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Optics & Laser Technology 40 (2008) 420–426
Optics & Laser Technology
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Research Note

# Research on laser welding of vehicle body

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Received 4 February 2007; received in revised form 7 April 2007; accepted 16 June 2007
Available online 30 July 2007

**Abstract**

Based on many experiments of $CO_2$ laser welding of vehicle body, joint microstructure and stress–strain curve of specimen are analyzed. The deep punching performance acquired by adopting Ar as protective gas is better than that of the one acquired by adopting $N_2$ as protective gas. Meanwhile the percentage of zinc in welding seam can be effectively controlled by means of blowing side protective gas. In this paper, welding penetration and width are shown to vary with laser power and speed of welding. The results indicate that some flaws such as gas hole, crack and softening of HAZ do not appear in laser welding seam in sheet steel of automobile bodies if technology parameters optimizes. The deep punching performance of tailor-welding sheet is fine.


*Keywords:* Laser welding; Sheet steel; Effects of zinc vaporation

## 1. Introduction

Currently, security, lightness and environmental protection have become more and more important in automobile industry, and adopting new material and new forming mode are significant methods of reducing the weight on condition of no increasing cost but maintaining function and shock resistance [1,2]. High-strength galvanized steel is the preferred material for this problem. Tailor-welded method is a new technology of forming the automobile body. The technique can weld different thicknesses, different materials, different intensities, different punching informances and different surface materials together so as to make integral structure of large-sized overlay. Making use of this tailor-welded board can scheme out appropriate intensity component. Further, it can also reduce the weight of the body and decrease the amount of work is manufacturing and assemblage, and further it can reduce cost.

Comparing laser welding with electroslag welding and other different gas shielded weldings, it's the new techniques prominent strongpoints are concentrated laser beam, high energy, quick speed, small heat affected zone and fine welding seam quality. It can therefore satisfy the demands of tailor-welded character [3,4]. In this work, we adapted self-made continuous $CO_2$ laser device with a power of 1500 W to carryout a large number of technical tests on automobile body sheet and we obtain favorable results.

## 2. Experimental procedures

### 2.1. Laser welding equipment

In this paper, we adapted self-made PHC-1500 folding approximate sealing-type $CO_2$ laser device to produce continuous laser with output pattern $TEM_{01}$. In addition, we used ZnSe to focus. Laser parameters are shown in Table 1. Meanwhile, this work uses self-made welding clamp to fix workpiece on clamping apparatus so that welding seam may become more even and smooth. The gap between workpiece is controlled within 0.10–0.15 mm.

### 2.2. Experimental material

The new technique employed high-strength galvanized steel (DOGAL 800DP) with thickness of 1.5 mm, made in

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0030-3992/$ - see front matter © 2007 Elsevier Ltd. All rights reserved.
doi:10.1016/j.optlastec.2007.06.004

Sweden, and general steel sheet BUSD, made in Baoshan Iron & Steel Co. Ltd. China. Thicknesses of BUSD used are 1.0, 1.5 and 2.0 mm. Quantity of Zn in high-strength galvanized steel is 140 g/m$^2$. Numbering, chemical constitution and mechanical property are shown in Tables 2–4. The metallurgical structure of base metal of high-strength galvanized steel is forrite + perlite; the metallurgical structure of base metal of general steel sheets is only forrite. They are shown in Fig. 1. The size of workpiece is 100 mm × 30 mm.

Table 1
Laser parameter

| Focus (mm) | Divergent half-angle (mrad) | Focal depth (mm) | Beam diameter before focusing (mm) |
|---|---|---|---|
| 127 | 1 | 3 | 28 |

Table 2
Numbering and thickness of welding sheet

| Numbering of material | M1 | M2 | M3 | M4 |
|---|---|---|---|---|
| Type of material | High-strength galvanized steel | General steel | General steel | General steel |
| Thickness (d/mm) | 1.5 | 1.0 | 1.5 | 2.0 |

Table 3
Chemical constitution of material

| Numbering of material | C ⩽ | Si ⩽ | Mn ⩽ | P ⩽ | Cr ⩽ | S ⩽ | Ti ⩽ |
|---|---|---|---|---|---|---|---|
| M1 | 0.18 | 0.5 | 2.0 | 0.025 | 0.8 | 0.015 | – |
| M2–M3 | 0.01 | – | 0.4 | 0.025 | – | 0.02 | 0.2 |

Table 4
Mechanical property of material

| Numbering of material | Yield strength (MPa) | Strength of extension (MPa) | Extensibility after breakage (%) |
|---|---|---|---|
| M1 | 500–650 | 800–900 | 10 |
| M2–M4 | 120–210 | 260 | 44 |

### 2.3. Experimental method

Experimental set-up is provided in Fig. 2. It employed butt welding. Considering influence of Zn and demand of deep punching technology to welding sheet, it adopted coaxial and side blowing protective gas so as to ensure minimum influence of Zn and to restrain the formation of ferric plasma to some extent. For the sake of reducing welding defect, welding position should be cleared with acetone and be kept dry before welding.

Firstly, welding experiments are carried out on high-strength galvanized steels, then we tailor weld the high-strength galvanized steel of thickness 1.5 mm with general steel sheets of different thicknesses, 1.0, 1.5 and 2.0 mm. Welding focus is located on facial seam of the thin sheet, laser beam deviates 5° from facial normal line of sample to the thin sheet to protect lens, and sample can move with operating platform. Steps are cutting welded sample against welding seam after welding, eroding with acid after burnishing, inspecting seam under metallographic microscope and, finally, analyzing the mechanical property of specimen with universal test machine. Thus, microstructure and distribution of hardness are obtained and as the task was to optimize welding technology based on many experiments.

## 3. Results and discussion

### 3.1. Comparing two protective gases

The important function of protective gas is to prevent facial oxidation of workpiece during welding and to wipe off plasma cloud that absorbs and scatters laser energy during high-power deep-penetration laser welding. Selecting appropriate protective gas can restrain plasma when density of plasma is not strong. While respectively adopting $N_2$ and Ar as side-blow protective gas to protect welding seam, we found a little difference in maximal penetration, but found, between the two results, no difference in hardness, toughness of joint and Erichsen number of welding sample. The experiments indicated that rigidity of joint acquired by adopting $N_2$ as protective gas

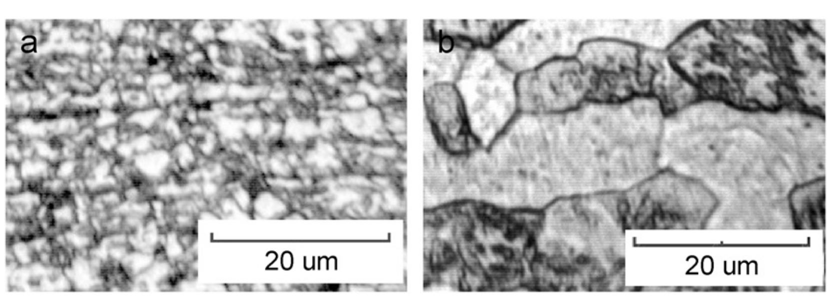


Fig. 1. Metallurgical structure of the material. (a) High-strength galvanized steel. (b) General steel.