Optimization for Welding Parameters of Magnetic Media Box based on Orthogonal Experiment

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Abstract. In The magnetic media box of the magnetic separator is used as the research object, because at present the argon arc welding speed and the welding quality of the magnetic media box are relatively low, so the orthogonal test is used to optimize the welding technology of the magnetic media box. According to the characteristics of magnetic media box welding technology, the influence of welding current, arc voltage and welding speed on the tensile strength of magnetic media box is investigated. By experimenting and recording the experimental results, then using the range analysis method to analyze the experimental results to determine the optimal combination of welding process parameters. The reliability of the test results is proved by experiments. Finding the law of welding process parameters affecting the tensile strength of magnetic media boxes. It provides reference for TIG.

1. Introduction
The reasonable setting of welding parameters of TIG has great influence on the welding quality of magnetic media box. In previous productions, the choice of welding process parameters based on experience or inquiries on welding manuals was often too conservative due to safety considerations. The choice of optimum welding process parameters was not achieved, and the welding quality of magnetic media boxes was also reduced, and the production efficiency could not be guaranteed. The optimization of welding process parameters is a key technology to ensure the quality of magnetic media boxes, improve processing efficiency, and reduce production costs.
In this paper, the orthogonal test is used to optimize the parameters, and the calculation is small. At the same time, it can meet the quality requirements of the optimized processing and it is easy to promote in actual production\cite{1}.

2. Selection of experimental indicators and factor levels
In this paper, the parameters of argon arc welding are optimized, and the main requirement of magnetic media box is the connection strength of magnetic rod and magnetic plate. Because when the magnetic separator is working, the magnetic media box is used to sift iron powder from iron ore, and the selected iron powder will be washed out by high-pressure water, thus the screening of iron ore will be realized. In the long-term operation, due to the friction of iron powder, the impact and corrosion of high-pressure water will cause the magnet bar to fall off from the magnetic plate, thereby affecting the beneficiation quality and efficiency. At present, the method of detecting the quality of the weld is to analyze the microstructure, phase composition and mechanical properties of the weld by means of metallographic microscope and X-ray diffractometer. The mechanical properties mainly consider the tensile strength and hardness of the weld. The greatest influence on the overall welding quality of the...
magnetic media box in the detected microstructure characteristics and mechanical properties of the weld is the tensile strength of the weld. Therefore, ensuring the tensile strength at the joint between the magnetic plate and the magnetic bar of the magnetic media box is a key factor to ensure the quality of the magnetic media box. By analyzing the mechanical and technical requirements of the magnetic media box, it must be ensured that the tensile strength of the weld seam of the media box is greater than 240 MPa[2].

The structure of the magnetic media box is shown in Figure 1. Both the magnetic plate and the magnetic bar are nickel-iron alloy. The purpose of this machining is to weld both ends of the magnet to the magnetic plate. The thickness of the magnetic plate is 3 mm and the magnetic bar is 3 mm in diameter. The test of tensile strength is shown in Figure 2.

![Figure 1. Magnetic media box](image1)

![Figure 2. Tensile strength test](image2)

The welding method of magnetic media box adopts argon arc welding, welding process parameters mainly include welding current, welding speed, arc voltage, argon flow, tungsten electrode diameter, welding gun angle, etc[3]. There are many process parameters affecting the welding quality of the media box, and many process parameters have little effect on the welding quality. After reviewing the relevant literature and field tests, this paper selects three influencing factors of welding current, arc voltage, and welding speed[4], and examines its influence on the tensile strength of magnetic media boxes. Consider the actual welding situation, select five levels for each factor to study. The specific level values are shown in Table 1.

| Factors                | Unit   | Levels |
|------------------------|--------|--------|
| Welding current (A)    | A      | 160 180 200 220 240 |
| Welding speed (B)      | mm/s   | 14 16 18 20 22 |
| Arc voltage (C)        | V      | 12 14 16 18 20 |

Table 2. experimental scheme

| Test number | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 |
|-------------|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| A           | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2   | 2   | 2   | 2   | 2   | 2   | 2   | 2   | 2   | 2   | 2   | 2   | 2   | 2   | 2   | 2   |
| B           | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5   | 1   | 2   | 3   | 4   | 5   | 1   | 2   | 3   | 4   | 5   | 1   | 2   | 3   | 4   | 5   |
| C           | 1 | 2 | 3 | 4 | 5 | 2 | 3 | 4 | 5 | 1   | 3   | 4   | 5   | 1   | 2   | 4   | 5   | 1   | 3   | 2   | 5   | 1   | 2   | 3   | 4   |

3. Select orthogonal table

The orthogonal table is a pre-prepared form by mathematicians, which has the outstanding advantages of uniform dispersion and uniformity. The general orthogonal table format is $L_{N}(q')$. In this paper, the
factors of A, B and C are selected, and each factor has five levels, so the degree of freedom is $f_A = f_B = f_C = 5 - 1 = 4$. Therefore, the orthogonal test of this paper is arranged 25 times. According to the above discussion, $L_{25}(5^3)$ orthogonal table is selected in this paper [5].

### Table 3. Factor Level Table

| Experiment times | Welding current (A) | Welding speed (B) | Arc voltage (C) | Tensile strength (MPa) |
|------------------|---------------------|-------------------|-----------------|------------------------|
| 1                | 160                 | 14                | 12              | 185                    |
| 2                | 160                 | 16                | 14              | 220                    |
| 3                | 160                 | 18                | 16              | 238                    |
| 4                | 160                 | 20                | 18              | 231                    |
| 5                | 160                 | 22                | 20              | 203                    |
| 6                | 180                 | 14                | 14              | 193                    |
| 7                | 180                 | 16                | 16              | 216                    |
| 8                | 180                 | 18                | 18              | 223                    |
| 9                | 180                 | 20                | 20              | 211                    |
| 10               | 180                 | 22                | 12              | 183                    |
| 11               | 200                 | 14                | 16              | 210                    |
| 12               | 200                 | 16                | 18              | 201                    |
| 13               | 200                 | 18                | 20              | 247                    |
| 14               | 200                 | 20                | 12              | 218                    |
| 15               | 200                 | 22                | 14              | 207                    |
| 16               | 220                 | 14                | 18              | 205                    |
| 17               | 220                 | 16                | 20              | 217                    |
| 18               | 220                 | 18                | 12              | 223                    |
| 19               | 220                 | 20                | 16              | 212                    |
| 20               | 220                 | 22                | 14              | 207                    |
| 21               | 240                 | 14                | 20              | 181                    |
| 22               | 240                 | 16                | 12              | 192                    |
| 23               | 240                 | 18                | 14              | 214                    |
| 24               | 240                 | 20                | 16              | 209                    |
| 25               | 240                 | 22                | 18              | 207                    |

### Table 4. Range Analysis

| Test number | Column number | 1  | 2  | 3  | Tensile strength (MPa) |
|-------------|---------------|----|----|----|------------------------|
| 1           | 1             | 1  | 1  | 1  | 190                    |
| 2           | 2             | 1  | 2  | 2  | 200                    |
| 3           | 3             | 1  | 3  | 3  | 210                    |
| 4           | 4             | 1  | 4  | 4  | 210                    |
| 5           | 5             | 1  | 5  | 5  | 185                    |
| 6           | 6             | 2  | 1  | 2  | 190                    |
| 7           | 7             | 2  | 2  | 3  | 210                    |
| 8           | 8             | 2  | 3  | 4  | 213                    |
| 9           | 9             | 2  | 4  | 5  | 211                    |
| 10          | 10            | 2  | 5  | 1  | 183                    |
| 11          | 11            | 3  | 1  | 3  | 225                    |
| 12          | 12            | 3  | 2  | 4  | 211                    |
| 13          | 13            | 3  | 3  | 5  | 247                    |
| 14          | 14            | 3  | 4  | 1  | 228                    |
| 15          | 15            | 3  | 5  | 2  | 217                    |
| 16          | 16            | 4  | 1  | 4  | 210                    |
| 17          | 17            | 4  | 2  | 5  | 217                    |
| 18          | 18            | 4  | 3  | 1  | 213                    |
| 19          | 19            | 4  | 4  | 3  | 212                    |
| 20          | 20            | 4  | 5  | 2  | 207                    |
| 21          | 21            | 5  | 1  | 5  | 190                    |
| 22          | 22            | 5  | 2  | 1  | 192                    |
| 23          | 23            | 5  | 3  | 2  | 204                    |
| 24          | 24            | 5  | 4  | 3  | 209                    |
| 25          | 25            | 5  | 5  | 4  | 207                    |

| K1          | 995           | 1005 | 1006 |
| K2          | 1007          | 1030 | 1018 |
| K3          | 1128          | 1087 | 1066 |
| K4          | 1059          | 1070 | 1051 |
| K5          | 1002          | 999  | 1050 |
| k1          | 199           | 201  | 201.2 |
| k2          | 201.4         | 206  | 203.6 |
| k3          | 225.6         | 217.4 | 213.2 |
| k4          | 211.8         | 214  | 210.2 |
| k5          | 200.4         | 199.8 | 210  |

**Range:** 26.6 - 17.6, **12**

**Excellent solution:** A3 B3 C3

### 4. Design header of orthogonal test and make experiment plan

The final design of the orthogonal table is shown in Table 2. According to the 25 sets of data proposed in the above table [6], this paper uses a 400A welding power source to weld 25 magnetic media boxes. Measure the magnetic media box tensile strength. The measurement results are recorded in Table 3, and the resulting orthogonal test data is shown in Table 3.

### 5. Range analysis of Multifactor Orthogonal Experiments

The range analysis method is the most commonly used method for analyzing the results of orthogonal experiments. The excellent level and excellent combination of experimental factors can be obtained through the range analysis of tensile strength. Also, it was found that each factor influences the strength of tensile strength. The range analysis table is calculated as shown in Table 4.
According to the analysis of table 4, the welding current size has the greatest influence on the tensile strength of the magnetic media box, the welding speed is the second and the arc pressure is the smallest. The higher the tensile strength, the higher the quality of the magnetic media box, so the optimal level of the process parameters is welding current 200A, welding speed 18mm/s, and arc voltage 16V.

6. Verify the results of orthogonal experiments

According to the experimental results, new welding process parameters were used to weld 5 magnetic media boxes. Then the tensile strength of the magnetic media box is calculated, as shown in table 5.

| Table 5. Magnetic Media Box Experiment Results |
|-----------------------------------------------|
| Product | 1   | 2   | 3   | 4   | 5   |
| tensile strength (MPa) | 263 | 257 | 271 | 264 | 266 |

From the above table, it can be seen that the welding quality of magnetic media boxes has been significantly improved. To achieve the purpose of this experiment.

7. Conclusion

This article orthogonal test is a three-factor five levels. The results show that when the welding current is 200A, the welding speed is 18mm/s, and the arc voltage is 16V, the magnetic media box has the highest tensile strength and satisfies the technical requirements. The optimization objective of this paper is the tensile strength of magnetic dielectric box, and its optimization experiment can be popularized, and its research idea also provides reference for relevant researches.

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