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Effect of Discharge Parameters on Surface Roughness and Material Removal Rate of GH4169 High Temperature Alloy by WEDM

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Abstract: GH4169 high-temperature alloy is a difficult-to-machine material commonly used in the aerospace industry. The surface roughness and material removal rate are important indicators in the production of WEDM processing GH4169 high-temperature alloy, and the discharge parameters directly affect the surface roughness and material removal rate. Several groups of optimized discharge parameters were used to process GH4169 high temperature alloy, and the specific influence of each discharge parameter on the surface roughness and material removal rate was obtained respectively. The results of the study provide a technical reference for the production of WEDM processing GH4169 high-temperature alloy, and a suitable combination of discharge parameters can be selected according to different production requirements.

Keywords: WEDM, GH4169 high temperature alloy, Discharge parameters, Surface roughness, Material removal rate.

1. Introduction

GH4169 high-temperature alloy is a difficult-to-machine material with high hardness and high toughness, and the material hardness reaches more than HRC56 after heat treatment. In the aerospace industry, WEDM is commonly used to process GH4169 high-temperature alloy to make complex parts. When WEDM processing GH4169 high-temperature combined, the discharge parameters (processing current, pulse width, pulse interval) affect the surface roughness and material removal rate of the material, which are important indicators of the machined surface quality and processing efficiency, respectively, as well as a pair of mutually constraining technical indicators [1]. The effect of WEDM on the surface roughness and material removal rate has been studied by many scholars [2-6]. Other scholars [7-10] have used orthogonal test methods to optimize the discharge parameters of WEDM processing of high-temperature alloys. In this paper, we will use EDM wire-cutting equipment to process GH4169 high-temperature alloy with three sets of optimized discharge parameters to observe and study the effects of various discharge parameters on the surface roughness and material removal rate of the processed material.

2. Experiment

2.1. Experimental materials

The size of the specimen in the experiment is 10×10×100mm, and the hardness reaches HRC56 after heat treatment; all surfaces of the specimen are pre-machined with a surface grinder to a surface roughness of Ra0.8μm.

2.2. Specimen preparation

DK7740 WEDM machine was used to process the specimens, and the electrode wire diameter was φ0.12mm molybdenum wire; the cutting fluid was emulsion of 2wt% concentration; the processing method was one time cutting. Different discharge parameters were used to process the specimens on the WEDM machine, and the specimens were cut to a thickness of 6 mm, and then the specimens were cleaned by ultrasonic waves for 10 min to remove the stains and attached electrolytes on the surface of the specimens. The discharge parameters are shown in Table 1, 2 and 3.

Table 1. Different processing current parameters

processing current parameter I (A)	pulse width parameter W (μs)	pulse interval paramete J (μs)	processing voltage V (V)	speed of the line S (m/min)
1.0、1.4、1.6、2.0、2.4、2.6、2.8、3.0	12	10	80	12

Table 2. Different pulse width parameters

processing current parameter I (A)	pulse width parameter W (μs)	pulse interval paramete J (μs)	processing voltage V (V)	speed of the line S (m/min)
2.0	6、8、10、12 14、16、18、20	10	80	12

Table 3. Different pulse interval parameters

processing current parameter I (A)	pulse width parameter W (μs)	pulse interval paramete J (μs)	processing voltage V (V)	speed of the line S (m/min)
2.0	12	6、8、10、12 14、16、18、20	80	12

2.3. Measurement of surface roughness and material removal rate

Using a roughness meter to measure the surface roughness of the specimen after the WEDM process, the material removal rate is calculated using the formula:

$$MRR\ (mm^2.min^{-1})=S\ (mm^2)/t\ (min)$$

Material removal rate: MRR;

Processing cross-sectional area: S

Processing times: t

In the experiments, the WEDM machine system comes with the machining time statistics function, and the machining cross-sectional area S is fixed at 100 mm^2.

3. Results and Analysis

3.1. Effect of different processing currents on surface roughness

The machining current is an important factor affecting the surface properties of the material processed. The processing current increases, the pulse energy increases, the ability to etch the material per unit time increases, and the cutting speed is accelerated, but too much current tends to cause processing instability, which will produce the phenomenon of wire breakage. Under the experimental conditions of processing current 1.0, 1.4, 1.6, 2.0, 2.4, 2.6, 2.8, 3.0A; pulse width 12μs, pulse gap 10μs, the surface roughness of the machined specimen reached Ra1.58, 1.69, 1.80, 2.27, 2.96, 3.48, 4.38, 4.99 respectively, with an increasing trend, and in the processing The surface roughness of the processed surface increased significantly after the current was greater than 1.6A. The material removal rate reached 10.2, 12.9, 13.9, 14.9, 20.8, 29.4, 35.8, 43.4 mm2/min, which was consistent with the surface roughness and showed an increasing trend, and the material removal rate increased significantly after the processing current was greater than 2.0A.

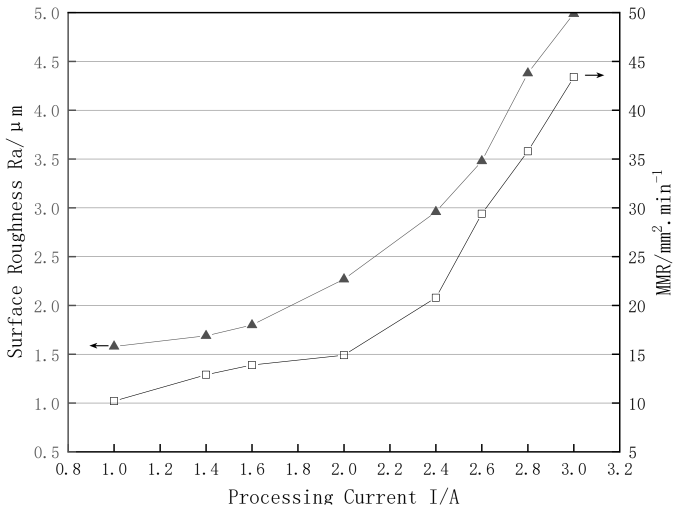

Figure 1. Surface roughness and materical removal rate with different processing current parameters

With the increase of processing current, processing pulse energy enhancement, material surface galvanic corrosion phenomenon is obvious, electrode wire and GH4169 high-temperature alloy specimen high frequency discharge instantaneous high temperature generated by the material surface vaporization and dissolution of the formation of compounds, these compound gases and cooling condensation under the action of the coolant, a small part of the fusion coating on the processing surface to form a recast layer, most of the electro-etching material into fine particles with the cutting fluid was discharged; the higher the processing current, the more surface fusion coating, recast layer thickness is greater, the surface produced more bumps and depressions, the surface roughness becomes worse.

3.2. The effect of different pulse width on surface roughness

Pulse width refers to the pulse power discharge time, and the pulse width value can be increased according to the actual situation when processing a workpiece with large thickness. Under the experimental conditions of processing current 2.0A, pulse width 6, 8, 10, 12, 14, 16, 18, 20μs; pulse gap 10μs, the surface roughness of the processed specimens reached Ra1.81, 1.89, 1.96, 2.36, 2.96, 3.88, 4.21, 4.52 respectively, with an increasing trend. The material removal rate reached 10.5, 11.9, 12.5, 14.9, 17.8, 26.5, 34.9, and 48.8 mm2/min, which were consistent with the surface roughness and showed an increasing trend, and the material removal rate increased significantly after the pulse width was greater than 12 μs.

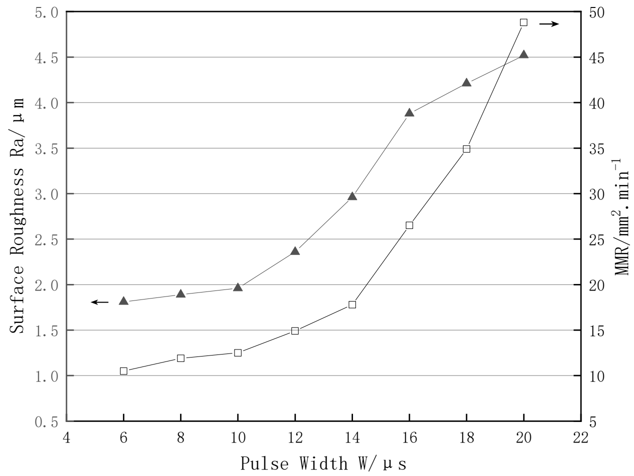

Figure 2. Surface roughness and Materical Removal Rate with different pulse width parameters

As the pulse width increases, the individual pulse energy is enhanced. The larger the pulse width, the more surface cladding, the more recast layer thickness increases, the more surface convexity, and the surface roughness becomes worse, but the effect of pulse width on surface roughness is slightly less than the effect of processing current on surface roughness.

3.3. The effect of different pulse interval on surface roughness

The pulse interval is the pulse stopping time, the pulse gap decreases, the number of cuts per unit time increases and the cutting speed is accelerated, but too small a pulse interval will easily ablate the electrode wire causing wire breakage; and too small pulse interval is not conducive to the discharge of galvanic corrosion, resulting in unstable processing; and too large a pulse interval will lead to discontinuous feeding and slow cutting speed. Under the experimental conditions of 2.0A processing current, 12μs pulse width, 6, 8, 10, 12, 14, 16, 18 and 20μs pulse interval, the surface roughness of the processed specimens reached Ra2.93, 2.64, 2.42, 2.37, 1.92, 2.23, 1.99 and 2.14 respectively, which showed a trend of decreasing and then small fluctuation towards smoothness. The material removal rate reached 32.6, 23.4, 19.5, 16.7, 14.2, 12.9, 11.2, and 10.7 mm2/min, respectively, with a decreasing trend, and the material removal rate slowed down after the pulse interval was greater than 10 μs.

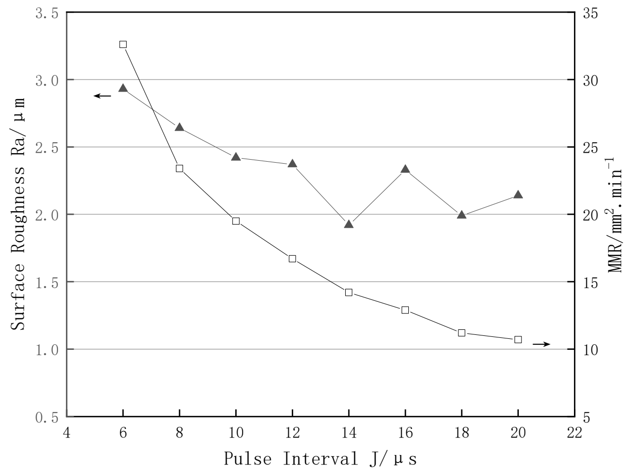

Figure 3. Surface roughness and materical Removal Rate with different pulse interval parameters

4. Conclusions

The WEDM processing of GH4169 high temperature alloy, the discharge parameters directly affect the surface roughness and material removal rate of the machined material. The surface roughness and material removal rate increase simultaneously with the increase of processing current and the trend is similar; the surface roughness and material removal rate increase simultaneously with the increase of pulse width; the material removal rate is decreasing, the surface roughness of the processed material decreases in the early stage, and the decreasing trend slows down after the pulse interval 10μs, and reaches the minimum value at the pulse interval 14μs, and slightly increases after the pulse interval more than 10μs, the change is not significant.In the process of GH4169 high temperature alloy, the influence of discharge parameters on surface roughness is from the largest to the smallest: processing current, pulse width, pulse interval; the influence of discharge parameters on material removal rate is from the largest to the smallest: pulse width, processing current, pulse interval. The results of the study provide a technical reference for the actual production of WEDM processing GH4169 high-temperature alloy, and a suitable combination of discharge parameters can be selected according to different production requirements.

References

[1] Wang P, Bai H Q,Shen Y, et al. Experimental study and optimization of process parameters for wire cutting HSS[J]. Manufacturing Technology and Machine Tool, 2018,(9):135-139.

[2] M.M.Bahgat, A.Y.Shash, M.Abd-Rabou, et al. Influence of process parameters in electrical discharge machining on H13 die steel[J]. Heliyon,2019,5(6): 1-6.

[3] Ashish Goyal. Investigation of material removal rate and surface roughness during wire electrical discharge machining (WEDM) of Inconel 625 super alloy by cryogenic treated tool electrode[J]. Journal of King Saud University-Science, 2017, 29(4): 528-535.

[4] Ying J K, Li W B. Influence of WEDM electric parameters on material removal rateand surface roughness of Cr12MoV [J]. Machine Tool and Hydraulics, 2016,44(3):147-150.

[5] M.Manjaiah, Rudolph F.Laubscher, Anil Kumar, et al. Parametric optimization of MRR and surface roughness in wire electro discharge machining (WEDM) of D2 steel using Taguchi-based utility approach[J]. International Journal of Mechanical and Materials Engineering,2016,11(1): 1-9.

[6] P.Dutta, S.C.Panja, G.R.K.Sastry. An investigation of machining time and surface roughness in wire-EDM for Inconel 800[J]. Applied Mechanics and Materials,2015,(9): 20-24.

[7] Deng P, Dong C S. Experimental research on parameters of the WEDM cutting Ti-6Al-4V titanium alloy[J]. Machinery Design and Manufacture, 2017,(1):69-71.

[8] Guo C X, Li G D, Liu K, et al. Parameter optimization of the second time cutting process of MS-WEDM based on orthogonal experiment[J]. Machine Tool and Hydraulics, 2018, 46(23):108-111.

[9] Ma X L, Teng K. Process parameter optimization of Ti-6Al-4V electric discharge machining base on BP neural network L-M algorithm[J]. Materials Reports, 2018,46(23):108-111.

[10] Zhang G J, Li H, Shao X Y, et al. Modeling and multi-objective optimization of medium-speed WEDM process[J]. Mechanical Science and Technology for Aerospace Engineering, 2015, 34(5):609-705.

[11] Teng K. Parameter optimization of Ti-6Al-4V alloy wire cutting process based on orthogonal test and BP neural network[J]. Manufacturing Automation, 2015,37(10):24-27.