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Experimental Research on D2 Mold Steel by WEDM

Wang Lei, Li Shan

Institute of Mechatronic Engineering, Lingnan Normal University, Zhanjiang 524048, China.

Abstract

In the process of D2 Mold Steel by WEDM, the effects of discharge parameters (processing current, pulse width, pulse interval) on surface roughness and material removal rate are analyzed. The experimental results show that the quality of the processed surface and the processing efficiency are a pair of mutually restrictive technical indicators, and it is necessary to select a suitable combination of discharge parameters in actual production.

Keywords

WEDM; D2 Mold Steel; Micro-morphology; Surface Roughness; Materical Removal Rate.

1. Introduction

D2 mold steel is a difficult-to-machine material with high hardness and toughness, which has good wear resistance and dimensional stability; after heat treatment, the hardness of the material can reach HRC60-62, and it is commonly used to produce parts with complex shapes by WEDM. The chemical composition of D2 mold steel is C:1.40～1.60%; Si:0.30～0.50%; Mn:0.30～0.50%; Cr:11.0～13.0%; V:0.80%; Mo:0.70～1.20%[1].

Some scholars use the method of Taguchi experiment to analyze the influence of machining parameters on different surface roughness and material removal rate in WEDM [2-6];Some scholars use specific algorithms to optimize WEDM parameters [7-10];Some scholars have studied the influence of WEDM on the micro-morphology and surface properties of machined surfaces [11-13].

In this paper, three groups of common and different discharge parameters (processing current, pulse width, pulse interval) are used to process D2 mold steel by WEDM. The effects of various discharge parameters on the surface roughness and material removal rate of the machined materials are observed and studied. The research results will provide technical reference for processing D2 mold steel by WEDM.

2. Experimental Work

2.1 Experimental materials

In the experiment, the D2 mold steel square bar with the sample size of 10×10 ×200mm was measured to have a hardness of HRC62 after heat treatment; all surfaces of the sample were processed to a surface roughness Ra0.8μm.

2.2 Experimental details

The diameter of molybdenum wire is φ0.12mm and the tension value is set to 10.0N; The D2 mold steel samples were processed by WEDM with different discharge parameters. The cutting thickness of the samples was 3mm, and then the samples were cleaned by ultrasonic for 20min to remove the stains and the attached corrosion on the surface of the samples. The sample clamping and processing are shown in Figure 1, and the discharge parameters are shown in Tables 1.

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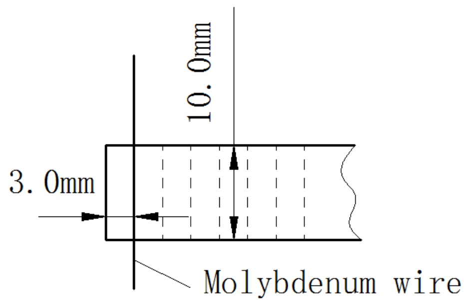

Fig.1 Processing schematic of WEDM

Tab.1 Different processing parameters

Processing current I（A）	Pulse width W（μs）	Pulse interval J（μs）	Processing voltage U（V）	Wire speed S（m/min）
0.5,1.0,1.5, 2.0,2.5,3.0, 3.5,4.0	12	6	80	13
1.5	4,6,8, 10,12,14,16,18	6	80	13
1.5	12	2,4,6, 8, 10,12,14,16	80	13

2.3 Measurement of surface roughness, micro-morphology and material removal rate

The surface roughness of the sample is measured by JIMtec TR200 surface roughness tester,the measuring range of the JIMtec TR200 surface roughness tester is 16μm, and the maximum scanning length is 17.5mm.The micro-morphology of the processed surface is observed by JEOL JSM-7610F scanning electron microscope with working voltage of 10kV.

The calculation formula of material removal rate is:

Material removal rate（$mm^2.min^{-1}$）= Processing cross-sectional area（mm^2）/ Processing time（min）

3. Results and discussion

3.1 Effect of different processing current on surface roughness and material removal rate

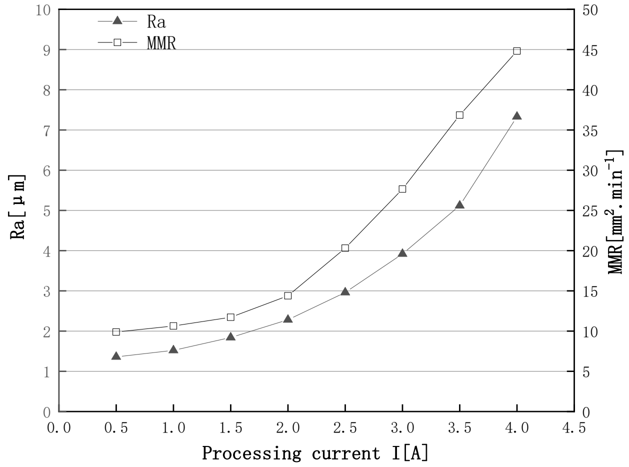

Fig.2 Surface roughness and materical removal rate with different processing current parameters

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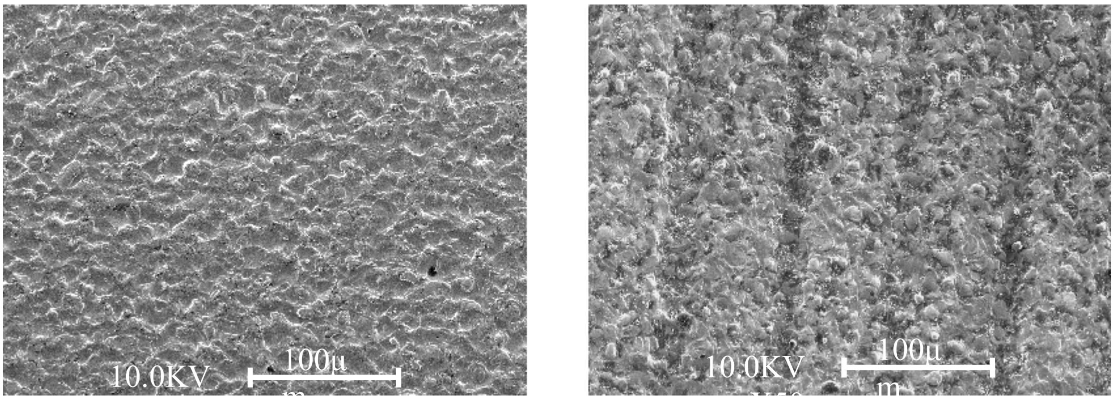
The processing current is an important factor that affects the performance of the processed surface of the material. The processing current increases, the pulse energy increases, the ability to erode the material per unit time increases, and the cutting speed is accelerated, but excessive current may easily cause processing instability and wire breakage. Under the experimental conditions of processing current 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0A; pulse width 12μs, pulse interval 6μs, after processing the surface roughness of the sample reaches Ra1.36, 1.52, 1.84, 2.28, 2.96, 3.92, 5.12, 7.33 respectively , showing an increasing trend, and the processing surface roughness increases obviously after the processing current is greater than 1.5A. The material removal rate reaches 9.88, 10.64, 11.72, 14.39, 20.31, 27.66, 36.85, 44.82mm^2 / min, and the surface roughness is basically consistent and showes an increasing trend, and the material removal rate increases obviously when the processing current is greater than 1.5A.

Fig. 3 (a) and (b) are scanning electron micrographs of the processed surface micro-morphology when the processing current is 1.0A and 3.5A respectively. It can be seen from the figure that the distribution of the electric pits on the processed surface is more uniform and orderly, and the surface roughness is better when the processing current is 1.0A .With the increase of the processing current, the pulse energy increases during processing, and the surface erosion phenomenon of the material is obvious. The high temperature generated by the high-frequency discharge of the electrode wire and the D2 mold steel sample vaporizes and dissolves the material surface to form compounds. Cooling and condensation under the action of the cooling fluid, a small part of the cladding forms a recast layer on the processing surface, and most of the fine particles that become erosion are discharged along with the cutting fluid;The greater the processing current, the more cladding on the surface, the greater the thickness of the recast layer, the more bumps and depressions on the surface, and the surface roughness becomes worse.



(a) **(b)**

Fig.3 The surface micro-morphology with different processing current parameters

3.2 Effect of different pulse width on surface roughness and material removal rate

The pulse width refers to the discharge time of the pulse power supply. When processing a thick workpiece, the pulse width can be increased according to the actual situation. Under the experimental conditions of processing current 1.5A, pulse width 4, 6, 8, 10, 12, 14, 16, 18 μs; pulse interval 6 μs, the surface roughness of the sample after processing reached Ra 1.51, 1.67, 1.72, 1.77, 1.84, 2.76, 3.92, 5.33 respectively , showing an increasing trend. The material removal rate reached 9.82, 10.32, 10.66, 11.03, 11.72, 12.42, 14.88, 19.21mm^2 / min, and the surface roughness was basically consistent with an increasing trend, and the material removal rate increased significantly after the pulse width was greater than 12μs.

Fig. 5 (a) and (b) are scanning electron micrographs of the processed surface micro-morphology when the pulse width is 12 μs and 18μs respectively.It can be seen from the figure that the processed surface has obvious ablation traces when the pulse width is 18 μs.This is because with the increase of pulse

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width, the energy of single pulse increases, the larger the pulse width, the more the surface cladding, the thickness of the recast layer, the more convex and concave the surface, and the coarser the surface The roughness becomes worse, but the effect of pulse width on the surface roughness is slightly smaller than that of processing current.

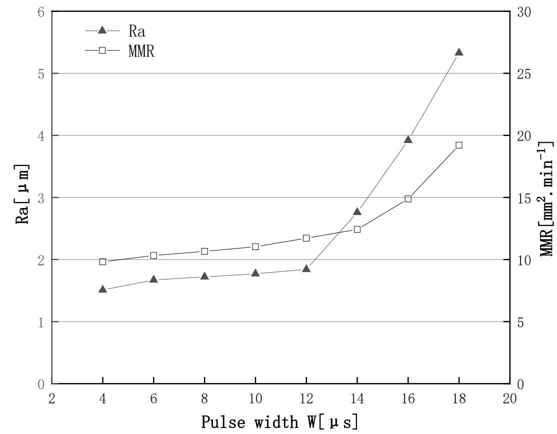
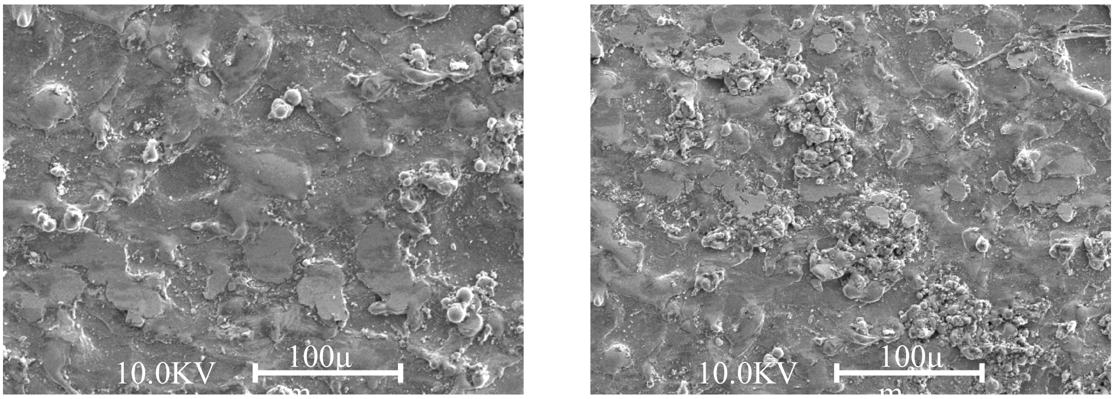


Fig.4 Surface roughness and materical removal rate with different pulse width parameters



(a) **(b)**

Fig.5 The surface micro-morphology with different pulse width parameters

3.3 Effect of different pulse interval on surface roughness and material removal rate

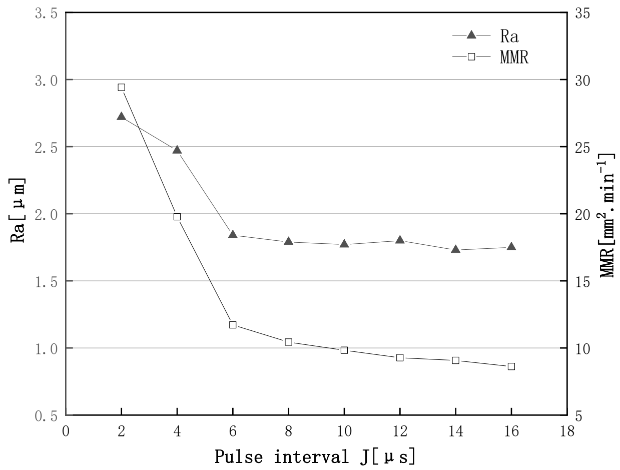


Fig.6 Surface roughness and materical Removal Rate with different pulse interval parameters

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The pulse interval is the pause time of the pulse, the pulse interval decreases, the cutting times increase and the cutting speed increases in unit time, but the pulse interval is too small, which is easy to burn the electrode wire and lead to wire breakage;And the pulse interval is too small, which is not conducive to the discharge of erosion, resulting in unstable processing;However, too much pulse interval will lead to discontinuous feeding and slow cutting speed.Under the experimental conditions of processing current 1.5A, pulse width 12μs; pulse interval 2,4,6,8,10,12,14,16μs, the sample surface roughness after processing reached Ra2.72,2.43,1.84, 1.79,1.77,1.80,1.73,1.75 respectively , showing a trend of decreasing first and then small fluctuations tending to be stable.The material removal rate reached 29.42, 19.77,11.72, 10.44,9.83,9.27,9.07,8.62 mm^2 / min respectively, showing a decreasing trend, and the material removal rate slowed down after the pulse interval was greater than 6 μs.

4. Conclusion

In processing D2 mold steel by WEDM, the discharge parameters directly affect the surface roughness and material removal rate.With the increase of processing current, the surface roughness and the material removal rate increase at the same time and the trend is similar; with the increase of pulse width, the surface roughness and material removal rate increase at the same time;With the increase of the pulse interval, the material removal rate shows a decreasing trend, and the surface roughness of the material decreases in the early stage after processing. The decreasing trend slows down after the pulse interval of 6 μs, and reaches the minimum value when the pulse interval was 6 μs. Slightly increased, with little change.

In the processing of D2 mold steel by WEDM, the degree of influence of the discharge parameters on the surface roughness from large to small is as follows: processing current, pulse width, pulse interval;The degree of influence of the discharge parameters on the material removal rate from large to small is as follows: pulse width, processing current, pulse interval.

The research results provide technical reference for the actual production of D2 mold steel processed by WEDM, and the appropriate discharge parameter combination can be selected according to different production requirements.

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