A new optimization method of high-precision microporous boring machining process

Li Zhong-xin,Zhang Pei-sen,Jin Xin,Lv Wei-wei,He Lilun
(School of Mechanical Engineering,Beijing Institute of Technology, Beijing 100081, China)

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Abstract. The study introduces a new method of microporous boring machining process for high-precision.First,it is difficult to get better surface quality of microporous with micro cutting technology.Second,using again boring processing methods and the reasonable process parameters can improve greatly the quality of microholes.The 3J33 martensite steel is boring with small holes Φ2.7mm through process optimization, so that the size precision of the hole can be IT4, surface roughness is up to 0.2 μm . Compared with drilling, boring hole surface quality improves significantly, the roughness value decreases 0.8 μm, the shape error is significantly improved.The results show the new optimization method of micro hole boring processing can guarantee the dimension precision and shape precision ,obtain better surface quality.

1 Introduction

Miniaturization is one of the most important techniques in 21th Century , a key factor that profoundly influenced the development of scientific progress and the cause of national defense.The application fields of various types of micro system is expanding,the demand of many kinds of micro structure parts is increasing year by year.Most of micro parts have complex characteristics and high-precision of machining[1].The general methods of drilling and reaming machining can't satisfy the need of surface quality of the micro hole,so the study proposes a new method that can improve the machining quality and efficiency with optimizing process parameters by orthogonal test.Through the tests,the influence of cutting depth, feed rate and cutting speed on surface roughness of boring can be studied about the small holes ϕ2.7mm.The results provide a method of machining parameters boring micro structure parts.

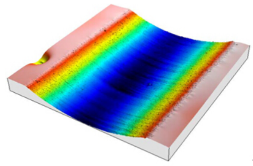
2 microporous boring processing method

The boring cutter is used to expand the circular contour diameter of work-piece and complete the process requirements from semi rough machining to precision work. In this test, first, a series of drilling small holes with a diameter ϕ2.7mm are drilled and then are boring to get high-precision microporous.The tested workpiece material is 3J33 maraging stainless steel,the basic performance parameter are E=180000MPa, G=69168MPa, HRC=42-55, Poisson's ratio υ =0.3[2]. It has the characteristic of high strength, good toughness. The tools are used by single blade boring cutter and hard alloy materials. The machinefor micro milling composite machine tool KNC-50FS are shown in figure 1, including: the power of the spindle and milling spindle, workpiece and fixture parts etc.Processed hole samples are shown as in figure 2.

A Taylor Talysurf CCI is used to measure the surface roughness of microporous, the measurement results are shown in figure 3, the boring processing surface roughness us the profile arithmetic average value of Ra (μm). The universal tool microscope (19JPC-V) is used to measure the diameter of the hole size,.In order to reduce the error, the average of the two vertical size is selected as the dimension of the hole boring and denoted as L (mm).

Fig 1 machine tool KNC-50FS

Fig. 2 hole boring processing sample data



ISO 4287						
		背景	Mean	Std dev	Min	Max
振幅参数 - 粗度轮廓						
Rp	μm	高斯滤波器, 0.25 mm	1.0015	0.4947	0.4666	3.7882
Rv	μm	高斯滤波器, 0.25 mm	0.9939	0.4003	0.5004	3.6870
Rz	μm	高斯滤波器, 0.25 mm	1.9954	0.7191	1.0886	5.7157
Rc	μm	高斯滤波器, 0.25 mm	0.7459	0.1631	0.4550	1.7533
Rt	μm	高斯滤波器, 0.25 mm	2.5119	1.2449	1.1442	8.6061
Ra	μm	高斯滤波器, 0.25 mm	0.2443	0.0317	0.1759	0.4226
Rq	μm	高斯滤波器, 0.25 mm	0.3228	0.0539	0.2332	0.6071
Rsk		高斯滤波器, 0.25 mm	-0.1379	0.7261	-3.9003	2.9191
Rku		高斯滤波器, 0.25 mm	5.2352	4.4220	2.4659	37.1751

Fig 3 white light interferometer output

3 The experiment data and analysis

3.1 Changes of single factor test

A hard alloy cutter with suspended depth 5mm, a diameter Φ2.9mm is used to boring bli nd hole with a diameter 2.7mm.Study the influence of various factors on the surface roughne ss of the machined surface.

3.1.1 Speed to boring after pore size and surface roughness effect

When the feed rate is 1.5mm/min, the effect of speed of boring cutter on the pore size and s urface roughness is shown in figure 4.

The Figure 4 shows that roughness of boring surface decreases with increasing tool rotatio nal speed, ,and the gotten hole size is close to the ideal size with Φ2.9mm. The reason is tha t as the speed increases, the cutting processing times per unit area increases, boring flexible be nding processing error can be reduced, and the cutting force decreases and improves the surfac e quality of processed samples. But as the tool rotation speed Increases,a lot of heat is prod uced and is also easy to damage the cutting tool,with the increase of rotational speed, the i mprovements of the surface quality and dimensional accuracy are not obvious [3].

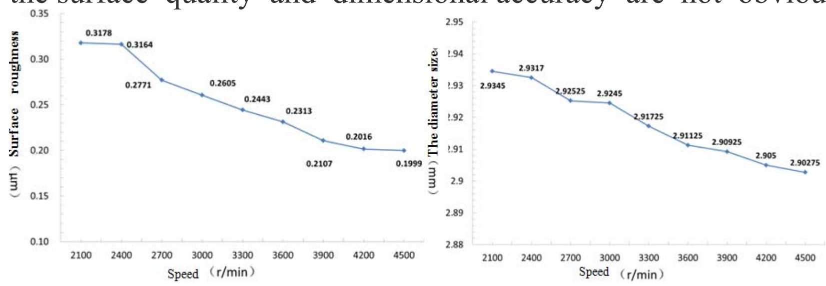


Fig. 4 surface roughness and the hole diameter size changes with the rotating speed

3.1.2 The effect of feed rate on boring holes after dimension and surface roughness

When the tool rotational speed is 4500r/min, the relationships between feed rate and surface roughness,boring hole size are as shown in figure 5.

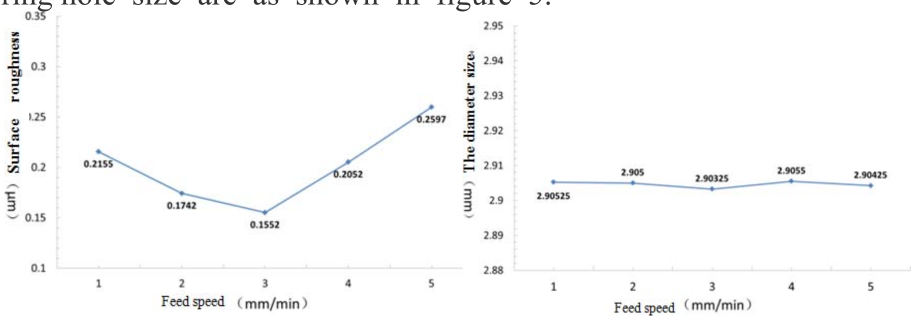


Fig. 5 curve surface rough degree and boring after the hole diameter size change with feed speed

The figure 5 shows that the change of feed rate has little effect on the hole diameter size after boring , but the surface roughness decreased with the increase of feed speed and then increased . The reason is that when the feed speed is low, cutting over on the same processing surface is damaged and need a longer processing time; when the feed rate is high, the action range feed per revolution of the boring cutter will exceed the knife point radius, so that the surface can not be fully processed, even draw groove and can not meet the requirements of surface quality[4].

When the tool rotational speed is 3000r/min, a similar phenomenon produced, and the best surface quality are still gotten in the feed rate 3mm/min,.It illustrates that the optimal feed rate has nothing to do with speed.

3.2 The effect of various factors on machining dimension and surface roughness

In order to compare the effects of various factors on machining dimension and surface roughness [6] , the cutting process is studied by the orthogonal test.

3.2.1 Design scheme of orthogonal test scheme

Parameter variables are selected as tool size, feed rate, tool rotational speed, three factors and three levels of tests by using L_9 (3^4) orthogonal table of orthogonal experiment, the design of orthogonal table is as shown in table 1.

Table 1 Factors and levels

Horizontal	boring size（A） mm	Feed rate (B) mm/min	speed(C) r/min	other (D)
1	Φ2.85	0.5	1500	
2	Φ2.90	1	3000	
3	Φ2.95	1.5	4500	

3.2.2 Test results and analysis

Test index for the surface roughness Ra and the value of blind hole diameter size L boring after . To make the test results more reliable, all of the experiments were repeated 3 times. To determine the influence degree of various factors and significant, the analysis of range and variance is carried out . Table 2 shows that the size and the surface roughness value is the average of the 3 test results. Table 3 shows the mean value of 9 groups of test results analysis. Table 4, 5 are the variance of 27 groups of experimental data [5-7].

Table 2 results of orthogonal test

Hole generation number	A	B	C	D	surface roughness	The diameter of the hole size after boring
H01	1	1	1	1	1.1119	2.8408
H02	1	2	2	2	0.8721	2.8345
H03	1	3	3	3	0.6354	2.8333
H04	2	1	2	3	0.2591	2.9025
H05	2	2	3	1	0.2155	2.9012
H06	2	3	1	2	0.2259	2.8975
H07	3	1	3	2	0.6688	2.939
H08	3	2	1	3	0.3662	2.942
H09	3	3	2	1	0.492	2.9293

It shows that boring size are the most striking on the surface roughness Ra value and boring blind hole diameter size, federate is more important than speed. Table 2 shows that if work-piece is boring with Φ2.90mm, H04, H05, H06 will have better surface quality and ideal processing size.So The boring before the hole diameter with Φ2.70mm can obtain better processing results with unilateral 0.1mm cutting depth .

4 Conclusion

Through the boring processing experiment and the data analysis, draws the conclusion as follows:

(1)The boring can achieve higher precision. the surface roughness Ra is up to 0.2 and can meet the requirements of production and processing.

(2) when the small blind hole is boring on alloy material with high strength and toughness, cutting depth Plays a very important role on cutting quality. Because the

boring when boring bar and deviation between the hole axis makes the cutting depth changing, cutting depth and tool force are into the approximate proportional relationship, boring stress occurs after the flexible bending, the boring process will aggravate the boring of the tremor, affect the machining surface quality. This can be achieved by increasing the diameter to curb this effect .

(3) Speed has a small influence on cutting quality of boring, but has greater effect on the pore size.The choice of high speed can help to get ideal surface quality and dimensional accuracy of obtaining.

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