F. B. CHANG, Y. GAO, L. GAO, L. Y. HUANG

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STUDY ON LASER WELDING OF DUAL PHASE STEEL

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In this paper, Neodymium-doped Yttrium Aluminum Garnet crystal laser welding machine is used to study the laser welding process of dual phase steel. The electric current, pulse width and frequency are selected as variables for welding, and the maximum force of weldment under different parameters is detected by tensile testing machine. Through the analysis of the experimental results, find out the influence of different parameters on the welding quality, select the best welding parameters. The analysis shows that the current has the most significant effect on the welding quality, followed by the frequency, and the pulse width has almost no effect.

Keywords: dual phase steel, laser welding, electric current, frequency,quality

INTRODUCTION

Automobile lightweight is a research hotspot in the field of manufacturing industry. High strength steel is the most effective method for automobile lightweight [1]. Dual phase steel has the advantages of good matching of strength and plasticity, high work hardening rate and good formability, so it is widely used in automobile body manufacturing and parts production [2].

Laser welding is widely used in high strength steel plate, which has been studied by scholars at home and abroad. The results show that with the increase of pulse power, the amount of depression in weld zone, weld penetration and weld width increase gradually, and the full penetration weld can be obtained when the pulse power is 75W or above. As the laser focus moves down into the work piece, the upper part of the weld becomes narrower and shorter, the number of pores in the weld decreases significantly, and the size of the heat affected zone does not change significantly. There is no softening zone in the weld, the tensile strength of the weld can reach the base metal level, and the impact toughness of the welded joint can reach 85,6 % of the base metal[3].

In conclusion, the laser welding quality of dual phase steel is very good. In this paper, yttrium aluminum garnet crystal pulse laser is used for laser welding of dual phase steel. The hydraulic tensile compression testing machine is used for tensile test [4]. The primary and secondary factors affecting the welding quality and the best process parameters are found, which will provide the basis for the optimization of the process parameters of laser welding dual phase steel [5].

F. B. Chang, Y. Gao:gy5520444@sina.com, L. Y. Huang, School of applied technology, University of Science and Technology Liaoning, Anshan, China
L. Gao: School of science, University of Science and Technology Liaoning, Anshan, China

EXPERIMENTAL MATERIALS AND METHODS

The experimental steel plate is hc340 / 590 dual phase cold-rolled dual phase steel produced by Shanghai Baoshan Iron and Steel Co.Ltd., with thickness of 1,0 mm and processing dimensions of 100 mm × 60 mm. The chemical composition of the materials is given in Table 1.

Table 1 **Chemical composition of HC340/590 dual phase steel / wt.%**

C	Mn	P	Si	S	Cr	Fe
0,15	2,5	0,04	0,6	0,015	0,02	Bal

Figure1 shows the metallographic microstructure of the material, which is composed of ferrite and martensite.

Experimental methods

Use wire cutting equipment to cut 6 cm nearly consistent end face of dual phase steel, and polish to en-

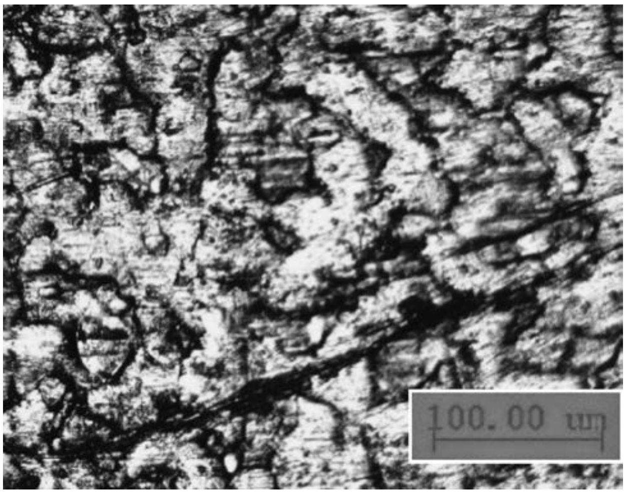

Figure 1 The microstructure of experimental materials

sure the consistency of each weld. Using JHM-1GY-400D laser welding machine produced by a company, the main parameters include: laser wavelength: 1,06 μ m; extinction ratio of yttrium aluminum garnet crystal 32 dB; rated average laser power 400 W; laser pulse frequency: 1-100 Hz (adjustable); laser pulse width: 0,1-20 ms (adjustable); pump lamp current: 50-200 A (adjustable). The machining path of 5cm straight line is drawn by the software CNC 2 000 of the machine, the two pieces of dual phase steel are butted and clamped by self-made fixture, and the red light indication is calibrated for many times. The machining speed is 500 mm / min, and the defocusing amount is positive 0,86 mm.

Table 2 **Experiment's results**

Serial number	Frequency /Hz	electric current /A	Pulse width /ms	Maximum force /kN
1	10	110	1,0	15,3
2	10	120	1,2	9,25
3	10	130	1,4	11,2
4	12	110	1,2	13,5
5	12	120	1,4	10,4
6	12	130	1,0	7,95
7	14	110	1,4	18,1
8	14	120	1,0	13,9
9	14	130	1,2	12,6

The three process parameters are frequency, current and pulse width. Each parameter is set to which different value, here 9 groups of test parameters are used for laser welding. Then, the maximum force of 9 groups can be measured by hydraulic tensile testing machine, and the results are shown in Table 2. The primary and secondary factors of each parameter and the best process parameters are analyzed. Finally, two groups of tensile tests of the best process parameters are carried out to verify the results, which have certain reference significance.

Analysis of experiment results

Use the hydraulic tensile testing machine to measure the maximum force that the weld can bear. The measurement results are shown in the last column of Table 2. It can be seen from Table 2 that the influencing factors of weld quality are current, frequency and pulse width in turn. The best parameters of the seventh group were frequency 14 Hz, current 110 A and pulse width 1,4 ms.

Variance analysis was used to verify the significance of the influence of each parameter on welding quality. Here we use the following concepts: sum of squares of deviation (SS), degree of freedom (f), degree of freedom of error (FE), and their mean square deviation (MS). Finally, F value is the evaluation index of ANOVA. F value is the ratio of mean square deviation and error of corresponding factors, and the calculation results are shown in Table 3.

By analyzing the F value of frequency, current and pulse width, it can be seen that the current and frequency have significant influence on welding quality, and the significance of current is greater than that of frequency, while pulse width has no significant influence on welding quality.

Table 3 **Variance analysis of weld quality**

	Sum of deviation square SS	Mean square error MS	F value	Significance
Frequency	28,46	14,23	12,82	**
electric current	45,67	22,83	20,57	***
Pulse width	3,12	1,59	1,43	
Error column	2,22	1,11		

In order to prove the accuracy of the results, it carried out two groups of experiments with the best parameters. The maximum force that the weld can bear is 20,35 kN and 17,55 kN respectively. The welded joint consists of weld zone, heat affected zone and base metal zone near the heat affected zone. The fracture is often in the range of heat affected zone after several tensile tests under the optimum parameters. The metallographic structure of the weld under the optimal parameters is shown in Figure 2. There are many molten materials in the weld pool, clear local pits and obvious slag splashing during welding. Because there is no welding wire or the temperature is too high in the welding process, the weld material is slightly gasified, and the weld surface is obviously depressed. Under the optimal parameters, the weld is mostly martensitic structure, so the weld strength is larger.

In the tensile test, the weld section with the best parameters has a certain ductility. As shown in Figure 3.

Because the length of weld is 50 mm and the thickness of steel plate is 1 mm, the original cross-sectional area of sample can be calculated as 50 mm^2. The tensile strength is 373,334 MPa. The tensile strength of this brand of dual phase steel is 590 MPa, so the tensile strength of laser welding of single-sided dual phase steel can reach 63,3 % of the base metal.

Figure 2 The Metallographic of welding line under optimal parameters

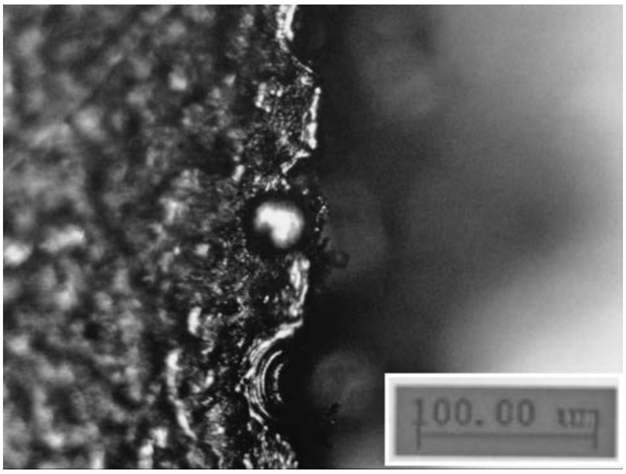

Figure 3 The tensile fracture of welding line under optimal parameters

CONCLUSION

In this paper, Neodymium-doped Yttrium Aluminum Garnet crystal laser welding machine is used to weld dual phase steel the conclusion is as follows: Through the experimental analysis, it can be concluded that the influence of current on welding quality is more significant than that of frequency, and the pulse width has little effect. The best parameters are: current 110 A, frequency 14 Hz, pulse width 1,4 ms. The average tensile strength is 373,334 MPa, which is 63,3 % of the base metal. Through continuous experiments, we believe that we will get better laser welding parameters.

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Note: The responsible translator for English language is L. Y. Huang, Anshan, China