OPTIMIZATION OF PROCESSING PARAMETERS FOR CUTTING NI60-CR12MOV COATED DIE STEEL BY MS-WEDM

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Ni60-Cr12MoV coated die steel is a material specially used for manufacturing die inserts. It has high hardness and good wear resistance, but it is difficult to process. Using MS-WEDM (Medium-speed Wire cut Electrical Discharge Machining) to cut Ni60-Cr12MoV can effectively improve the surface quality and processing speed, and get better precision stamping parts. In this study, orthogonal test of cutting Ni60-Cr12MoV coated die steel was carried out on the MS-WEDM with the processing parameters use pulse width, inter-pulse, processing current and wire-speed as variables. Through the range analysis, it can be known that the processing current has the most significant effect on cutting speed and the pulse width has the most significant effect on surface roughness Ra. Cutting speed and surface roughness Ra are insensitive to the change of wire-speed. Cutting speed and surface roughness are a pair of contradictory indicators. It is necessary to use the comprehensive balance method to determine the optimal parameter combination in order to obtain the fastest cutting speed under certain surface roughness conditions. The experimental results show that the optimal parameter combination considering cutting speed and surface roughness Ra is as follows: pulse width 15μs, inter-pulse 60μs, processing current 8th gear, and wire-speed 2nd gear. Under this condition, the theoretical value of the process index is the surface roughness Ra can get 3.2μm, and the machining speed can get about 80mm^2/min. The results of the experiment and analysis in this paper solve the problem of selection and optimization of processing parameters, which is beneficial to improve the processing efficiency and quality of die inserts, and can provide a theoretical reference for actual production.

Keywords: WEDM, die steel, orthogonal test, processing parameters, range analysis, cutting speed, surface roughness.

1. Introduction

At present, Cr12MoV steel is widely used in the die industry [1]. It has high hardness, wear resistance and strength after quenching and tempering. It is generally used to produce various cold stamping dies with large section and complex shape. However, in the actual working environment, the surface damage at the corner of the die is serious. In order to improve the service life of the die on

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the premise of ensuring the stamping quality, the movable insert can be used at the corner of the die. The material selection and processing technology of movable insert has become a new focus in die research. The material of punch and die of stamping die has high hardness, and the corner insert in a stamping die is generally of through structure. The material can be Ni60-Cr12MoV coated die steel, its surface wear resistance is much better than Cr12MoV. WEDM (Wire cut Electrical Discharge Machining) has unique advantages in machining such hard metal materials [2]. The processing parameters of WEDM are important factors affecting material removal rate and surface roughness. Therefore, the study of processing parameters is of great significance. International scholars have done a lot of work on the experimental research of WEDM. For example, Guo Chongwen et al. [3] conducted cutting experiments on YG6 cemented carbide on a high-speed WEDM, and studied the effects of various electrical parameters (pulse width, inter-pulse, peak current and gap voltage) on cutting speed and surface roughness of cemented carbide. Yin Jingkai et al. [4] selected electrical parameters such as pulse width, inter-pulse, peak current and gap voltage on the high-speed WEDM, and conducted an experimental study on Cr12MoV with material removal rate and surface roughness as indicators. Wang Zhiyong [5] selected pulse width, inter-pulse, peak current, feed speed and other factors on the fast-spinning electric spark machine. An experimental study on HP-Si3N4 conductive ceramics was carried out. Jaafar N A et al. [6] selected pulse width, inter-pulse, peak current and servo voltage as parameter variables on the WEDM, and conducted cutting experiments on 2379 steel. Selvakumar G et al. [7] made experimental research on WEDM of 5083 aluminum alloy, the four technical parameters: pulse width, inter-pulse, peak current and wire tension, are optimized. The purpose is to get a set of optimal parameter combinations of the above four electrical parameters when machining 5083 aluminum alloy by WEDM, the surface roughness value is the smallest and the machining speed is the fastest. U.A.Dabade et al. [8] used Taguchi experiment, the effect of processing parameters on material removal rate, surface roughness, slit width and dimensional deviation was investigated, it was concluded that the most important processing parameter was pulse width. Yasir Nawaz et al. [9] Used Taguchi L27 orthogonal test, analysis of variance (ANOVA) is used to find the significant factor on each machining characteristic, while analysis of means (ANOM) of signal to noise (S/N) ratio is used to find the optimal value of factors for improving each machining characteristic. It is concluded that current intensity is most significant on MRR and SR, while pulse on time is most significant on kerf width. P mathan Kumar et al. [10] Established a surface roughness regression model including all input processing parameters. Optimized values were predicted using genetic algorithms. Predicted optimized value is compared with experimental value, and the closeness with obtained experimental value is stated interns of percentage. Monika Deshwal et al. [11] Machined H13 Steel Using WEDM. Four Parameters (T_{ON}, T_{OFF}, WF and voltage) are chose to consider its impact on cutting rate and surface harshness. Observations brings voltage is the most noteworthy boundaries on surface roughness where T_{ON} and T_{OFF} are less critical and also observed that material removal rate amplify with enhance in T_{ON} and WF and diminish on escalating of V_g and T_{OFF}. Mudassar Rehman et al. [12] Studied cutting DC53 steel with gamma phase coated wire, their work was performed to study the effect of machining variables like sparks on duration, sparks off duration, arc-on time, and servo voltage on response variables. Optimal set of machining parameters resulted in 14.02 % improvement in material removal rate and 19.24 % reduction in workpiece surface roughness. A Ramaswamy et al. [13] used the response surface method to optimize the WEDM processing parameters of D3 die steel. They carried out 52 experiments, and analyzed and graphical the experimental results using Minitab software. The results revealed that wire tension, current, and their interactions have significant effects on surface roughness, whereas, pulse on time and current have significant effects on material removal rate and also been observed that wire feed and interaction between current and pulse off time have significant effects on wire consumption rate. Mustafa Ay et al. [14] determined the best machinability of DIN 1.2316 plastic mold steel for wire EDM. The table feed rate, pulse on time and pulse off time are used as processing parameters. In order to optimize the wire discharge process, the gray relational analysis (GRA) optimization method is adopted. X Q Shen et al. [15] studied the machining quality and coating combination of WEDM after laser cladding composite coating on Ti6Al4V titanium alloy surface. the results show that we can obtain the ideal processing quality. There are micro－cracks and micro－pits on the surface of the coating. The cladding coating is dense and well－bonded with the matrix metallurgy. The WEDM undestroyed the coating structure by laser cladding technology. Although scholars from all over the world have done a lot of research on WEDM, there are few reports on the processing of Ni60-Cr12MoV coated die steel by MS-WEDM (Medium-speed Wire cut Electrical Discharge Machining). MS-WEDM can not only cut parts multiple times, but also cut quickly. The microscopic mechanism of MS-WEDM is complex, and there are many influencing factors. Due to the increase in the number of cuts in the multiple cutting process, the process requirements and the requirements for the machine tool and the operator are also higher than a single cutting, so the research on the multiple cutting process is difficult to deepen. In this paper, only a single cutting in MS-WEDM is tested, the pulse width, inter-pulse, processing current and wire-speed were selected as processing parameters, and study the effect of processing parameters on cutting speed and surface roughness Ra.

2. Test conditions and methods

Many factors that affect the technical indexes of MS-WEDM, and the adjustable range is extensive. If the technical scheme of the comprehensive tests are adopted to optimize the technical parameters, the workload is enormous. Because the orthogonal test has obvious orthogonality, obvious representativeness and obvious comprehensive comparability, the optimized result has high reliability [16]. Based on the principle of orthogonal test, partial tests can be used instead of all tests, which can significantly reduce the workload of tests. Therefore, the experimental research of this paper adopts the orthogonal test method as the research plan to optimize the processing parameters [17].

2.1. Experimental equipment.

The test material used in this study is Cr12MoV steel coated with Ni60 powder. The coating technique is plasma spray welding. The process parameters used in spray welding are the current 110A, the spray welding speed 70mm/min, the powder feeding voltage 10V, and the distance between the nozzle and the workpiece surface is 10mm. The size of the test material is 200mm×30mm×20mm, and a total of 8 identical test materials are produced. Two specimens can be taken from each piece of material. As shown in Fig.1.

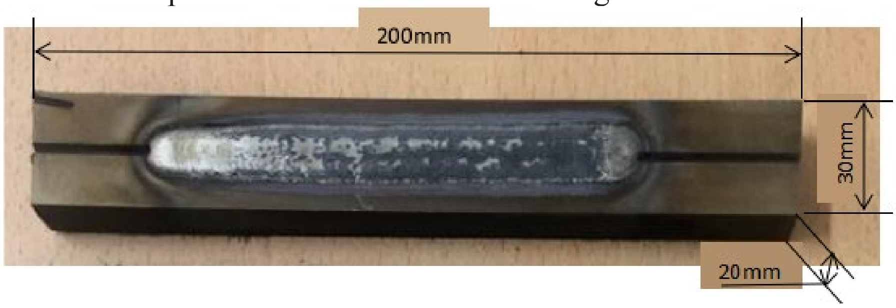

Fig. 1. Test material

The experiment was carried out on DK7732Z MS-WEDM is shown in Fig.2. The cutting fluid is JR2A water-based composite working fluid with a ratio of 1:15, and is filtered by a circulating filtration system with paper filter factors during processing. The electrode wire used in the test is Ø0.18mm molybdenum wire, a total of 16 samples were extracted, and each specimen was cut into a cube of 10mm×10mm×10mm. As shown in Fig.3. Cutting speed is the ratio of cutting area to cutting time under each orthogonal test, and surface roughness is the average value measured by selecting the same three positions on the cutting surface under each orthogonal test using TR210 hand-held roughness measuring instrument (Fig.4).

Fig. 2. MS-WEDM

Fig. 3. Cube specimens

Fig. 4. TR210 hand-held roughness measuring instrument

2.2. Orthogonal test design.

Since the cutting speed and the surface roughness Ra are two target parameters that are inversely proportional, the cutting speed index is generally pursued on the premise of satisfying the processing quality.

The selected process parameters are briefly described as follows: The pulse width refers to the duration of the voltage pulse across the discharge gap. As the pulse width increases, the energy of a single pulse increases, and the larger the discharge pit, the rougher the surface. However, when the pulse width increases to a critical value, the processing stability will become worse, thus affecting the processing speed. Inter-pulse refers to the time interval between two voltage pulses. When the inter-pulse decreases, the pulse frequency will increase, the number of discharges per unit time will increase, the energy will increase, and the processing speed will increase. However, the inter-pulse should not be too small. Generally, the inter-pulse should be more than twice the pulse width, otherwise it will affect the discharge and deionization of galvanic corrosion products, resulting in unstable processing. The processing current refers to the instantaneous maximum value of the pulse current during the gap spark discharge. It is an important parameter that affects the processing speed and surface quality. As the current increases, the energy of a single pulse increases, and the larger the discharge pit, the rougher the surface. However, when the current increases to a certain critical value, the processing stability will become worse, which will affect the processing speed and even cause wire breakage. The wire-speed refers to the linear speed of the electrode wire. If the wire-speed is too high, it will increase the consumption of the electrode wire, increase the vibration of the electrode wire, reduce the cutting speed, and increase the cutting cost; however, if the wire-speed is too slow, the wire will be broken.

According to the orthogonal test method, the factor level table is constructed.

Table 1

Factors and levels of a single cutting

level	A: pulse width (μs)	B: inter-pulse (μs)	C: processing current (gear)	D: wire-speed (gear)
1	15	30	5	1
2	20	40	6	2
3	25	50	7	3
4	30	60	8	4

The values of processing current and wire-speed in Tab.1 only represent the corresponding gear, not the actual values of parameters, as the gear position increases, the actual value of the corresponding parameter becomes larger. For example, selecting 1st, 2nd, 3rd and 4th gear of wire-speed means that the actual wire-speed is 1.3m/s, 3m/s, 6m/s, and 12m/s, respectively.

According to the test factors and level values listed in Tab. 1, we can draw up the test scheme by using $L_{16}(4^4)$ orthogonal table, and fill in pulse width (A), inter-pulse (B), processing current (C) and wire-speed (D) in the table respectively. The measured results of the following 16 experiments are filled in Tab.2 of orthogonal test results.

Table 2

Results of primary cutting orthogonal test

No.	A	B	C	D	Cutting speed (mm^2/min)	Surface roughness Ra (μm)
1	1	1	1	1	40.52	2.356
2	1	2	2	2	45.42	2.867
3	1	3	3	3	50.71	2.404
4	1	4	4	4	48.36	2.951
5	2	1	2	3	74.21	3.167
6	2	2	1	4	46.33	3.056
7	2	3	4	1	74.43	3.983
8	2	4	3	2	55.81	3.162
9	3	1	3	4	87.05	4.277
10	3	2	4	3	93.30	4.329
11	3	3	1	2	47.96	3.373
12	3	4	2	1	55.64	3.601
13	4	1	4	2	96.37	4.667
14	4	2	3	1	82.35	4.742
15	4	3	2	4	64.20	4.120
16	4	4	1	3	42.56	4.003

3. Analysis and discussion of test results

3.1. Range analysis of orthogonal test

In any experiment, the influence of each factor on the experimental index is usually different. In order to find out the relationship between each factor and the index, grasp the change law between the index and the factor, and determine the optimal level of each factor, the range analysis method can be used. The basic principle of the range analysis method is to use the magnitude of the range to determine the degree of influence of each factor [18]. The formula for calculating the range R is: $R=\mu_{max}-\mu_{min}$

In the formula: R is the range of each influencing factor; μ_{max} is the maximum value of the mean value of each factor under the three levels; μ_{min} is the minimum value of the mean value of each factor under the three levels.

According to the test results in Tab.2, considering the effect of pulse width, inter-pulse, processing current and wire-speed on cutting speed, the range analysis table of cutting speed is constructed. The value of K is the sum of test data at a particular level. K-avg value is the corresponding average value; The best level is the level number corresponding to the best K-avg value when a particular factor; R is the range of factors. As shown in Tab.3:

Table 3

Range analysis table of cutting speed

Item	Level	A	B	C	D
K-value	1	185.01	298.15	177.37	252.94
	2	250.78	267.40	239.47	245.56
	3	283.95	237.30	275.92	260.78
	4	285.48	202.37	312.46	245.94
K-avg value	1	46.25	74.54	44.34	63.24
	2	62.70	66.85	59.87	61.39
	3	70.99	59.33	68.98	65.19
	4	71.37	50.59	78.12	61.48
R		25.12	23.94	33.77	3.80

If a particular factor has more significant effect on the test index, the greater the range R-value of this factor is. As to the cutting speed, according to the comparison of the ranger in Tab.3, $R_C>R_A>R_B>R_D$, so the order of the effect of the four factors on the cutting speed is: processing current > pulse width > inter-pulse > wire-speed.

To more intuitively see the changing trend of the effect of each level of each factor on the cutting speed, draw the trend diagram of the effect relationship between the K-avg value of each factor and the cutting speed, as shown in Fig.4.

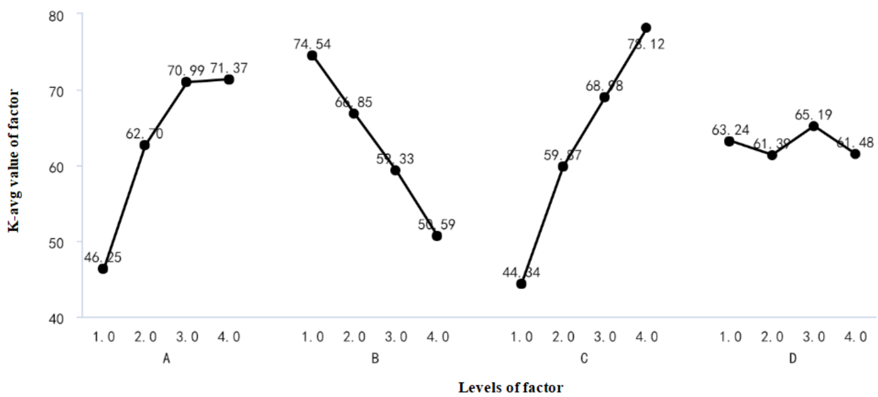

Fig. 4. Trend of effect relationship between K-avg value and cutting speed.

The higher the cutting speed, the higher the processing efficiency. According to the direct observation in Tab.2, the value of the test index of the 13th test combination is the largest, and the cutting speed of the test scheme

A4B1C4D2 is the largest among all the test combinations, and its value is 96.37 mm^2/min. However, whether this experimental scheme is the best combination of various factors still needs further study. So, for the optimal levels of factors A, B, C and D in Tab.3, the maximum value of K-avg should be selected. It can be seen from Fig.4 that the optimal level of factor a is level 4; The optimal level of factor B is level 1; The optimal level of factor C is level 4; The optimal level of factor D is level 3. Therefore, the optimal parameter combination among various factors is A4B1C4D3. And it can be seen that the most significant increase or decrease of these factors is factor C, followed by factor A, factor B and factor D is the least significant. Therefore, the primary and secondary order affecting cutting speed can be indirectly reflected.

Table 4

Range analysis table of surface roughness

Item	Level	A	B	C	D
K-value	1	10.58	14.47	12.79	14.68
	2	13.37	14.99	13.75	14.07
	3	15.58	13.88	14.59	13.90
	4	17.53	13.72	15.93	14.40
K-avg value	1	2.64	3.62	3.20	3.67
	2	3.34	3.75	3.44	3.52
	3	3.89	3.47	3.65	3.48
	4	4.38	3.43	3.98	3.60
R		1.74	0.32	0.79	0.19

About surface roughness Ra, it can be concluded from Tab.4 that $R_A>R_C>R_B>R_D$, so the order of factors affecting surface roughness Ra of Ni60-Cr12MoV coated die steel specimen is pulse width > processing current > inter-pulse > wire-speed.

To more intuitively see the changing trend of the effect of each level of each factor on surface roughness Ra, draw the trend diagram of the effect relationship between the K-avg value of each factor and surface roughness Ra, as shown in Fig. 5.

The smaller the surface roughness Ra value, the smoother the surface and the higher the surface quality. According to the direct observation in Tab.2, the value of the test index of the first group of test combinations is the smallest; that is, the surface roughness Ra of the test scheme A1B1C1D1 is the smallest among all test combinations, and its value is 2.356μm. However, whether this group of experimental schemes is the best combination of various factors still needs further study.

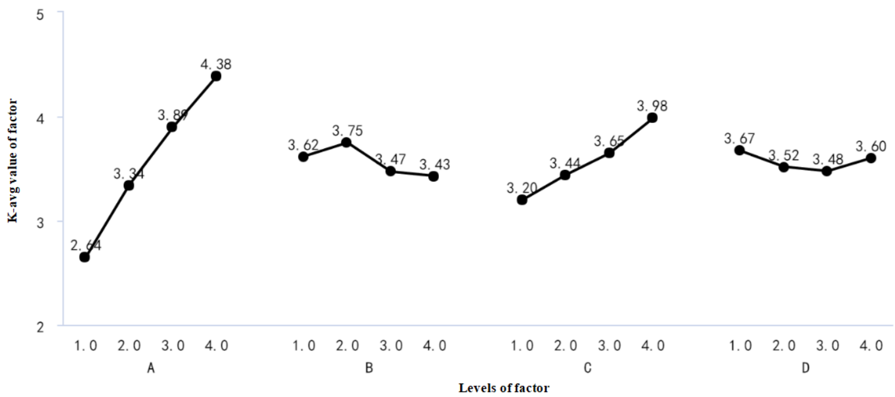

Fig. 5. Trend of effect relationship between K-avg value and surface roughness Ra

For the optimal levels of factors A, B, C and D in Tab.4, select the minimum value of K-avg. It can be seen from Fig.5 that the optimal level of factor A is level 1; The optimal level of factor B is level 4; The optimal level of factor C is level 1; The optimal level of factor D is level 3. Therefore, the optimal parameter combination among all factors is A1B4C1D3. And it can also be seen that the most significant increase or decrease of these factors is factor A, followed by factor C, factor B and factor D is the least significant. Therefore, the primary and secondary order of influencing surface roughness Ra can be indirectly reflected.

3.2. Discussion of test results

The results are obtained by direct observation and range analysis of cutting speed and surface roughness Ra, it can be concluded that in the orthogonal test of cutting speed, the results obtained by direct observation and range analysis are inconsistent, and the optimal parameter combination obtained by direct observation is A4B1C4D2, but the optimal parameter combination obtained by range analysis is A4B1C4D3. In the orthogonal test of surface roughness Ra, the results obtained by direct observation and range analysis are also inconsistent. The optimal parameter combination obtained by direct observation is A1B1C1D1, but the optimal parameter combination obtained by range analysis is A1B4C1D3. Because this paper studies four factors, and each factor has four levels, 256 sets of experiments are needed if comprehensive experiments are conducted. Therefore, to obtain the best results in all experiments, two more comparative tests are required.

Table 5

The results of these two comparative tests

Experimental combination	Cutting speed	surface roughness Ra	optimal combination
A4B1C4D3	97.51 mm^2/min		Yes
A4B1C4D2	96.37 mm^2/min		
A1B4C1D3		2.309 μm	Yes
A1B1C1D1		2.356 μm	

When the test target is the maximum cutting speed, the result obtained by the range analysis parameter combination A4B1C4D3 is compared with the result obtained by the direct observation parameter combination A4B1C4D2, and the maximum value is taken as the optimal solution. When the test target is the minimum value of surface roughness Ra, the minimum value is the optimal solution by comparing the results obtained by the range analysis parameter combination A1B4C1D3 with the results obtained by the direct observation parameter combination A1B1C1D1. As shown in Tab.5, Obviously, according to the range analysis, the surface roughness Ra value of the optimal parameter combination A4B1C4D3 is larger than that of the parameter combination A4B1C4D2 obtained by direct observation. According to range analysis, the surface roughness value of the optimal parameter combination A1B4C1D3 is smaller than that of the parameter combination A1B1C1D1 obtained by direct observation.

The cutting speed and surface roughness Ra of the specimen are singnificant indexes in the processability of WEDM, and they are also a pair of contradictory indexes. However, the range analysis method can't get the optimal test scheme for both cutting speed and surface roughness Ra of the specimen.
The single cutting described in this paper, the problem to be solved is how to find the fastest cutting speed under particular roughness according to the results of the orthogonal test. Therefore, it is necessary to use the comprehensive balance method to determine the optimal parameter combination and predict the process goal that the optimal process parameters can achieve: Theoretical values of cutting speed and theoretical values of surface roughness Ra.

The comprehensive balance method is a method that starts from the overall process goal and coordinates the relationship between different process parameters in terms of numerical selection, so as to achieve multiple process goals.In the work of multi-objective optimization, the comprehensive balance method can be used as a simple and effective reference method. Comprehensive balance is a global balance, not a single, local balance.Therefore, a single process target can be used as a reference for balance in specific operations to ensure its correctness.

In the influencing factors of cutting speed, we can see $R_C>R_A>R_B>R_D$. So the order of effect of the four factors on cutting speed is: processing current >

pulse width > inter-pulse > wire-speed. In the influencing factors of surface roughness, the order of effect of four factors on Ra is $R_A>R_C>R_B>R_D$. Therefore, the order of factors affecting the surface roughness of Ni60-Cr12MoV coated die steel specimens are pulse width > processing current > inter-pulse > wire-speed. According to China's national surface roughness standard, the surface roughness Ra value of wire cutting can be divided into six levels of 2.0, 2.5, 3.2, 4.0, 5.0, 6.3 μm to meet the requirements of use. Under the premise of meeting a particular level of surface roughness Ra value, from the two optimal parameter combinations in Table 5, we will select the optimal processing parameters again according to the significance of the effect of all factors on the surface roughness Ra and the cutting speed.

A factor has the most significant effect on surface roughness Ra. still, it has a minor effect on cutting speed, so the A1 level should be selected according to the requirement of minimum surface roughness Ra. B factor has little effect on cutting speed and surface roughness Ra, so B4 level is determined according to the requirement of minimum surface roughness Ra. C factor has the most significant effect on cutting speed, the effect on surface roughness Ra is slight, so the C4 level should be selected according to the requirement of maximum cutting speed. D factor has no apparent effect on surface roughness Ra and cutting speed, so the D3 level can be chosen according to the maximum requirement of cutting speed. Therefore, the optimal combination parameters that can comprehensively consider the requirements of surface roughness Ra and cutting speed are A1B4C4D3, pulse width 15μs, inter-pulse 60μs, processing current 8th gear,wire-speed is 2nd gear. The theoretical values of the process index that can be achieved by this set of parameters are the surface roughness Ra can reach 3.2μm, and the cutting speed can reach about $80mm^2/min$.

To verify the reliability of the optimization results, the cutting test was completed again on the optimized processing parameters under the same conditions. The test results show that the optimized method is reliable; the theoretical value and the measured value have high consistency in the surface roughness Ra index. Although the processing speed index is quite different, it conforms to the rule. Under this test condition, the verification results of theoretical and measured values of several processing parameters optimized based on the orthogonal test are shown in Tab.6.

Table 6

The theoretical values and measured values of process indexes that can be achieved by several processing parameters

S/N	A	B	C	D	Actual cutting speed.	The theoretical value of cutting speed.	The actual value of surface roughness.	Theoretical value of surface roughness.	Roughness standard	remark
1. (A4B1C4D3)	30	30	8	3	97.51	110	4.337	4.7	5.0	The fastest. cutting speed
2. (A1B4C1D3)	15	60	5	3	53.26	62	2.309	2.5	2.5	Minimum surface roughness.
3. (A1B4C4D3)	15	60	8	3	70.17	80	3.112	3.2	3.2	Optimal parameter combination

The results are obtained from the three sets of processing parameters in Tab.6, which further confirms the characteristics of the wire cutting machine tool.Use high-speed cutting for roughing and low-speed cutting for finishing. In this way, the operation will be stable and the jitter will be small. The deformation of the material will be reduced by multiple cuttings, and the processing quality will be relatively improved. The processing quality can be between the high-speed wire feeder and the low-speed wire feeder.

For the first cutting, use high processing current and long pulse width for high current cutting to obtain higher cutting speed. Adopt high-speed wire feeding to achieve maximum processing efficiency (A4B1C4D3).For the second cutting, use medium parameter values, and limit the feed speed within a certain range to eliminate the round-trip cutting stripes and obtain the required machining dimensional accuracy (A1B4C4D3).For the third cutting, the minimum pulse width is used to trim the workpiece, and the processing current varies with the quality of the machined surface, which can be appropriately adjusted to obtain a better surface quality (A1B4C1D3).

4. Conclusion

In this paper, Ni60-Cr12MoV coated die steel is machined by MS-WEDM. The effects of processing parameters on the two processing indexes of cutting speed and surface roughness are studied, and a group of parameter combinations are optimized to optimize the two performance indexes. The following work has been carried out:

(1) The experimental research on optimizing the processing parameters of the MS-WEDM based on the orthogonal experiment method is an effective method. The experimental results achieved by the process parameters optimized by the comprehensive balance method have been verified to be reliable.

(2) In the single cutting, the order of effect of four factors on cutting speed is: processing current > pulse width > inter-pulse > wire-speed, and the order of effect of four factors on surface roughness Ra is: pulse width > processing current > inter-pulse > wire-speed. In the process of cutting, the wire-speed can be appropriately reduced.

(3) Under the experimental conditions, the processing parameters of the maximum cutting speed are pulse width 30μs, inter-pulse 30μs, processing current 8th gear, and wire-speed 3rd gear. If it is the first cut of multiple cuts by the MS-WEDM, it is suggested that these processing parameters can be used. If it is the final cutting process, the corresponding processing parameters can be adapted according to the technical requirements of surface roughness Ra of parts drawing. If the surface roughness Ra must be ≤ 2.5μm, the following options can be selected: pulse width 15μs, inter-pulse 60μs, processing current 5th gear, and wire-speed 3rd gear.

(4) The optimal combination parameter considering the requirements of surface roughness Ra and cutting speed is A1B4C4D3, pulse width 15μs, inter-pulse 60μs, processing current 8th gear, and wire-speed 2nd gear. The theoretical values of the process index that can be achieved by this set of parameters are: the surface roughness Ra can get 3.2μm, and the machining speed can get about 80mm^2/min.

With the rapid development of manufacturing industry, WEDM will comply with the development of the times and meet the requirements of high precision, high hardness and high complexity. Due to time constraints, there are still more problems to be explored, and the following work needs to be carried out in the future:

For the arrangement of orthogonal test factors, the influence of the interaction between electrical parameters on surface roughness and cutting speed should also be considered. In addition to the two performance indexes of cutting speed and surface roughness considered in WEDM, other performance indexes, such as residual stress and change of metallographic structure, should be deeply discussed.

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