Machining Precision Research for Two WEDM Processes

Li Xiaojing, Hu Yanhui
Mechanical Engineering Department
Henan Polytechnic Institute
Nanyang, China
hnpilxj@126.com

Abstract—Plenty of round holes or especial holes distributed in measuring device and mold component with higher positional requirement, in general, are formed in WEDM technology. In the process of WEDM operation, whole holes with high requirement should be finished in one time, which can avoid of positional error and enhance the positional precision effectively. Investigate into the geometrical tolerance and present in an improved process. This process can both suitable for WEDM-HS and WEDM-LS.

Keywords-component; WEDM; Positional precision; Finished accuracy

I. INTRODUCTION

Electric discharge machining has gained importance in the manufacturing world since its discovery 50 years ago by B. R. Lazarenko and N. I. Lazarenko[1]. In recent years, research has successfully shown that EDM can be applied to conductive hard and brittle materials if the electrical resistivity is low. One important characteristic of the EDM is very low efficiency of sparking in the forms of frequent open circuit, arcing pulse, and short circuit.

EDM is a machining method primarily used for hard metals or those that would be impossible to machine with traditional techniques. One critical limitation, however, is that EDM only works with materials that are electrically conductive[2]. EDM or Electrical Discharge Machining, is especially well-suited for cutting intricate contours or delicate cavities that would be difficult to produce with a grinder, an end mill or other cutting tools. Metals that can be machined with EDM include hast alloy, hardened tool-steel, titanium, carbide, inconel and kovar[3].

In the process of machining, the system take molybdenum wire as cutting tool electrode, the wire cylinder instruct molybdenum wire move along positive and alternate direction and the pulse power supply processing energy. Pouring liquid medium into the space of wire electrode and workpiece[4]. At the same time, the workbench moves in two coordinate directions of horizontal plane according to control procedures. In according to the spark gap, the two servo consequently drive the platform movement, the various curve guide the workpiece cutting path[5]. The WEDM can be classified as high-speed wire-EDM machine mode and low-speed wire-EDM machine mode. Both the two machine modes are shown in Fig.2 and Fig.3. The main technical items of two working modes are compared in Table.1. The common machining steps and requirements of WEDM is shown in Fig.4.

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<th>Table.1 Comparison of two cutting machine process</th>
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Fig.2 High-speed wire-EDM machine mode

Fig.3 Low-speed wire-EDM machine mode
Wire feeding speed (m/mm) 360~660
Wire feeding direction Alternate motion
Directed movement
Wire electrode Molybdenum wire Copper wire, tungsten wire
Operating fluid Emulsified liquid Deionized water
Discharging gape (mm) 0.01 0.02~0.05
Cutting speed (m²/mm) 20~160 20~240
Finished roughness (Ra) 3.2~1.0 1.6~0.2
Repeatability precision (mm) ±0.01 ±0.002
Wire electrode loss 0.01 Ignore

**Wire feeding speed**
The wire feeding speed ranges from 360 to 660 m/mm, or 1 to 15 m/mm. This indicates the speed at which the wire is fed into the workpiece during the machining process.

**Wire feeding direction**
The wire feeding direction is specified as alternate motion or directed movement, depending on the specific requirements of the machining process.

**Wire electrode**
Molybdenum wire, copper wire, and tungsten wire are listed as options for the wire electrode material. Molybdenum wire is often used due to its high melting point and good thermal conductivity.

**Operating fluid**
An emulsified liquid is used as the operating fluid, which is beneficial for cooling and lubrication during the machining process.

**Discharging gape**
The discharging gape ranges from 0.01 mm to 0.05 mm, which is a critical parameter in determining the accuracy of the machined surface.

**Cutting speed**
The cutting speed ranges from 20 to 160 m²/mm, indicating the speed at which the wire is moved across the workpiece.

**Finished roughness**
The finished roughness ranges from 3.2 to 1.0 Ra, indicating the smoothness of the machined surface.

**Repeatability precision**
The repeatability precision is ±0.01 mm, ensuring high accuracy in the machining process.

**Wire electrode loss**
A wire electrode loss of 0.01% is specified, which is a measure of the wire wear during the machining process.

**Fig.4 Machining steps and requirements of WEDM**
An example is provided to demonstrate, which is shown in Fig.4. The example is a punch concave die with special holes. The material of the workpiece is Cr12MoV steel with a thickness of 30 mm and hardness of 58~62HRC. In addition, the diameter of the guide sleeve mounting holes are Φ20 and Φ22, and the middle of the irregular hole is concave die shape hole. According to technical regulations, the primary task of the machine concave die is to ensure the positional precision of Φ20, Φ22, and irregular holes.

**Fig.4 Drawing of Concave die part**

**II. GENERAL PROCESS**
During the cutting of a shape hole with a general process, the hole for molybdenum silk is often employed to locate the electrode wire, so the form and position accuracy of the hole for molybdenum silk must be guaranteed. The hole for molybdenum silks is made by jig grinding finish machining, which is beneficial for location of the electrode wire during cutting and ensures position accuracy.

The machine process of the workpiece is as follows:
01 Preparation dimension. 200X180X35
02 Milling end surface
03 Grinding flat surface with the thickness of 31.5
04 CNC milling. Milling base surface process and drilling hole from Φ20 to Φ19.5, drilling hole from Φ22 to Φ21.5. Drilling the irregular hole for molybdenum silk to Φ3.5.
05 Machining four M8 holes with center drill
06 Clamping, drilling and tapping
07 Quenching with the required temperature
08 Grinding surface with the thickness of 30
09 Machining the shape hole with WEDM

If the mutually perpendicular surfaces are utilized to locate the electrode wire, though the hole for molybdenum silk need not be finished machining, the surface A and the surface B in Fig.1 need finish machining. There is an error in positioning the electrode wire, furthermore, the workpiece must be supported in the form of a cantilever, which lowers reliability.

The above process can satisfy present requirements of position accuracy, but the process is complicated. Besides WEDM, finish machining includes jig grinding. The process is not economical and efficient. Under machining shape holes through WEDM, when finish hole for molybdenum silk is used as positioning, there is positioning error. It takes much time to prepare machining.

**III. THE IMPROVED TECHNOLOGY PROCESS**
The traditional process is improved, which can be described as follows:
01 Preparation dimension 200×180×35
02 Milling end surface
03 Grinding flat surface with the thickness of 31.5
04 NC milling, milling the datum surface, drilling the hole of Φ20, Φ22,4-M8
05 Drilling and threading the hole, drilling Φ20,Φ22 and Φ4 pylon
06 Quenching with the required temperature
07 Grinding flat surface with the heights of 30
08 Process shape hole with WEDM

From the view of process content, the improved process 04 is less, and just need to drill a few center holes, reducing the boring time. The improved process 08 is to cut out all holes in one time, although the processing time increases, the efficiency is certainly higher than the process of boring and grinding. When aligning, just align a work-piece side (as the front), while the electrode wire locates the hole center only by eyeballing and saves more alignment time. Which completely avoids the alignment error, the location accuracy after processing only relate to the precision of the device.

When cutting the first hole, it doesn't need precise positioning of electrode wire, when cutting the subsequent holes, positioning of the electrode wire is ensured by the machine to that eliminates alignment error of the center hole.
IV. CUTTING ROUTES AND PROCEDURES

Such as using HS-WEDM to process the graphic above, the 3B procedure generated by CAXA cutting software is as follows:

```
N 1. B 9900 B 0 B 9900 GX L1 . -217.326 , 58.689
N 2. B 9900 B 0 B 39600 GY NR1 . -217.326 , 58.689
N 3. B 9900 B 0 B 9900 GX L3 . -227.226 , 58.689
N 4. D
N 5. B 70000 B 60000 B 70000 GX L1 . -157.226 , 118.689
N 6. D
N 7. B 3005 B 16249 B 16249 GY L2 . -160.231 , 134.938
N 34. B 3005 B 16248 B 16248 GY L4 . -157.225 , 118.689
N 35. D
N 36. B 70000 B 60000 B 70000 GX L1 . -87.225 , 178.689
N 37. D
N 38. B 10902 B 0 B 10902 GX L1 . -76.323 , 178.689
N 39. B 10902 B 0 B 43608 GY NR1 . -76.323 , 178.689
N 40. B 10902 B 0 B 10902 GX L3 . -87.225 , 178.689
N 41. DD
```

N1–N3 is the cutting process for Φ20 hole, N2 is for cutting round, N1 and N3 are feed and return, respectively, which are necessary for each part of the graphics. N4 is the pause, suggesting the operator undo the wire. N5 is the Hopstop procedure, the position of table moves from Φ20 center to the center of irregularly-shape hole. N6 is the pause. N7–N34 is for the procedure of irregularly-shape holes. N38–N40 is for the processing of Φ22 hole. N41 is the end. N35 and the N4, N36 and N5, N37 and N6 have the same meaning.

The process measures to solve misalignment of the start and end point

Although inside and outside shape cutting ensures location accuracy, the misalignment appears at the start point and end point of every closed graphics, the produced macroeffect is that, convex hull would appear in there, as shown in Fig.5.

The main reason of producing this kind of situation is that span of wire electrode is bigger when the distance between upper guide wheel and under guide wheel on machine tool is larger. The force generated by electrodischarge when cutting processing will make electrode wire bend and wire electrode deviate a tiny distance. Sketch map about wire electrode force offset is shown in Fig.6. The first section and last section of linear wire electrode will be affected by radial inward force when cutting round hole in Fig.5 is linear, so right quadrant point in round contour would leave convex bag.

The method to solve the defects is that continue cutting a certain distance along circumference direction after round cutting completion, then returns to starting point of the last part line. Inserting two parts program between N2 and N3 in the above mentioned procedure is available. As shown below.

```
B 9900 B 0 B 1000 GY NR1; // excess cutting part at counterclockwise more
B 9848 B 1000 B 1000 GY SR1; // return to starting point of N3
```

The remaining two contour graphics can adopt to this method, which ensured precision and shape of tolerance of each outline graphic and reduced fitter grinding and polishing workload.

V. CONCLUSION

WEDM wire-cutting processing is a special machining method using pulse discharge happens between electrodes and workpieces. This paper have analyzed and compared the two working modes of high-speed wire-EDM machine and low-speed wire-EDM machine. For the holes or slots distributed in mould device should be machined by WEDM method and could meet technical regulation. If all the holes or slots with higher accuracy requirement are machined in one process, the form accuracy and positional accuracy might be achieved. The paper compared two machining methods for the special holes with experiment. The result indicates that the improved process can greatly improve the machining accuracy and this method can be used in WEDM-HS and WEDM-LS process.

REFERENCES


