Study on Laser Welding Technology of PC Plastic

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ABSTRACT

For the PC plastic laser welding, the equipment system and welding requirements were designed. The fixture was used to press the PC plastic for laser welding. The color of the PC were designed that the up layer was white, and the lower was black, so the up layer absorbed laser energy and melt in the plastic contact surface, forming a welding area. Then the orthogonal optimization experiment was designed under the laser power, defocusing distance and the welding speed. It finally obtained the optimum process parameters that the welds was without bubble and space. The further tensile test results showed that the tensile strength increased with the increase of the welds width, the tensile strength reached to the top when the welds width was 1.2 mm.

INTRODUCTION

As an alternative of metal materials, plastics had been widely used in industrial manufacture and daily life, including aircraft, locomotives and electronic products [1-3]. The connection methods of plastic products mainly included mechanical connection, adhesive bonding and welding. The welding method which done not only need to increase product weight but also done not need to use glue, was very environmental [4-6].

Plastic welding mainly adopted the way of ultrasonic welding and laser welding. Laser welding which with high precision, small heat affected zone and non-contact with the work-piece, could realize soft process by the conduction between high energy optical fiber and laser, it was easy to achieve production automation [7-8]. However, there were still a lot of problems in the process of plastic laser welding, such as the limited type, the limited choice of color and sensitive to impurities inside the plastic [9-10].

In this paper, for the requirements of PC plastic welding, designed optimum welding technology parameters, and got the optimum parameters according to the tensile test results.

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EQUIPMENT SYSTEM AND WELDING REQUIREMENTS

The Structure of the System

The whole laser welding system comprised semiconductor laser, scanning vibrating mirror, focusing lens, motion control board, manual Z shaft lifting platform and fixture for clamping the plastic plates, the whole mechanism structure was shown in figure 1. The operation process of the fixture was as follows: cylinder remains retracted - draw out fixture pull block-- place product module -- pull block push-- cylinder stretch --move upward the product and press together (to ensure the joint pressure) with the press plate (transparent glass) - start welding (cylinder offer pressure that was adjusted by air valve, the buffer limit bolt adjust limit (accuracy 0.1mm).

![Figure 1. Schematic diagram of the temperature feedback laser.](image)

Welding Products and Requirements

Plastic laser welding was two kinds of clamped plastic and suffers laser irradiation, cross a plastic product, and then absorbed by another product, products that absorb laser energy convert optical energy into heat energy, melt and freeze in the plastic contact surface, forming a welding area. Plastic laser welding was not only selective for the type of material, but also the color, PC plastic was a thermoplastic material, so in theory, the laser can be welded by laser. The best color match of the material was that the up layer was light transparent material, the lower layer was light absorbing material. In this paper, the up layer of PC material was white, 0.2 mm, the lower was black (add some certain mass ratio of carbon black before plastic injection), 0.2mm, using lap connection, the material was shown in Figure 2.

![Figure 2. PC plastic materials.](image)
EXPERIMENT METHODS AND RESULTS

Orthogonal Experiment and Results

The laser power, welding speed and defocusing distance (distance between the laser focal point and the surface work-piece) were main factors that affect laser plastic. While keeping other factors unchanged, the above three factors were tested by orthogonal experiment, parametric design of the orthogonal experiment was shown in table 1, the welding result standard was penetration, and whether there were marks behind the lower layer and air bubble in the weld. The results of the table showed that test number 5, 7, 8 were qualified products.

| number | Laser power/W | Welding speed/mm*s⁻¹ | defocusing distance/mm | Penetration condition | Air bubble |
|--------|---------------|-----------------------|------------------------|-----------------------|-----------|
| 1      | 20            | 5                     | 0                      | complete              | yes       |
| 2      | 20            | 10                    | 2                      | complete              | yes       |
| 3      | 20            | 15                    | 4                      | incomplete            | no        |
| 4      | 40            | 10                    | 2                      | complete              | yes       |
| 5      | 40            | 15                    | 4                      | complete              | no        |
| 6      | 40            | 5                     | 0                      | complete              | yes       |
| 7      | 60            | 15                    | 2                      | complete              | no        |
| 8      | 60            | 5                     | 4                      | complete              | no        |
| 9      | 60            | 10                    | 0                      | complete              | yes       |

Tensile Strength Experiment

In order to further test the tensile strength of the welding joints, standard tensile test specimens were made and tested by the tensile machine. The strength of number 5 was 9 kg, number 7 was 12 kg, number 8 was 6 kg, the process parameters in Number 7 was optimal, which of that power was 60W, welding speed was 15mm/s, the defocusing distance was 4mm. Then had a further experiment of the weld width, the weld width of number 5, 7, 8 was 0.5mm, 1.1mm 1.8mm respectively. The diameter of the fiber core was 200 microns, accurate direct lens focal length was 50mm, focusing lenses focal length was 150mm, so the theoretical focus spot was 0.6mm, when the weld width was 2 times of the theoretical focus spot, the tensile strength was maximum. When the weld width was consistent with the theoretical focus spot size, the contact area of the upper and lower layer was smaller, so the...
tensile strength was lower. Therefore, to achieve the best tensile strength and appearance effect, the ratio between the weld width and theoretical focus spot should be 2.

**SUMMARY**

(1) Through the welding experiment between PC plastic and semiconductor laser, and by means of orthogonal test and tensile test, the best technological parameter was achieved: power 60W, welding speed 15mm/s, defocusing distance 4mm.

(2) The analytic result between tensile strength and weld width showed that when the weld width was 1.2mm, the maximum tensile strength of PC plastic was 12 kg.

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