Academic Journal of Engineering and Technology Science

ISSN 2616-5767 Vol.3, Issue 6: 14-26, DOI: 10.25236/AJETS.2020.030603

Effect of Discharge Parameters on Surface Properties of A8 Tool Steel by Wedm

WANG Lei, LI Shan, HUANG Zhi-wei

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

ABSTRACT. *A8 tool steel is often used in wire electrical discharge machining (WEDM) to make various stamping dies and drawing dies. The discharge parameters of WEDM equipment affect the surface properties of materials after processing. In this paper, the surface properties of materials including surface hardness, surface roughness and friction factor are studied when the A8 tool steel is processed by different discharge parameters (processing current, pulse width, pulse interval). The results show that the influence of discharge parameters on the surface properties of materials processed are as follows: processing current >pulse width> pulse interval; to obtain a balanced processing surface quality, a combination of parameters of processing current 2.5A, pulse width 16μs, and pulse interval 8μs can be used.*

KEYWORDS: *Wedm, Tool steel, Discharge parameters, Surface property, Friction coefficient*

1. Introduction

Electrode wire (tungsten wire, tungsten molybdenum wire) is used as tool electrode in WEDM,under the action of high frequency pulse power supply, the spark discharge is formed between the tool electrode and the workpiece,and the high temperature is generated in the spark channel at the moment, which makes the surface of workpiece eroded, so as to achieve the purpose of material removal.

A8 tool steel is a kind of hard-to-process material with high hardness and toughness. In the mold manufacturing industry, WEDM is often used to process A8 tool steel to produce precision stamping die and drawing die with complex shapes. In the forestry industry, A8 tool steel is also often used for wood cutting tools. The chemical composition of A8 tool steel is C: 0.50-0.60%; P: < 0.03%; Si: 0.75-1.10%; Mn: 0.20-0.50%; s: < 0.03%; Cr: 4.75-5.50%; W: 1.00-1.50%; Mo: 1.15-1.65% [1].When the A8 tool steel is processed by WEDM, the change of the discharge parameters will affect the surface properties of materials such as surface hardness, surface roughness, surface morphology and friction coefficient, and the surface properties will directly affect the accuracy and service life of the mold.Many scholars have studied this issue in terms of the effect of WEDM on the surface properties of materials processed with different discharge parameters.

ISSN 2616-5767 Vol.3, Issue 6: 14-26, DOI: 10.25236/AJETS.2020.030603

Some scholars have studied the influence of discharge parameters on the material removal rate (MRR) and surface roughness (SR) in the process of WEDM of metal materials; and optimized the discharge parameters using the Taguchi experiment method to obtain the optimal parameter combination[2-13]. Some scholars have studied the discharge parameters on the micro-morphology of the processed surface of the material, modified layer, friction and wear characteristics[14-16].

In this paper, we will use WEDM to process A8 tool steel with different discharge parameters (processing current, pulse width, pulse interval), observe and study its influence on the surface performance of the material, and provide technical reference for WEDM to make A8 tool steel mold.

2. Experimental Work

2.1 Experimental Materials

The A8 tool steel with the size of 10×10×120mm is used in the experiment. The surface of all samples is processed by surface grinder, and the surface roughness reach Ra0.8μm

2.2 Experimental Details

The equipment is QC500 type machine produced by Sichuan Shenyang CNC Machinery Co., Ltd. The wire is molybdenum wire with diameter φ0.18mm and the tension value is set to 13.0N;The concentration of cutting fluid is 2wt%; A set of 4 samples are processed with different processing current, pulse width and pulse interval, clean the sample with ultrasonic for 30 minutes after processing. The surface hardness with different processing parameters is measured by hardness tester, and the surface roughness is measured by MarSurf PS1 surface roughness tester. The morphologies of the machined surface under different processing parameters is observed by JSM-7610F scanning electron microscope (SEM). The working voltage is 12.0KV.

The CFT-I material surface performance comprehensive tester produced by Lanzhou Zhongke Kaihua Technology Development Co., Ltd. is used to measure the friction and wear characteristics of the machined surface under different processing parameters, and the experiment was carried out under dry friction conditions by means of reciprocating friction. GCr15 steel ball with a diameter of 4mm is used in the equipment, the surface roughness of the steel ball is≤0.01μm. The experimental parameters are as follows: the load sensor is 200N; the load is 20N; the experimental time is 20min; the running speed is 300t /m; the reciprocating length and scanning length are set to 4mm; the sampling frequency is 1Hz; the measurement method is reciprocating friction. The friction coefficient of the machined surface was measured, and then the influence of different processing parameters on the surface morphology, mechanical properties and friction and wear properties of the sample is analyzed.

ISSN 2616-5767 Vol.3, Issue 6: 14-26, DOI: 10.25236/AJETS.2020.030603

The surface of sample 10×10mm is processed by WEDM with a processing depth of 4 mm; the clamping and processing diagram of sample is shown in Fig.1.

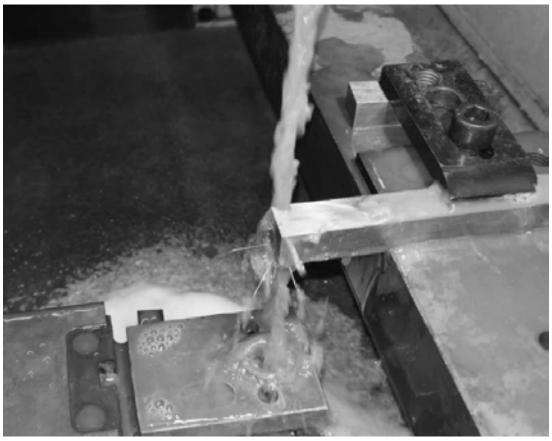


Fig.1 Processing Map of Wedm

Three sets of different discharge parameters(processing current, pulse width, pulse interval) are set on WEDM equipment to process A8 tool steel samples. The specific discharge parameters are shown in Table 1, 2 and 3. The surface hardness, surface roughness, surface morphology and friction coefficient of the processed samples are tested.

Table 1 Different Processing Current Parameters

No	processing current (A)	pulse width (μs)	pulse interval (μs)	Voltage (V)	Speed of the electrode wire (m/min)
1	1.5	16	16	100	12
2	2.5	16	16	100	12
3	3.5	16	16	100	12
4	4.5	16	16	100	12

Table 2 Different Pulse Width Parameters

No	processing current (A)	pulse width (μs)	pulse interval (μs)	Voltage (V)	Speed of the electrode wire (m/min)
5	2.5	8	32	100	12
6	2.5	16	32	100	12
7	2.5	32	32	100	12

ISSN 2616-5767 Vol.3, Issue 6: 14-26, DOI: 10.25236/AJETS.2020.030603

8	2.5	64	32	100	12

Table 3 Different Pulse Interval Parameters

No	processing current (A)	pulse width (μs)	pulse interval (μs)	Voltage (V)	Speed of the electrode wire (m/min)
9	2.5	16	4	100	12
10	2.5	16	8	100	12
11	2.5	16	12	100	12
12	2.5	16	16	100	12

3. Results and Discussion

3.1 Effect of Processing Current on Surface Properties of Materials

Processing current is an important factor affecting the surface properties of materials.With the increase of processing current ,the pulse energy increases, the ability of material removal per unit time increases, and the cutting speed increases. However, if the current is too large, the processing is unstable, and the wire breakage phenomenon occurs, so the appropriate processing current parameter should be selected.

Fig.2 is a line chart of the change of surface roughness and surface hardness of the sample after processing with a set of different processing current parameters shown in Table 1. It can be seen from the figure that in the process of cutting A8 tool steel by WEDM, with the processing current increases, the surface roughness and hardness of the surface increase, and the change is significant.

ISSN 2616-5767 Vol.3, Issue 6: 14-26, DOI: 10.25236/AJETS.2020.030603

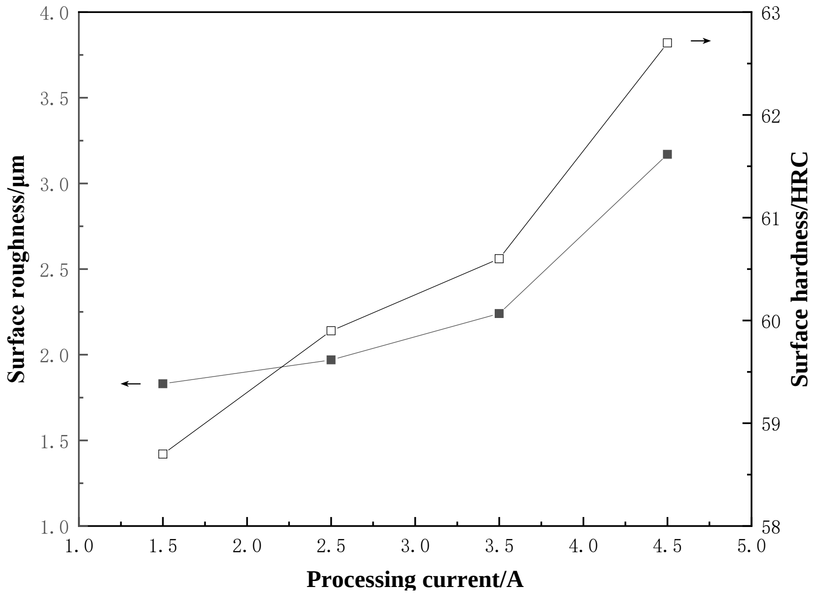


Fig.2 Surface Roughness and Hardness with Different Processing Current Parameters

Fig.3 is a comparison of the changes of the surface morphology of the samples processed by different currents. It can be seen from the figure, with the increase of processing current, the pulse energy increases, and the surface erosion phenomenon is obvious. The high temperature generated at the moment of high frequency discharge of electrode wire and A8 tool steel sample makes the material surface vaporize and dissolve to form compounds, which are cooled and condensed under the action of coolant, a small part of which is melted on the machining surface A recast layer is formed on the top of the layer, and most of the fine particles are discharged along with the cutting fluid; As the processing current increases, the amount of cladding on the surface increases, the thickness of the recast layer increases, and the number of bumps and depressions on the surface increases.

ISSN 2616-5767 Vol.3, Issue 6: 14-26, DOI: 10.25236/AJETS.2020.030603

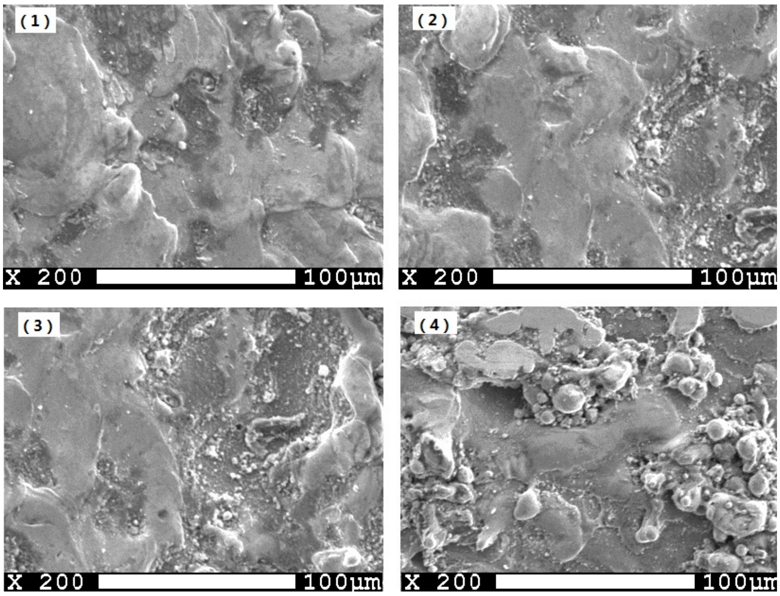


Fig.3 Sem Morphologies of the Surface with Different Processing Current Parameters

Fig. 4 is a graph showing the change of the friction factor of the surface processed by different currents. Due to the high temperature vaporization and re-cladding of the compound recast layer on the processed surface, when the friction and wear test was carried out, under the experimental conditions of 20N loading load, the When the currents are 1.5, 2.5, 3.5, and 4.5A, respectively, the friction coefficients of the processed surface are 0.88, 0.72, 0.60, and 0.52, respectively.

ISSN 2616-5767 Vol.3, Issue 6: 14-26, DOI: 10.25236/AJETS.2020.030603

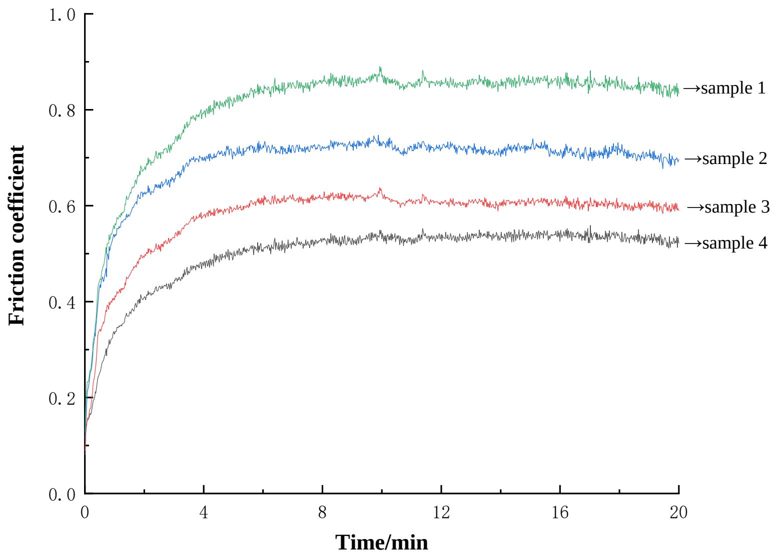


Fig.4 Curves of Friction Coefficient with Different Processing Current Parameters

3.2 Effect of Pulse Width on Surface Properties of Materials

Pulse width refers to the pulse power discharge time. When processing a thick workpiece, the pulse width can be increased according to the actual situation; Fig. 5 is a line chart of the surface roughness and surface hardness of the sample after processing the sample with a set of different pulse width parameters shown in Table 2. It can be seen from the figure that in the process of machining A8 tool steel by WEDM, when the pulse width increases, the discharge time increases, the pulse energy increases, the processing speed increases, the surface roughness and hardness increases, and the change is obvious, but less than the effect of the change of processing current on the surface roughness and hardness.

ISSN 2616-5767 Vol.3, Issue 6: 14-26, DOI: 10.25236/AJETS.2020.030603

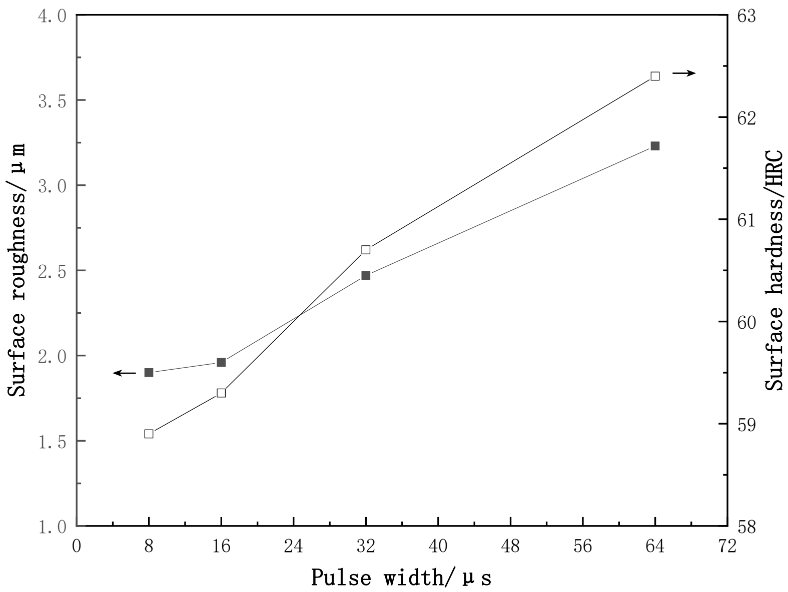


Fig.5 Surface Roughness and Hardness with Different Pulse Width Parameters

Fig. 6 is a comparison diagram of the changes of the surface morphology of the samples processed with different pulse width. It can be seen from the comparison diagram of surface morphology after machining, with the increase of pulse width, the energy of single pulse increases, and the pulse width increases, the more the surface is melted, the greater the thickness of the recast layer, and the more bumps and depressions are produced on the surface. However, the effect of pulse width on the surface morphology is less than that of processing current.

ISSN 2616-5767 Vol.3, Issue 6: 14-26, DOI: 10.25236/AJETS.2020.030603

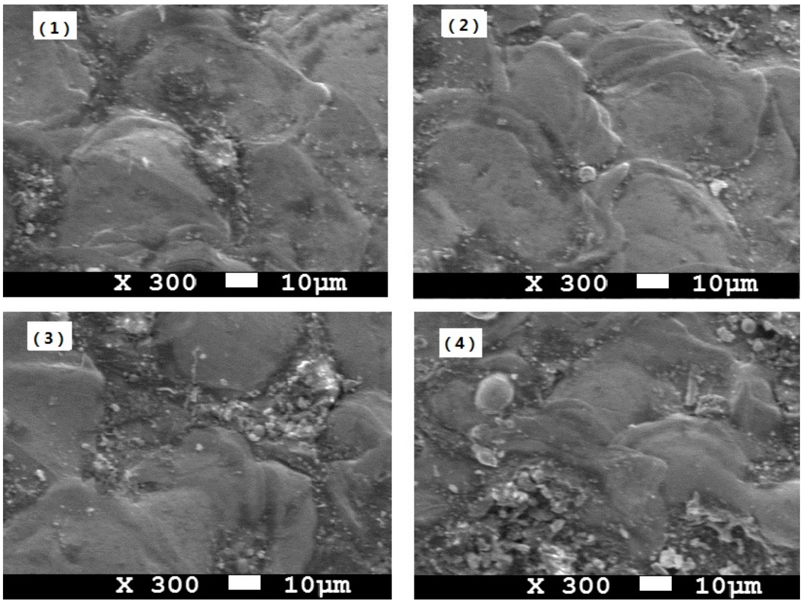
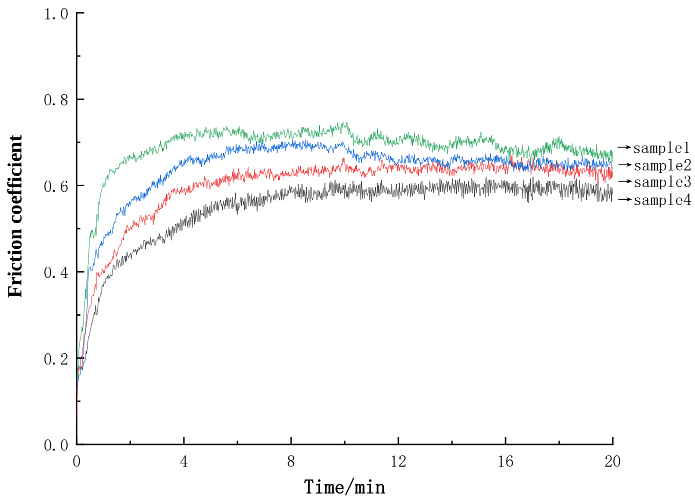


Fig.6 Sem Morphologies of the Surface with Different Pulse Width Parameters

Fig.7 is a graph of the change of friction coefficient of the surface processed with different pulse widths,during the friction and wear test, under the experimental conditions with a load of 20N. As the pulse width increases to 8, 16, 32, and 64 μs, respectively; The friction factors of the machined surfaces were 0.68, 0.64, 0.61, and 0.56, respectively, which decreased accordingly.



ISSN 2616-5767 Vol.3, Issue 6: 14-26, DOI: 10.25236/AJETS.2020.030603

Fig.7 Curves of Friction Coefficient with Different Pulse Width Parameters

3.3 Effect of Pulse Interval on Surface Properties of Materials

The pulse interval is the pulse rest time. Under certain conditions, the pulse interval decreases, the number of cuttings per unit time increases, and the cutting speed is accelerated, but the pulse interval is too small, the first knife is easy to ablate the workpiece and the electrode wire, and it is easy to cause wire breaking; And the pulse is too small, which is not conducive to the removal of erosion chips, resulting in unstable processing; If the pulse length is too large, the cutting speed will be slow and continuous feed will not be possible. Therefore, for small-sized and easy-to-process workpieces, the small pulse interval can be used appropriately; For workpieces with high machining difficulty and unfavorable chip evacuation, the pulse width can be enlarged appropriately. Set different pulse to pulse parameters on WEDM equipment to process A8 tool steel samples, the specific discharge parameters are shown in Table 3; Test the surface hardness, surface roughness, surface morphology, and friction factor of the sample after processing. The results are shown in Fig.8, Fig.9, and Fig.10.

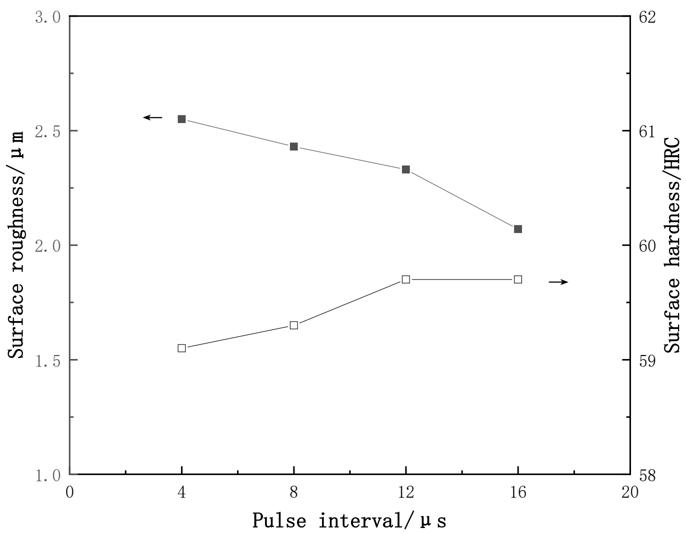


Fig.8 Surface Roughness and Hardness with Different Pulse Interval Parameters

ISSN 2616-5767 Vol.3, Issue 6: 14-26, DOI: 10.25236/AJETS.2020.030603

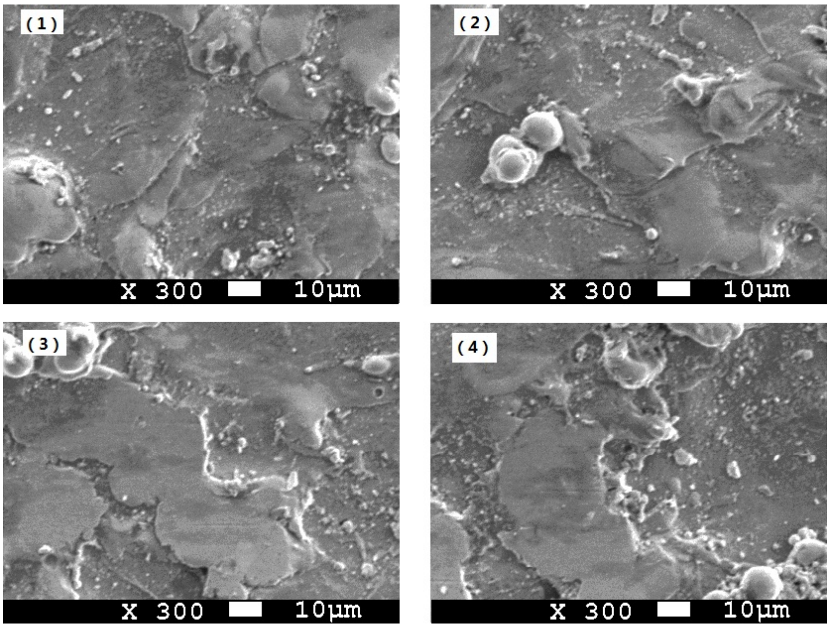


Fig.9 Sem Morphologies of the Surface with Different Pulse Interval Parameters

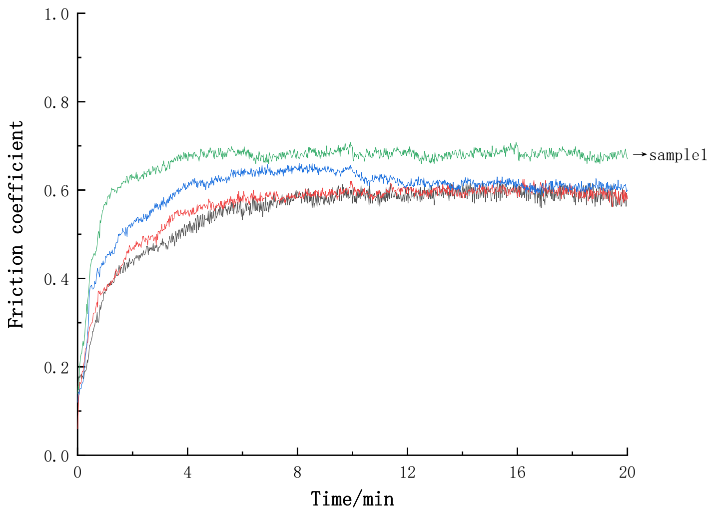


Fig.10 Curves of Friction Coefficient with Different Pulse Interval Parameters

ISSN 2616-5767 Vol.3, Issue 6: 14-26, DOI: 10.25236/AJETS.2020.030603

When the pulse interval increases, the discharge interval increases, and the machining erosion can be taken away by the emulsified coolant, so that the machining surface is smoother. From the experimental results, it can be seen that with the increase of the pulse interval, the machining surface roughness decreases The hardness does not change much; In the friction and wear experiment, when the load is 20N, the friction coefficient decreases with the increase of pulse width; The friction factor is 0.69 at 4 μs between pulses. The friction coefficient is 0.58 after the pulses increase to 8 μs, but as the pulses continue to increase, the friction coefficient hardly changes.

4. Conclusion

1. When machining A8 tool steel by WEDM, the selection of discharge parameters is very important, which has an important influence on its surface processing quality, surface morphology, mechanical properties, etc.

2. Among the three processing parameters, the change of processing current, pulse width and pulse interval, the change of processing current has the greatest influence on the surface performance of material processing, which shows that with the increase of processing current, the surface hardness and surface roughness of the processing surface increase, and the friction coefficient of the processing surface decreases; with the increase of pulse width, the surface hardness and surface of the processing surface With the increase of roughness, the friction coefficient of machined surface decreases, but the influence of pulse width on the surface performance is less than that of processing current; with the increase of pulse interval, the surface roughness of machined surface decreases, the surface hardness of machined surface slightly increases, and the friction coefficient of machined surface decreases; however, when the pulse interval is greater than 8 μs, the surface hardness hardly changes, and the friction coefficient of machined surface also changes slow down.

3. Considering the influence of three discharge parameters on the surface roughness, surface hardness, surface morphology and friction coefficient, the most balanced discharge parameters are obtained, which are processing current 2.5A, pulse width 16μs. and pulse interval 8μs.

References

[1] ASTM A681-08, Standard Specification for Tool Steel Alloy[S]. Annual Book of ASTM Standards, 2015.

[2] Bisaria, Shandilya.Experimental investigation on wire electric discharge machining (WEDM) of Nimonic C-263 superalloy[J]. Materials and Manufacturing Processes,2019,34(1): 83-92.

[3] 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.

ISSN 2616-5767 Vol.3, Issue 6: 14-26, DOI: 10.25236/AJETS.2020.030603

[4] Sujeet Kumar Chaubey,Shankar Singh,Abhishek Singh.Some investigations into machining of AISI D2 tool steel using wire electro discharge machining (WEDM) process[J]. Materials Today: Proceedings,2018,5(11): 24347-24357.

[5] Basil Kuriachen, K.P.Lijesh, P.Kuppan.Multi response optimization and experimental investigations into the impact of wire EDM on the tribological properties of Ti–6Al–4V[J]. Transactions of the Indian Institute of Metals, 2018,71(6): 1331-1341.

[6] 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.

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

[8] LIAO Y S. A study to achieve a fine surface finish in Wire-EDM[J].Journal of Materials Processing Technology,2004 149:165-171.

[9] Li X Z, Sun Y B, Xu J K, et al. Research on 304 stainless steel surface properties by wire electrical discharge machining [J]. Surface Technology, 2015,44(6):104-108.

[10] Ge X Y. The influence of electronic parameters of wire cutting machine on electronic index[J]. Machine Tool and Hydraulics, 2009,37(5):66-67.

[11] Xiaoyu Wu, Shujuan Li, Zhen Jia,et al.Using WEDM to remove the recast layer and reduce the surface roughness of WEDM surface[J]. Journal of Materials Processing Tech, 2019,268(6): 140-148.

[12] Wang Wei, Liu Zhidong, Shi Wentai,et al. Surface burning of high-speed reciprocating wire electrical discharge machining under large cutting energy[J]. The International Journal of Advanced Manufacturing Technology, 2016, 87 (9-12):2713-2720.

[13] Zhen Zhang, Wuyi Ming, Hao Huang, et al. Optimization of process parameters on surface integrity in wire electrical discharge machining of tungsten tool YG15[J]. The International Journal of Advanced Manufacturing Technology, 2015, 81 (5-8):1303-1317.

[14] Ding H J, Cui H, Zhang Z H, el al. Tribological properties of the micro-WEDM surface under dry friction and wear conditions[J]. Transactions of the Chinese Society for Agricultural Machinery, 2011,42(1):228-232.

[15] Cui H, Guo L B,Zhang B, el al. Tribological property comparison between micro-WEDM and superfinishing grinding machining surfaces[J]. Journal of Central South University (Science and Technology), 2013,44(9):3687-3692.

[16] K.Mouralova, J.Kovar, L.Klakurkova,et al.Analysis of surface morphology and topography of pure aluminium machined using WEDM[J]. Measurement, 2018,114(1): 169-176.