Selection of EDM Electrode Materials for Valve Grinding

Jie Zhan
School of Mechanical Engineering
Shanghai University of Engineering Science
333 Long Teng Road
Shanghai, 201600
China

Minliang Zhang
Professor
School of Mechanical Engineering
Shanghai University of Engineering Science
Shanghai
China

Pengcheng Huo

Yankai Liu
School of Mechanical Engineering
Shanghai University of Engineering Science
Shanghai
China

Youlei Qin
Jiang Nan University
China

Abstract

With the strongly support from the country for the manufacturing industry, valve industry will be gradually appreciated. This paper mainly introduces some technical parameters requirements of ball valve. During the analysis of traditional valve machining process, proposing a new processing mode about ball valve grinding: Electrical Discharge Machining (EDM). By comparing three different electrode materials at different stages in processing results, selecting the most reasonable electrode materials correspond to the process stages to increase the accuracy and efficiency of machining core of ball valve.

Keywords Technical parameters, Ball valve grinding, EDM, Comparing different electrode materials

1. Introduction

Grinding is a micro-machining process, using abrasive tools effect on the work piece surface by grinding medium. To meet the complex and changing market demands, grinding miller expand towards high efficiency, high stability, and high accuracy direction currently. At present, internal grinding is mainly still uses loose abrasives grinding on the slow-grinding machine. The grinding millers traits are as follows: high precision, processing equipment, low investment, but unstable machining precision, high cost, low efficiency has been made some restrictions to grinding application. Now in domestic sphere grinding has two types: hand lapping and mechanical lapping. But hand and mechanical lapping only applies to surface hardness < 60 HRC and roundness tolerances < 0.1 mm sphere, and have low production efficiency, labor intensive traits. Therefore it is vital to develop a ball valve grinding, based on the traditional ground, but differs from the traditional ground, with wide processing range, high efficiency [1].

2. Technical Parameter Requirements of Ball Valve

2.1 Structural Features of Ball Valve Core

The key to the ball valve sealing is the ball core. From the structure of ball core, it can be divided into two types: with and without the support shaft.

This paper mainly research the ball valve of no support shaft, the structure is shown in Figure 1. The ball valve materials are determined by its application, it can be divided into cast iron, carbon steel, stainless steel and non-metallic material. The cast iron ball valve core is utilized by casting rough. Small size of the steel ball valve element can be directly machined by bars, and the others are mostly adopting roughcast forging [2].

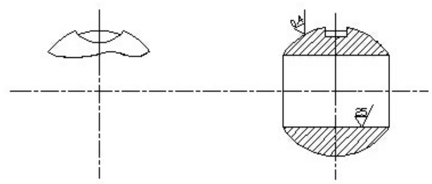


Figure 1: Structure of Valve Core

2.2 Main Technical Parameters of Ball Valve Requirements

1. Precision of ball valve core general in 9~11-level, the scope of Surface roughness is 1.6~0.4um.
2. No matching surface precision demand M band, surface roughness Ra under 25um.
3. The roundness of the sphere is not more than 0.02~0.10mm.
4. Sphere of circular grooves on both sides of the face axis of symmetry should not be greater than the specified parameter value.

2.3 Ball Valve Machining Process

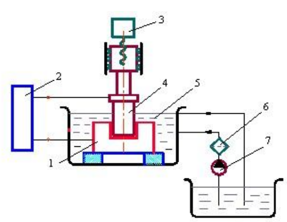
The surface of spherical ball valve core, without axial support, is the primary machined surface. The machining order is according to the requirement, lathing the through hole, then using hole as location datum to machine spherical surface [3]. Specific processes are shown in table 1:

Table 1 Machining Process

Number	Process content	location datum
1	Lathe sphere-end and internal hole	Cylindrical outside surface
2	Lathe other sphere- end	Cylindrical inside surface
3	Rough turned spherical surface	Cylindrical inside surface
4	Finished turned spherical surface	Cylindrical inside surface
5	Hole round off	Cylindrical inside surface
6	Milling arc groove	Cylindrical inside surface

3. EDM

EDM is a new technical process that using electrical and thermal energy, it also known as electrical discharge machining. EDM is differing from general machining. Tool electrode and work-piece do not contact in EDM machining, basing on the tool and the work-piece continuous pulse spark discharge, using localized ,instantaneous high temperatures gradually removal of metallic materials during discharge. During the discharge process generated visible electric sparks, so called EDM. The EDM Principle is shown in Figure 2.



1: work-piece 2: impulsing power source 3: worktable 4：tool electrode 5：working fluid 6：flow control valve 7：pump

Figure 2: Principle of EDM

Medium between electrodes minimum or lowest dielectric strength will be breakdown, rising spark discharges, causing transient high temperature, making tool and work-piece surface corrosion to get rid of a few of the metal, forming a small dent during a voltage is applied between the two electrodes of work-pieces and tools at about 100V. Tool continuously closes to the tool, causing a shape on the work-piece when machining work-piece.

Electrical discharge revolution machining means work-pieces and tools doing relative rotational movement, with it processing ball valve, avoiding the focus of spark discharge. Galvanic corrosion products are more likely to bring out, due to work-pieces and tools electrodes continuously rotating causing fluid flowing. Traditional grinding is often through outer and inner cylindrical surface of cylindrical to machine spherical surface. And design of grinding device tends to focus on the design of mechanical parts. While composite electrical discharge turning machining requires a combination of specific conditions for the innovation of lapping machine designing. Among the institution electrode designing and exercising are very important parts of the device [4-5].

4. Selection of Electrode Materials

4.1 Electrode Selection Principle

In EDM process, reasonable selection of electrode materials ensures the quality of processing and improvement of production efficiency. Therefore, electrode material selection must be given a high priority. Meanwhile, as electrodes processing different sizes ball valve, this will cause the electrode also have different specifications. Must following these principles when selecting tool electrode materials.

(1) Select electrode materials according to the ball valve material and technical requirements, on the basis of analysis ball valve core technical requirements .(tolerances, surface roughness)

(2) Select high melting point and good thermal conductivity material for electrode material in priority.

4.2 Common Electrode Constant

Thermal physics constants	Red copper	Graphite	Steel	Hangzhou Iron
melting point (Tr) /℃	1083	3500	1527	1083
3oiling point (T_f)/ ℃	2360	3700	2735	
Heat diffusivity (λ)/J·(cm·s·℃)$^{-1}$	3.852	0.49	0.335	
Volume mass (ρ)/g·cm^{-3}	8.9	2.2	7.9	8.4~8.85
ermal capacity (C)/J·(g·℃)$^{-1}$	0.3936	1.675	0.695	
'emperature coefficient $\alpha=\lambda/C_P$	1.1	0.133	0.061	
latent heat(q_q)/J·g^{-1}	3592.2	46054.8	6647	
latent heat of fusion (q_r)/J·g^{-1}	180		209.3	

Table 2: Commonly Used Electrode Physical Constants

As seen form the table2, graphite has a high melting point and boiling point, leading it has a high corrosion. And it have a large heat capacity, relying on adsorption of free carbon to compensation of electrode wear to cause relatively low loss in the time of wide pulse processing. However, Hangzhou Iron has a relatively large coefficient of transmission and heat conductivity, bringing out it has a high decay resistance. So it usually process margins that are relatively small parts of electrode materials. Abrasive ball valve core is divided into three stages, coarse grinding, grinding and fine grinding. EDM technology used in coarse grinding and grinding stages, not only can improve the accuracy of grinding, but also boost their efficiency. Two stages corresponding to the different electrode material in EDM, reasonable selection of electrode materials are crucial in keeping the ball valve grinding accuracy.

Selection of different electrode materials will make processing speed, processing polarity effects and processing different. Following the experimental data adoption, the effects of electrode materials is detailing on processing results.

4.3 Comparison of Different Electrode Materials in Coarse Grinding Stage

EDM Machines: E46PM.
Process Conditions: Negative rough Machining.
Experimental material: heat treatment for 45 steel, thicknesses of 35mm.
Operating fluid: EDM special dedicated kerosene.
Electrical source: unidirectional pulse power
The process results seen in table 3:

Number	Machining electrodes	Current(A)	Pulse width (us)	Inter pulse （ us)	UP/DN	Processing results	Comparison of comprehensive
1	Red copper	6	500	3	2/3	Phenomenon: large spark, more bubbles, white smoke ,low productivity. Ra: 8.0um Machining time:1248s	Bad
2	Cr12 steel	6	500	3	2/3	Phenomenon: large spark, white smoke, many chip Ra:8.0um Machining time:641s	Medium
3	Graphite	6	500	3	2/3	Phenomenon: large spark, little white smoke, high productivity. Ra:7.2um Machining time:502	Good

Table 3: Comparison of Process Results in Course Grinding Stage

As seen from the table3: in the conditions of long-pulsed negative processing , selecting graphite electrode machining is better than red copper in erosion speed, machined surface precision and machining productivity. Although the density and heat conductivity of graphite is no better than red copper, its melting and vaporization points are far better than red copper. That makes its sublimation temperature higher and amount vaporized more little, which is helpful for reduction of electrode wear. Meanwhile, graphite adsorbs free carbon to offset losses when as the negative electrode, which makes reduction of electrode more little. Owing to the large density of Cr12 and red copper, when using them as negative electrode machining 45 steel, most of ablation particles sink into the bottom of the tank, which causing working liquid turbidity and density increased. These questions lead the machining surface secondary discharge, appearing burns and arcing. In the last, the work-piece surface roughness is increasing and precision losses. Therefore, in the coarse grinding stage of ball core, using graphite as electrode is better than Cr12 and red copper. Not only its processing results are well, but also reducing the electrode wears.

4.4 Comparison of different electrode materials in fine grinding stage

EDM machines: E46PM.
Process conditions: Positive rough Machining.
Experimental material: heat treatment for 45 steel, thicknesses of 35mm.
Operating fluid: EDM special dedicated kerosene.
Electrical source: unidirectional pulse power.
The process results seen in table 4:

Number	Machining electrodes	Current (A)	Pulse width (us)	Inter pulse （us)	UP/DN	Processing results	Comparison of comprehensive
1	Red copper	3	15	5	1/2	Phenomenon: little spark and bubbles, no white smoke, fine surface. Ra: 3.2um Machining time: 5630s。	Good
2	Cr12 steel	3	15	5	1/2	Phenomenon: bad stability, carbon deposits on the surface. Ra: 3.4um Machining time:9927s	Medium
3	Graphite	3	15	5	1/2	Phenomenon: little spark, bad stability Ra: 3.5um Machining time: 7173s。	Bad

Table 4: Comparison of Process Results in Fine Grinding Stage

As seen from the table: Using Cr12 steel and graphite as electrode in the fine grinding stage, the machining surface is hardly reaching the level of light. And the productivity and stability is lower. Seen from the processing effects, using red copper as a tool for positive electrode in the fine grinding stage is obviously better than graphite and Cr12 steel. In order to the corrosion products discharged in time, the pressure should appropriate increased when red copper as electrode machining. This will improve process stability, increasing productivity and achieve satisfactory effect [6].

5. Conclusion

In EDM, reasonably electrode material selection is important to ensure ball core quality. Seen from the above analysis, comparing three different materials processing results, using graphite as negative electrode in the coarse grinding stage and using red copper as positive electrode in the fine grinding stage can achieve satisfactory effect, greatly improving the efficiency of processing precision.

References

Xifeng Zhou. (2006). Model and predict surface roughness in grinding process. International Journal of Machine Tools & Manufacture, (42), 969-977.

Xichun Liu. (2003). Processing of turn-on mounted ball valve. Journal of Ball Valve, (1), 24-26.

Jiandong Yang&Chunling Tiani. (2005). High speed grinding technology. China: National Defense Industry Press.

Haiyun Hou, Dongdong Li&Dejing Hu.(2011). The surface roughness distribution of cup wheel grinding spherical. Journal of Shanghai Jiao Tong University (Natural Science).

Yundong Cai, Liming Xu&Dongdong Li.(2012). The digital control technology of high hardness spherical rotary precision grinding system. Journal of Manufacturing technology and machine tools, (6), 44-46.

Kaizhou Xu, ChengXie Wei. (2011). Geometric error compensation of generating grinders. Journal of Shanghai Jiao Tong University (Natural Science, (4), 478-483.