Experimental Study on High Speed Cutting of 7075 Aluminum Alloy

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Abstract. A 4-edge cemented carbide end mill with a diameter of 6 mm was used to mill a single factor groove of 7075 aluminum alloy. The results show that the surface roughness of the bottom surface of the narrow groove decreases with the increase of the cutting speed in the range of variable cutting speed. Moreover, when the cutting speed is the highest, the burr on the edge of the narrow groove is not completely eliminated, and there are more burr and curling. When the feed rate is selected as a variable, the surface roughness of the bottom surface of the milling narrow groove increases with the increase of the feed rate. When the cutting depth is selected as a variable, the surface roughness of the bottom surface of the milling narrow groove increases with the increase of the cutting depth. There are obvious extrusion bulge marks between the two intersecting steps on the bottom surface of the milling narrow groove. The reason of extrusion bulge on the bottom surface of milling may be due to the large width and elastic deformation of 7075 aluminum alloy material, which results in large plastic flow under the cutting extrusion of milling tool.

1. Introduction
With the development of China’s manufacturing industry, micro parts processing and high-speed cutting are closely related. In particular, aluminum alloy is used in aerospace, medical equipment and electronic equipment.

Junteng Wang believes that the blade parts based on clamping force monitoring can perceptively predict the milling residual stress and deformation [1]. Xiangyu Hou Youxi Lin and Xinxin Meng studied the influence of milling residual stress on aluminum alloy [2]. Ying Niu used longitudinal torsional ultrasonic milling residual stress three-dimensional finite element simulation and experiment research, the effect is remarkable [3]. Bin Lei, Jianjun Wu, Zhenbing Gu, Yanzhou Li and Ganwei Cai believe that the residual stress of continuous machining of machining and heat treatment has coupling phenomenon [4]. Aiqin Lin, Minli Zheng, Chunguang Fan, Yannian Gu studied the deformation of aluminum alloy 7475 plate by using the analytical method [5].

In this paper, a 4-edge cemented carbide end mill with a diameter of 6 mm was used to mill a single factor groove of 7075 aluminum alloy. The variation of machined surface roughness, milling surface residual stress and groove bottom surface quality with cutting parameters was studied.

2. Experimental Equipment and Conditions
The CNC machining center, surface roughness and profile measuring instrument, scanning electron microscope and X-ray residual stress measuring instrument are shown in Fig.1. In this experiment, a 4-edge cemented carbide end mill with a diameter of 6 mm and a surface coating of TiSiN is used.
selected tool has high hardness and good wear resistance, and can process high hardness and high strength materials. The cutting blank of 7075 aluminum alloy is 15mm in length, 10mm in width and 8mm in height [6-9]. The milling cutter picture is shown in Fig.2.

![Image](image1.png)

**Figure 1.** Experimental equipment diagram

![Image](image2.png)

**Figure 2.** Ø6 mm carbide end mill with TiSiN coating

In this cutting experiment, dry cutting was used to cut 7075 aluminum alloy samples. Single factor experiment of narrow groove machining, experimental cutting parameter scheme is shown in Table 1.

| Cutting parameters            | Variable          |
|-------------------------------|-------------------|
| Cutting speed (m/min)         | 90, 100, 110, 120|
| Feed rate (mm/min)            | 100, 150, 200, 250|
| Cutting depth (μm)            | 25, 30, 35, 40    |

3. Experimental Study on Cutting 7075 Aluminum Alloy

3.1. Influence of Cutting Speed V on the Characteristic Structure of Milling Narrow Groove

In the experiment, the feed rate F=100mm/min, the cutting depth ap=25μm remain unchanged, and the cutting speed is variable. As shown in Fig. 3, the relationship between cutting speed and surface roughness is shown. With the increase of cutting speed, the surface roughness of the narrow groove decreases gradually. The reason is that with the increase of cutting speed, the material removal rate of 7075 aluminum alloy sample will decrease, and the cutting times of milling cutter on the sample surface will also increase. Therefore, the surface roughness will also decrease. It can be seen from Fig.4 that with the increase of cutting speed, the surface residual stress also decreases. The reason is that the higher the cutting speed, the milling force and cutting heat will gradually decrease, and the residual stress on the surface will also decrease. There are obvious extrusion bulge marks between the two intersecting cutting areas on the bottom surface of milling narrow groove. The reason of extrusion bulge on the bottom surface of milling may be due to the large width and elastic deformation of 7075 aluminum alloy material, resulting in large plastic flow under the cutting extrusion of milling tool. After milling, the burr and curl on the edge of narrow groove were cleaned by ultrasonic vibration cleaning machine, and then the surface morphology of narrow groove was scanned by electron microscope. The scanning results showed that the burr at the edge of down milling area of narrow groove after milling with high cutting speed was not eliminated, and there were many burr and curling edge, as shown in Fig5. It can be seen from the topography of the bottom surface of the machined narrow groove in Fig.5 that with the increase of cutting speed, the tool mark becomes more and more smooth, and there is no surface defect on the bottom surface of the machined narrow groove.
3.2. Influence of Feed Rate on the Characteristic Structure of Milling Narrow Groove

In the experiment, cutting speed $v=120$ m/min, cutting depth $a_p=25$ μm remain unchanged, cutting variable is feed rate $F$. It can be seen from Fig. 6 that with the increase of experimental cutting variable feed rate, the bottom roughness $R_a$ of the machined narrow groove also increases. This is because the increase of feed rate will increase the cutting force in the milling direction, and the material removal rate will naturally increase. In this way, larger chips will be cut out, which will cause greater wear between the chip and the bottom surface of the narrow groove, and the chip deposition will also be serious, which will lead to the increase of surface roughness. When the feed rate increases from 100 mm/min to 250 mm/min, the increasing trend of surface roughness $R_a$ of 7075 aluminum alloy narrow groove is stable. It can be seen from Fig. 7 that with the increase of experimental cutting variable feed rate, the residual stress of machined surface also increases. The reason is that the higher the feed rate, the greater the material removal rate, the milling force and cutting heat gradually increase, and the residual stress on the surface also increases. As shown in Fig. 8, with the increase of feed rate, the tool mark becomes smoother and smoother, the edge burr becomes larger, and the defects on the bottom surface of the narrow groove become more and more serious.
3.3. Influence of Cutting Depth on Characteristic Structure of Milling Narrow Groove

In the experiment, the cutting speed $v=120$ m/min, the feed rate $F=100$ mm/min remain unchanged, and the cutting variable is the cutting depth $a_p$. According to the Fig. 9, the surface roughness of narrow groove increases with the increase of cutting depth. The reason is that the material removal rate will increase when the cutting depth increases, and the milling force between the tool and the workpiece is increased, the friction between the tool and the workpiece will increase, and the surface roughness will increase accordingly. According to the Fig. 10, with the increase of cutting depth of experimental cutting variables, the surface residual stress of the bottom surface of narrow groove increases, because the larger the cutting depth, the greater the material removal rate, the more milling force and cutting heat, the more residual stress left on the surface. According to the Fig. 11, when the cutting depth is the lowest, the bottom surface of narrow groove is the best, and the blade marks are smooth. The reason is that when the selected cutting depth variable is the smallest, the cutting force is the smallest, and the chip is discharged smoothly along the chip chute, thus avoiding the phenomenon of chip accumulation. The residual chip can be removed from the cutting area timely from the blade, which reduces the wear of the chip on the bottom of the narrow groove, so the surface integrity of the machining is also the best.
4. Conclusions

Through the research of 7075 high speed milling, the conclusions are as follows:

1. The experiment of 7075 aluminum alloy cutting without cutting fluid is carried out. The cemented carbide tool selected in the experiment can obtain high surface integrity.

2. With the increase of cutting speed, the surface roughness of the narrow groove decreases gradually. Moreover, the burr on the edge of the narrow groove after milling is not completely eliminated at the highest cutting speed, and there are more burr and curling edge.

3. When the feed rate is selected as a variable, the surface roughness of the bottom surface of the milling narrow groove increases with the increase of the feed rate.

4. When the cutting depth is selected as a variable, the surface roughness of the bottom surface of the milling narrow groove increases with the increase of the cutting depth.

5. There are obvious extrusion bulge marks between the two intersecting steps on the bottom surface of the milling narrow groove. The reason of extrusion bulge on the bottom surface of milling may be due to the large width and elastic deformation of 7075 aluminum alloy material, which results in large plastic flow under the cutting extrusion of milling tool.

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