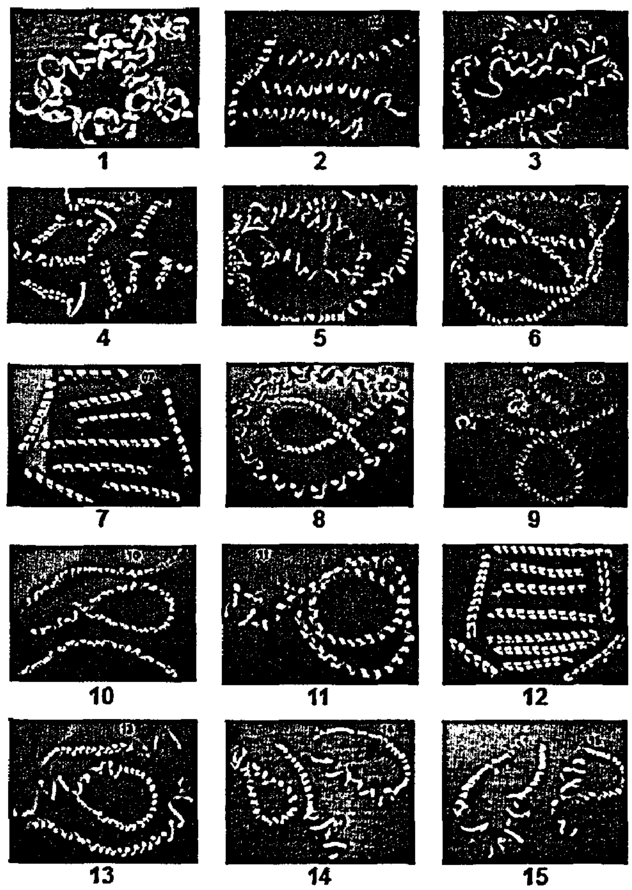

Fig. 2. Chip form of AA7050 aluminium alloys.

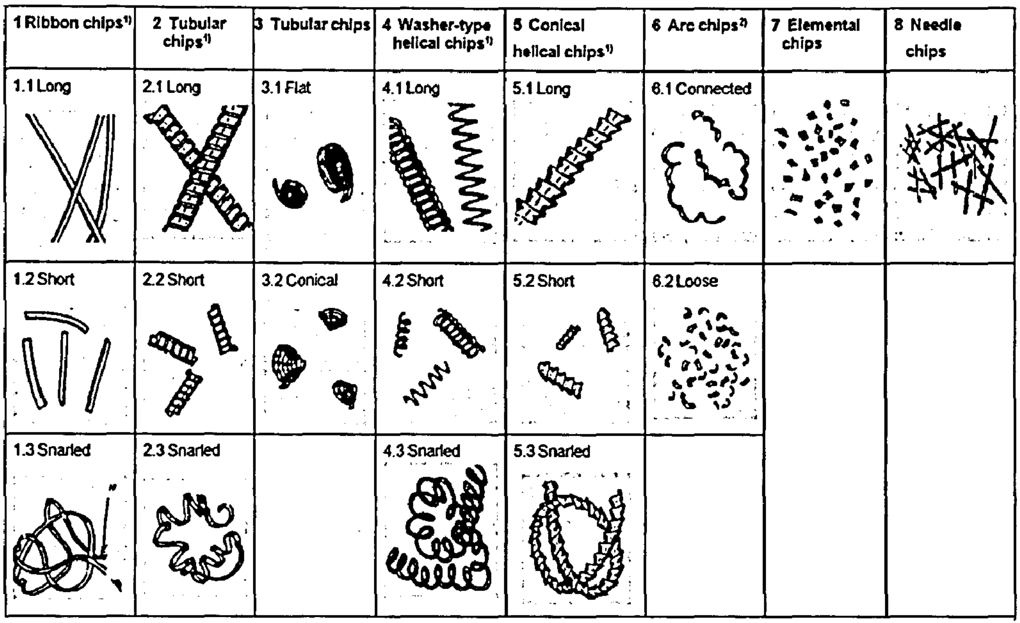

Fig. 3. Chip form produced in turning operations.[13]

Table IV. The cutting condition models and chip characteristics.

	Cutting parameters			Chip form	
Cutting model	v	f	a_p	LM6	AA7050
1	100	0.05	1	4.2 Short	4.3 Snarled
2	250	0.05	1	4.2 Short	4.1 Long
3	100	0.2	1	1.1 Long	2.3 Snarled
4	250	0.2	1	1.3 Snarled	4.2 Short
5	100	0.125	0.5	4.2 Short	4.3 Snarled
6	250	0.125	0.5	1.1 Long	4.3 Snarled
7	100	0.125	1.5	4.1 Long	5.1 Long
8	250	0.125	1.5	4.1 Long	5.3 Snarled
9	175	0.05	0.5	6.1 Connected	5.3 Snarled
10	175	0.2	0.5	1.1 Long	5.3 Snarled
11	175	0.05	1.5	4.2 Short	5.3 Snarled
12	175	0.2	1.5	4.1 Long	5.1 Long
13	175	0.125	1	1.3 Snarled	5.3 Snarled
14	175	0.125	1	1.3 Snarled	5.3 Snarled
15	175	0.125	1	1.3 Snarled	5.3 Snarled

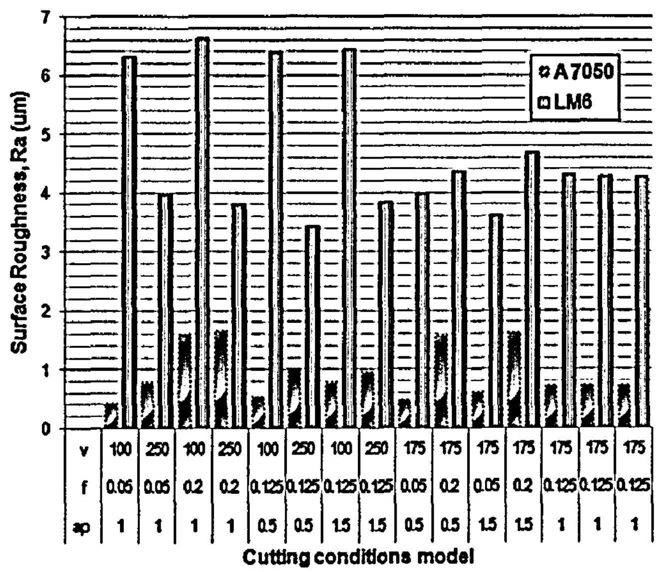

Fig. 4. The surface roughness on the each cutting condition model.

by combination of cutting parameter when machining of aluminium alloys. The good quality of surface roughness was found in the cutting model no. 1 (cutting speed = 100 m min^{-1}, feed rate = 0.05 mm rev^{-1} and depth of cut = 1 mm) when turning of AA7050 aluminium alloys, and in the cutting model no. 6 (cutting speed = 250 m min^{-1}, feed rate = 0.125 mm rev^{-1} and depth of cut = 0.5 mm) when turning of LM6 aluminium alloys.

4. CONCLUSIONS

In this paper, an analysis of the type of chips and surface roughness were found when turning of LM6 and AA7050 aluminium alloys has been made.

Chip produced under different cutting conditions has been classified by their shapes according to ISO 3685. The chip characteristics produced in turning of LM6 and AA7050 aluminium alloy was found continuous chip and noncontinuous chip.

Surface roughness values of AA7050 alloy was found to be lower as compared to surface roughness values of LM6 alloy in the similar of cutting condition model. The values of surface roughness also has affected by combination of cutting parameter when machining of aluminium alloys. The good quality of surface roughness was found in the cutting model no. 1 (cutting speed = 100 m min^{-1}, feed rate = 0.05 mm rev^{-1} and depth of cut = 1 mm) when turning of AA7050 aluminium alloys, and in the cutting model no. 6 (cutting speed = 250 m min^{-1}, feed rate = 0.125 mm rev^{-1} and depth of cut = 0.5 mm) when turning of LM6 aluminium alloys.

Finally, the relationship between cutting parameters and chip characteristic and product surface finish has been studied through the comparison between chip form and *Ra* parameter for different cutting condition models.

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