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Research on Principles and Processes of Electrochemical Finishing with Ultrahigh-frequency Group Pulse

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Key words: Ultrahigh-frequency group pulse; finishing; single-factor experiment

Abstract. On the foundation of the methods and mechanisms of electrochemical finishing with high-frequency group pulse we studied before, properties of the finishing process with ultrahigh-frequency group pulse were studied, effects of pulse effect on the finishing result were also researched. With the Ultrahigh-frequency group pulse power we designed, we designed a equipment with high precision and easy operation. After some single-factor experiments, we obtained the laws of how the main pulse influenced the result, from the Ra of 2Cr13 stainless steel surface.

1. Introduction

Electrochemical finishing technology is a non-traditional machining technology, it is based on the electrochemical anodic dissolution theory. With high efficiency, no apparent residual stress, no tool wear, ECM can machine any conductive material no matter how hard it is. High-frequency group pulse electrochemical finishing is a new electrochemical finishing method, which uses pulse modulation power supply increasing the pressure wave and the reverse current between polars. This can further improve the machining conditions. Compared with the traditional ECM, it has a bigger advantage[1,2]. On the base of high-frequency group pulse electrochemical finishing we studied before, some finishing experiments with the ultrahigh-frequency group pulse were conducted. Reasons for the pulse effect improving the result were studied. There are many factors affecting ultrahigh-frequency group pulse electrochemical finishing, but the levels are different. In this paper, with the ultrahigh-frequency group pulse electrochemical machining equipment as the experiment platform, single-factor experiments were conducted. The effects of machining conditions rules were studied. The influence of main pulse frequency to the result was also studied. In the end, we drew some important conclusions.

Figure.1 The ultrahigh-frequency group pulse power we designed before

2. Test Equipment and Principle

2.1 Ultrahigh-frequency group pulse power

The width of pulse produced by the ultrahigh-frequency group pulse power is only about several microseconds, whose frequency is increased significantly compared with the high-frequency group pulse power we designed before. It is consist of power supply part, ultrahigh-frequency signal circuit board, signal receiving circuit board, signal transmission and ultrahigh-frequency electric power output board, and so on. The main pulse signal is generated by a quartz crystal oscillator, the modulation pulse signal is generated by a 555 timer connected as a multivibrator circuit. Frequency of the modulation pulse signal is adjusted by an external potentiometer. Waveform of the modulation pulse signal is shaped by some one-shot triggers, and the width of modulation pulse is adjusted by an external potentiometer of the he one-shot triggers[3].

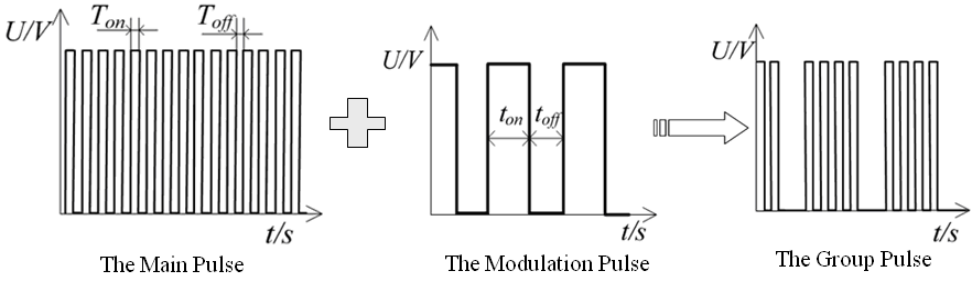
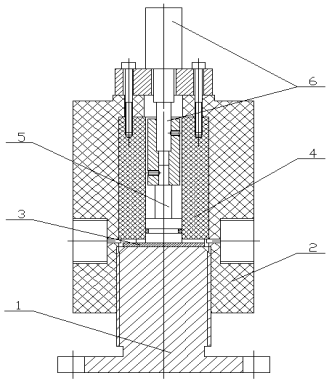


Figure.2 The modulation waveform of ultrahigh-frequency group pulse power

The ultrahigh-frequency group pulse signal transmits through an optical fiber and a coaxial cable, because of this, the ultrahigh-frequency group pulse signal can achieve a long-distance transmission. Besides, power signal is transmitted by two copper boards. Figure 1 shows the ultrahigh-frequency electric power in kind.

Figure 2 shows the output waveform of group pulse power supply. In the figure, T_{on} is the main pulse duration and T_{off} is the main pulse off time. t_{on} is the modulation pulse duration and t_{off} is the modulation pulse off time. Group pulse is obtained by multiplying the modulation pulse and the main pulse, then, the ECM goes on under this intermittent voltage[4].



1- The base 2- Jacket 3-Workpiece
4-Inner sleeve 5- Cathode 6-Spiral tuning rod
Fig.3Drawing of installation structure

Fig.4 Partial picture of the equipment

2.2 Test setup

To conduct the high-frequency group pulse electrochemical finishing experiment, a test device was designed, Figure 2 shows the structure chart and Figure 3 shows the device in kind. Jacket 2 and inner sleeve 4 is made of non-conductive material. Jacket 2 is made of plexiglass, through

which the workpiece can be observed in the trial process, in order to facilitate the experiment phenomena more detailed recorded. The inner sleeve 4 is made of Nylon. Cathode and the base are made of aluminum bronze, with good conductivity and corrosion resistance. When fixture assembly is completed, there will be a closed space among the base piece, jacket, the inner sleeve and cathode, as electrolyte flow region. Width of the region is designed to be narrow at the import, wide at the export, so that the electrolyte in the machining region can wash away the electrolysis products and provide a back pressure.

In the experiment, the workpiece was placed between the base and inner sleeve. The current transmit from anode to wokpiece, then electrochemical reaction occurs between the anode and cathode. The fine-tuning institution feeds the cathode by micrometers to control the gap with high precision. A threaded hole and a slot were machined at each side of the jacket 2,the threaded holes are linked up with fittings. In the experiment, the electrolyte flows through the pipe and the threaded hole in turn. The base moves out from the coat, the workpiece machined can be removed.

3. Single-Factor Experiment and analysis

3.1 Experiment program

Composite neutral electrolyte of NaCl and $NaNO_3$ is used in the experiment, the concentration of electrolyte NaCl 2% and $NaNO_3$ 4%.The workpiece used is stainless steel sheet of 2Cr13,the Ra is about from 3 to 5 μm. Other parameters are as follows: power main pulse frequency 6 to 200 KHz；the machining gap is 0.2 mm; machining voltage is 5 V; electrolyte pressure 0.1Mpa；pulse modulation frequency 600Hz；Test temperature 25 ^{0}C.

3.2 Experiment result analysis

Figure 5 shows that the Ra value reduces as the main pulse frequency is increased, and the finishing result is improved gradually. This is mainly because of the ultrahigh-frequency group pulse power used in our experiment. Compared with the finishing process with the high-frequency group pulse, pulse effect is enhanced significantly. In the machining process, the pressure wave becomes considerable as we increase the main pulse frequency. The intermittent pressure wave generated by the ultrahigh-frequency group pulse stir the electrolyte strongly, flow field of the electrolyte and temperature conductivity become more uniform. The concentration polarization and the stray corrosion reduce. This also improved the physical and chemical properties in the machining gap such as temperature field and flow field. Besides, nonlinearity of the η - i curve and anode potential characteristics are improved by the ultrahigh-frequency group pulse, all of these are good to the finishing result.

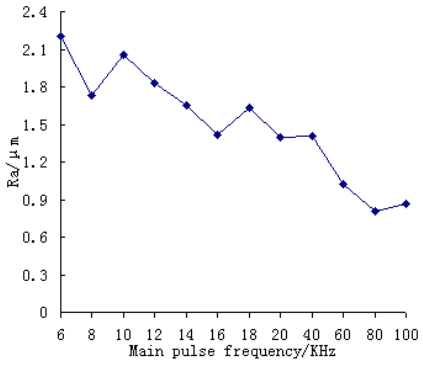


Fig. 5 Relationship between frequency and roughness

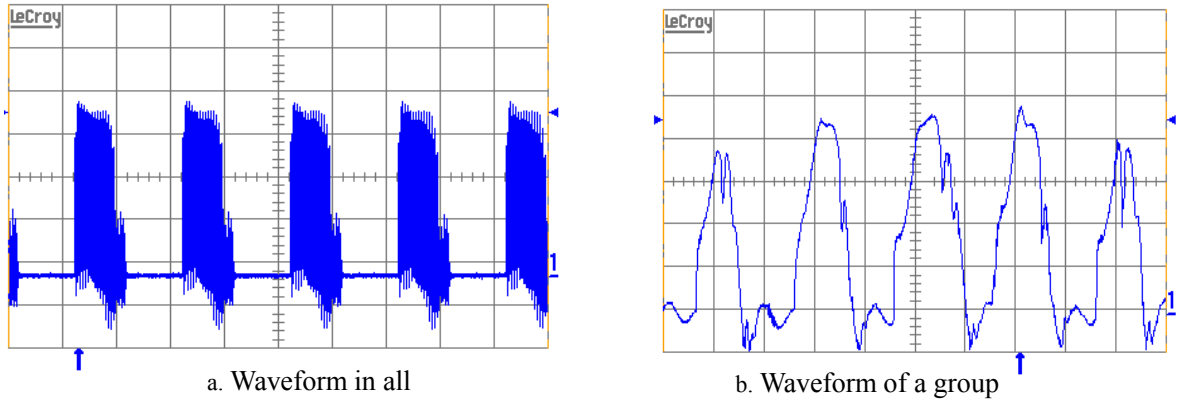
4. Features of electrochemical finishing with ultrahigh-frequency group pulse analysis

In our experiment, the workpiece is finished with ultrahigh-frequency group pulse (the width of the pulse is about several micrometers) without moving. Compared with the research we conducted before, such as machining principles of direct-current, group pulse, high-frequency group pulse, ultrahigh-frequency group pulse, we can draw some conclusion of electrochemical finishing with ultrahigh-frequency group pulse as follows:

（1）Nonlinearity of the η - i curve is improved by ultrahigh-frequency group pulse

Nonlinearity of the η - i curve in DC ECM is mainly depend on the match condition of the workpiece material and the electrolyte. In the finishing process, nonlinearity of the η - i curve is improved by our ultrahigh-frequency group pulse significantly. Compared with DC ECM, the machining process will occur at strong current density field. The balance machining gap will decrease and this will improve the machining precision. Cause of this is that the area of the active dissolution, passivation solution reactivation solution in the η - i curve will be enlarged as the current density is increased. That is, reactivation solution will occur when the current is more denser. What is more, the curve is more steeper, which is useful to the result[5].

（2）Anode potential characteristics is improved by ultrahigh-frequency group pulse



a. Waveform in all b. Waveform of a group

Fig. 6 Waveform of ultrahigh-frequency group pulse power in kind

Figure 6 shows the waveform of ultrahigh-frequency group pulse power in kind. It illustrates that when the frequency is very high, strong reverse current will occur in the machining gap, and there will be some micro-EDM. The reverse current is conducive to the polarization so to improve the anode potential characteristics[6]. The micro-EDM will shorten the polishing process.

（3）Physical and chemical properties in the machining gap is improved by ultrahigh-frequency group pulse

This is mainly because of the pressure wave cause by the H_2 generated by the pulse at the anode. The intermittent pressure wave generated by the ultrahigh-frequency group pulse stir the electrolyte strongly, flow field of the electrolyte and temperature conductivity become more uniform. The concentration polarization and the stray corrosion reduce. This also improved the physical and chemical properties in the machining gap such as temperature field and flow field. Besides, heat only generates at T_{on} time, and it will cool down at the long T_{off} and t_{off} , all of these improve the machining conditions. The machining process is improved by co-pressure wave generated by the main pulse and the modulation pulse. The defects of partial passivation, sparks, passivation are decreased by the pressure wave, which improve the result again[7].

5. Conclusion

Compared with the common high-frequency group pulse electrochemical finishing we studied before, finishing result was further improved by the pulse effect of the ultrahigh-frequency group pulse power we designed.

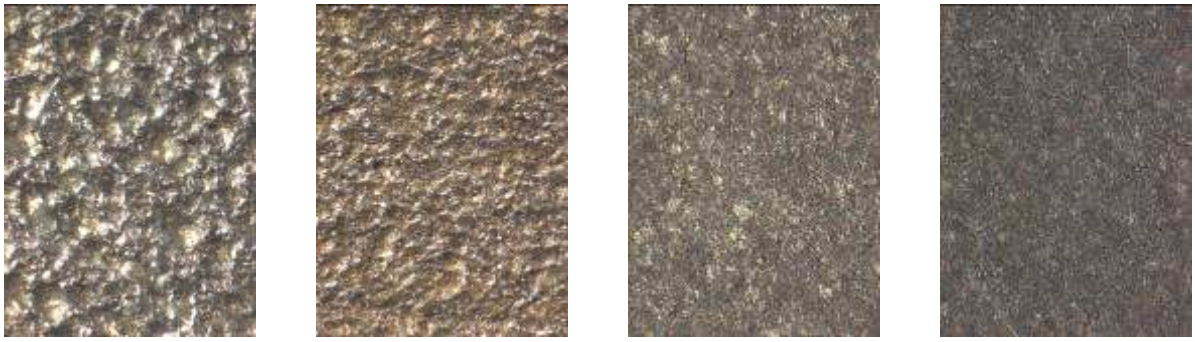
(1) A substantial increase in machining precision. This is mainly because that nonlinearity of the η - i curve is improved by our ultrahigh-frequency group pulse significantly. The balance machining gap will decrease and this will improve the machining precision. All of this solve the two most fundamental issues in DC ECM.

(2)The surface quality is further improved. This is mainly because of the pressure wave cause by the H_2 generated by the pulse at the anode. The intermittent pressure wave generated by the

ultrahigh-frequency group pulse stir the electrolyte strongly, flow field of the electrolyte and temperature conductivity become more uniform. And the flow marks reduce.

(3)Be more efficient. The reasons are as follows, with the ultrahigh-frequency group pulse, small machining gap can be achieved. The average current density is also higher. Besides, the reverse current is conducive to the polarization so to improve the anode potential characteristics. The micro-EDM will shorten the polishing process.

(4) Processing stability, process simplification and easy to be extended. For the flow field of the electrolyte and temperature conductivity become more uniform, this afford that we must not control other machining conditions that accurate as usual any longer[8].



a. $f = 6KHz$ b. $f = 20KHz$ c. $f = 50KHz$ d. $f = 200KHz$

Fig. 7 Change of work piece surface microscopic appearance after machining

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