MAGNESIUM ALLOY CHIP FORMATION MECHANISM

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INSTRUCTIONS

Magnesium is known as one of the highest specific strength in conventional metals. A nominal density is only 1.8 g/cm^3. Some of industrial parts which were made by magnesium alloy are usually manufactured by plastic working such as press, bending, drwaing and casting. However, in the case of production of patrs with higher precision accuracy, cutting shoud be adopted as a finishing process. Furthermore, cutting process presents higher production rate. Some book says that mage-nisium cuttig is one of the easiest metals to machine:less power is required for removing a given volume of magnesium by machining than for any other commonly machined metal:the chips produced with single point tools during turning, boring, shaping, and milling fall into three general types, (1)short and well broken, (2)short and partially broken, (3) long and curled [1].

However, chip formation mechanism of magnesium alloy was not sufficiently determined yet. Hence, orthogonal cutting experiments were conducted in order to examine detailed chip fomation mechnism, then lubricant applying effect[2] in magnesium alloy cutting was also investigated.

EXPERIMENTALS

<u>Work material</u>

One of the most conventional magnesium alloy AZ31 was selected because of its wide variety of use. The dimensions were 800 × 30 × 3 t. Cemented carbide K10 with a rake angle of 0 ° and a clearance angle of 7 ° was used as the tool material. The tool edge was carefully ground by a #800 diamond wheel, and its tool edge roundness was measured to be less than 2μm.

<u>Experimental set up</u>

The cutting experiment has been conducted on an NC orthogonal precision cutting machine with a stiffness of 78.4 N/μm and a positioning. The NC orthogonal precision cutting machine was a kind of double-housing planer in order to make single point process.

<u>Cutting method</u>

Extreme pressure type oil was selected as the cutting fluid in all experiments. The cutting forces were measured by a piezoelectric dynamometer. The depth of last pre-cut t_L ranged from 10 to 100 μm. The experiment has some cutting processes to exactly control deformed layer under the machined surface because the cutting forces depend on thickness of the deformed layer in the part to be cut[1]. The thickness of deformed layer changed according to t_L. Therefore, t_L was one of the most important parameter in this experiment. The depth of cut t_1 also ranged from 10 to 100 μm.

TABLE1) summarizes the cutting conditions.

TABLE 1 Cutting conditions

Work material	AZ31
Tool material	Cemented Carbide K10
Rake angle °	0
Relief angle °	7
Cutting form	Orthogonal
Cutting speeds m/min	5.3, 25.7. 50.0
Depth of cut t_1	10, 30, 50 70 100
Depth of cut at last pre-cutting t_L	10, 30, 50 70 100
Cutting fluids	Extreme pressure oil

EXPERIMENTAL RESULTS

<u>Chip foramtion type</u>

TABLE 2) shows crelationship between chip formation type and cutting conditions. In the *TABLE 2)*, shear type is one of discontinuous type chip, on the other hand saw-toothed chip is semi-discontinuous type where each segment is barely linked. *FIGURE1)* shows SEM micro-

Table 1. Chip formation type - cutting condions

a) V=5.3m/min

		t_1				
		10	30	50	70	100
t_L	10	○	○	○	×	×
	30	○	○	○	×	×
	50	○	○	○	×	×
	70	○	○	○	×	×
	100	–	○	○	×	×

b) V=25.7m/min

		t_1				
		10	30	50	70	100
t_L	10	○	○	○	○	×
	30	○	○	○	○	×
	50	○	○	○	○	×
	70	○	○	○	○	×
	100	○	○	○	○	×

c) V=50.0 m/min

		t_1				
		10	30	50	70	100
t_L	10	○	○	○	○	×
	30	○	○	○	○	×
	50	○	○	○	○	×
	70	○	○	○	○	×
	100	○	○	○	○	×

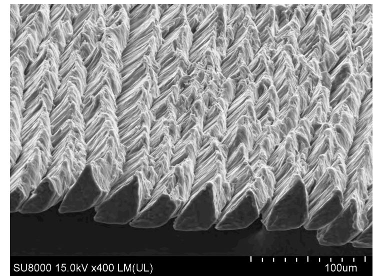
○ : Saw-toothed type(Semi-continuous)
× : Shear type(Discontinuous)

two types of chip. The former has a different chip formation mechanism from the latter, then which produces different cutting forces and surface roughness from the latter.

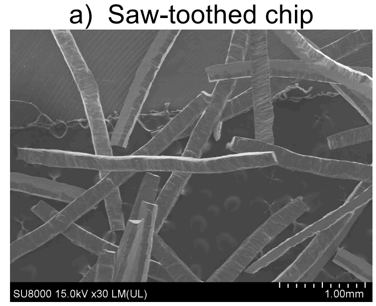
Chip morphology

FIGURE 1) shows SEM micrographs of two types of chip. Saw-toothed chip offered alomost uniformly spaced segements which were not seperated each other. On the other hand, shear type offered independent segments which were short and well broken.

FIGURE 2) shows two types of chip formation mechanism. The shear type deteoriated the machined surface due to the shape of crack initiation. That is to say, the crack was initiated at the top of the clearance face, then ran towards downwards the designated cutting line, whicl leads to a partially overcut surface.

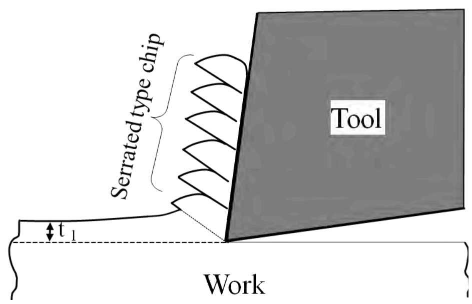


a) Saw-toothed chip

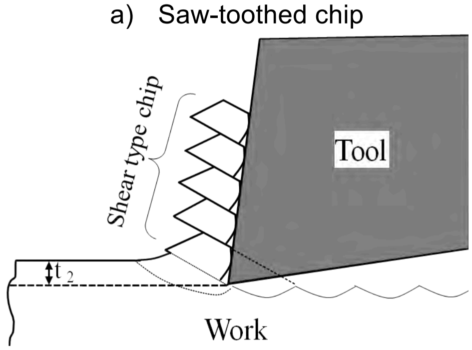


b) Shear type chip

FIGURE 1. SEM micrograph of chip



a) Saw-toothed chip



b) Shear type chip

FIGURE 2. Chip formation mechanism

[1] Metal Handbook Ninth Edition. Volume 16 Machining, ASM Inrernational, Metals Park:1989, 820.
[2] Kaneeda T, kinugawa K Lubricant Applying Effect in Ti Alloy Ti-6Al-4V Cutting, Proc. of 23rd ASPE Meeting &12th ICPE Meeting. 2008; CD-ROM.