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QUALITY STUDY ON LASER WELDING 304 STAINLESS SHEET

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High automation, high speed and high efficiency are the advantages of laser welding metallurgical products. It is a great significance to study the quality of laser welding. In the paper, the input current and pulse width of laser are used as variables to improve the tensile strength of welding samples. Firstly, the effect of current and pulse width on tensile strength is obtained through experiments. Then the fitting formula and cureve of experimental data are obtained by orthogonal regression method. Finally, the prediction and optimization of tensile strength are carried out, and the error of the results is less than 12,5 %, indicating that they have a certain guiding role.

Key words: 304 stainless, sheet, laser welding, current, tensile strength

INTRODUCTION

304 austenitic stainless steel has good toughness, ductility and high mechanical strength. Comparable to mild steel, it has good corrosion resistance in most environments. This type of steel is widely used in metallurgical equipment, support structures, pressure vessels and other fields [1-2]. As an advanced welding technology, laser welding is playing an increasingly important role in high precision, high efficiency and high-quality welding. Because laser welding uses high energy laser beam as welding heat source, which has the advantages of heat concentration, easy control of heat source, narrow heat affected zone, small welding stress and welding deformation [3-4]. This paper mainly studies the influence of laser welding process on welding quality to find out the welding process law for stainless steel welding manufacturing to provide a theoretical basis.

Figure 1 Laser welding machine

EXPERIMENTAL MATERIALS AND EQUIPMENT

The stainless steel specification used in the experiment is 100 mm×30 mm×2 mm. The experimental equipment is JHM-1GY-300 laser welding machine. Laser wavelength is 1,06 μm. The average rated power of laser is 300 W. Laser pulse frequency is 1~100 Hz. Laser pulse width is 0,1~20 ms. The focal length of the focus lens is 160 mm. The spot diameter is 1~3 mm. As shown in Figure 1. The model of the tensile test prototype is WEW-1000. The maximum force of the parameter is 1 000 kN, as shown in Figure 2.

Figure 2 Tensile testing machine

Y.X. Chen, L. Gao, School of Applied Technology, University of Science and Technology, Liaoning, Anshan, Liaoning China;
Y.X. Chen (Email:chenyuxianglkd@163.com)

EXPERIMENTS

Different laser parameters were used to weld stainless steel plate in the experiment. The welding sample is shown in Figure 3. Then a tensile test machine was used to break the welded sample, and the tensile force curve was obtained, as shown in Figure 4.

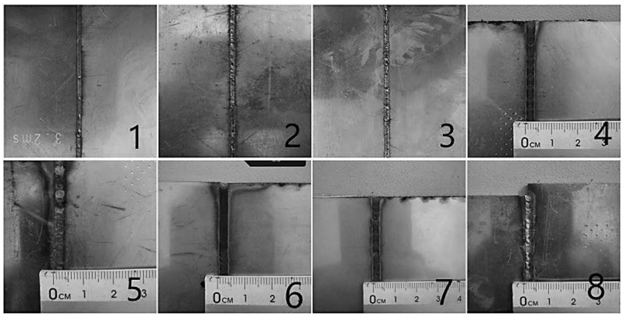

Figure 3 Laser welding sample

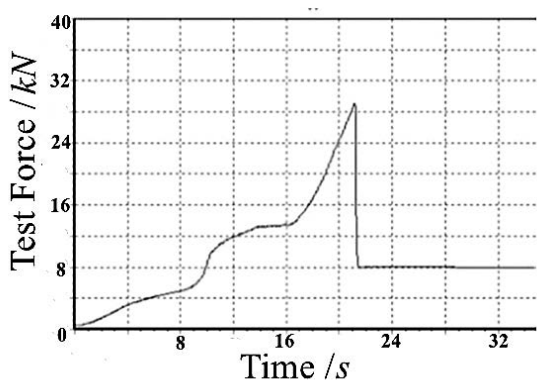

Figure 4 Test force curve of sample 1

As shown in Figure 4, the maximum tensile force can be obtained, and the corresponding tensile strength can be calculated, as shown in Table 1.

Table 1 **Sample parameters**

Factor / No.	Current /A	Pulse /ms	Tensile strength /MPa
1	380	3,2	484
2	380	3,4	517
3	380	3,6	558
4	300	4,5	345
5	300	5	448
6	300	5,5	532
7	315	5	458
8	330	5	475

According to Table 1, the tensile strength increases with laser pulse width, as shown in Figure 5. Because the larger the pulse, the longer the molten pool generated by laser irradiation, the better the metal metallurgy bonding effect, so the tensile strength is improved.

As shown in Figure 5, the larger the laser pump source input current, the higher the laser intensity, the better the quality of laser welding. Higher tensile strength can be obtained with a smaller pulse width. This can be verified from Figure 6. Under the same

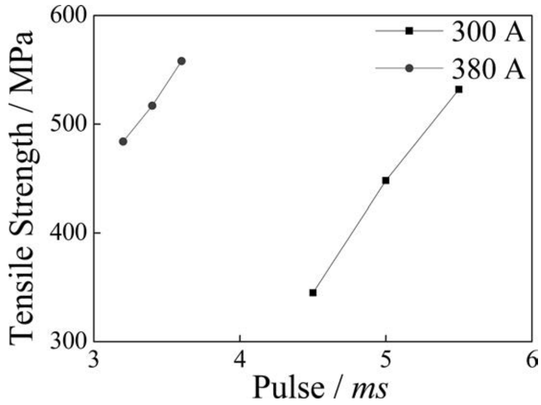

Figure 5 Laser pulse and tensile strength

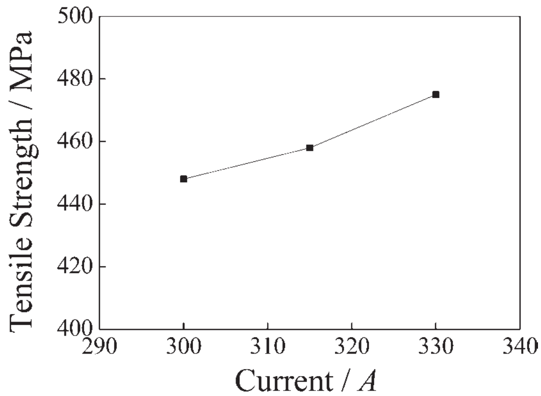

Figure 6 Current and tensile strength

pulse width, the tensile strength of the sample increases with the increase of current.

OPTIMIZATION

Binary quadratic regression orthogonal design table was used for experiments, as shown in Table 2.

Table 2 **Orthogonal experiments**

Factor / No.	Current /A	Pulse /ms	Tensile strength /MPa
1	380	5	684
2	380	3	467
3	300	5	458
4	300	3	245
5	383	4	588
6	297	4	302
7	340	4,1	448
8	340	3,9	425
9	340	4	442
10	340	4	435

By fitting the data shown in Table 2 with binary quadratic regression equation, the relationship between current A and pulse width B and tensile strength y is:

$$y = 611{,}74 - 4{,}66A - 20{,}2B + 0{,}025AB + 0{,}011A^2 + 10{,}45B^2 \quad (1)$$

According to Formula (1), the effect of pulse width B on tensile strength Y is higher than that of current A. The fitting curve is shown in Figure 7.

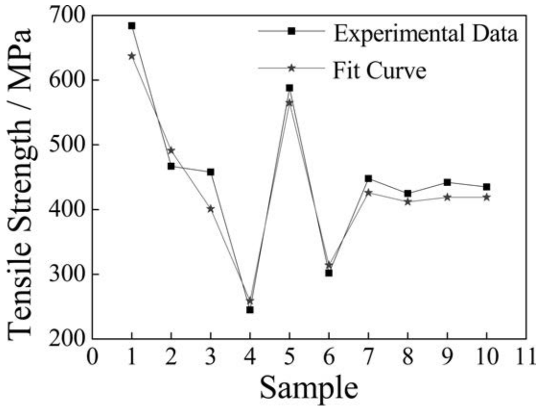

Figure 7 Fit curve

It can be seen from Figure 7 that the trend of the fitting curve is relatively consistent with the experimental data, and the maximum error is less than 12,5 %.

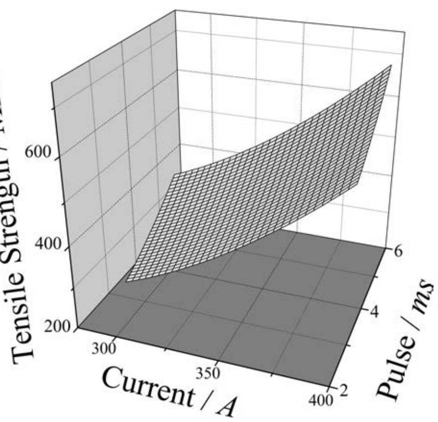

Figure 8 Response surface

Formula (1) can be used to simulate and predict the experimental results. The surface response method was used to optimize the tensile strength, as shown in Figure 8. As can be seen from Figure 8, the tensile strength increases with the increase of current and pulse width. Therefore, within the value range of current and pulse width, the maximum tensile strength is predicted to be 702 MPa, at which time the current is 383 A and the pulse width is 5 ms. The actual tensile strength is 690 MPa. This shows that the surface response method has a certain guiding role in the optimization of tensile strength.

CONCLUSIONS

The experimental results show that the tensile strength increases with the increase of current (297 A~383 A) and pulse width (3 ms~5 ms). The fitting formula of orthogonal regression equation can guide the prediction of tensile strength, and the maximum error is less than 12,5 %. The optimal process parameters, such as current 383 A, pulse width 5 ms and tensile strength 690 MPa, can be obtained by using the surface response method, which is far higher than the tensile strength of the material itself.

Acknowledgements

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Note: The responsible translator for English language is Y.X. Chen, Anshan, China.