Design and Analysis on Mixed Line Welding Fixture for Light vehicle

SUN Shu-guang¹, WANG Meng²*

¹ East University of Heilongjiang Department of Mechanical and Electrical Engineering, Harbin 150066, China
²* East University of Heilongjiang Department of Mechanical and Electrical Engineering, Harbin 150066, China
E-mail address: wushen@hiylink.net.cn

Abstract. The existing welding has some defects that can only be used for a single type of vehicle body and cannot apply to mixed line welding for several vehicle types. According to the structure characteristics and normalization design requirements of body welding fixture, the existing four light vehicle body structure parameters, clamping fixture and welding process requirements are analysed, so that a modular fixture which is suitable for four kinds of light vehicle body with mixed line repair welding is designed, which includes flexible clamp concrete, pressure control system, the single-chip microcomputer control, and mixed line of three kinds of switch control method.

1. Introduction
In recent years, as China's sustained and rapid economic growth, the vehicle industry also expand rapidly, and the production has become the world's largest. But most of the auto manufacturing companies blindly expand the production scale. The product variety is single, and product update is slow. It is because, on the one hand, the design strength of the product is relatively weak. On the other hand, manufacturing resilience for parts is weak. For example, supporting fixture cannot adapt to the requirements of the new product, so that it wastes a lot of time and human resources. In this paper, the welding fixture for light vehicle is studied and analysed, so that it can adapt to the requirements of product renewal quickly.

2. Underbody parameters of light vehicle with mixed welding line
Mixed line production of body is also known as flexible body welding line, which can produce two or more vehicle bodies in a mixed flow on a production line. There are 4 types of mixed line production of single row and double row light vehicle (4399×1528×1830), light bus (3948×1525×1855) and half row light vehicle (4399×1528×1845). The difference of the body length is 451mm. The difference of the body width is 3mm. And the difference of the body height is 25mm.

3. Positioning principle and positioning analysis of welding fixture

3.1. "N-2-1" positioning principle of welding fixture
In order to determine the position of an object, six possible motion directions must be constrained. Six support points should be added. Three support points should be arranged in the first datum. Two
support points should be arranged in the second datum. One support point should be arranged in the third datum. That is the "3-2-1" positioning principle. The automobile body is welded by hundreds of flexible stamping parts which are made of metal sheet. In the welding process, the upward deformation of stamping parts and the deformation caused by the weight of parts will lead to the size of the body have some problems. In other words, three support points at the first datum that cannot solve the deformation problem of parts. More than 3 positioning points must be placed on the first datum plane for thin plate, which is more reasonable "N-2-1" positioning principle should be adopted. And the "N-2-1" positioning principle is more suitable for the fixture design of thin plate and flexible parts.

3.2. Principle of locating pin parallelism
In principle, the positioning pin should be parallel to each other; otherwise the workpiece is not easy to be taken out after welding parts. The left/right positioning state of the welding fixture should be determined by using the left and right symmetry of the underbody parts. The fitting gap and edge state of the left/right welding joint and the left/right fixture should be uniform.

3.3. Positioning analysis of welding fixture
For the thin sheet metal parts of vehicle body which is poor rigidity, if using one side two pin positioning form which conclude a cylindrical pin and a diamond pin for its positioning, central frame itself may appear downward deflection which influence each position of welding parts due to the body deformation of metal sheet parts and gravity itself after welding, so that the frame welding quality is not qualified. In addition, as a result of the existence of the diamond pin, the diamond pin short side is unable to stop positioning parts having downward displacement with the positioning hole in the process of bending which deviate from the correct position, so that the parts positioning will lose its role positioning. At this time if using two cylindrical pin positioning among the left and right beam which increase auxiliary supporting and clamping point, positioning performance will be improved significantly. Flexible welding fixture is a kind of welding fixture that can adapt to different products or different models and specifications of the same product. The welding fixture of light vehicle underbody mixed line can be used to produce four types of vehicle body mixed line in one production line.

4. Design of flexible welding fixture for light vehicle underbody mixed wire

4.1. The composition of the flexible welding fixture for light vehicle underbody mixed wire
The vehicle underbody repair welding fixture of light vehicle is mainly composed of positioning device, fixture device, mixed line control device, other devices and so on. According to the vehicle body welding fixture "N-2-1" positioning principle, design positioning device mainly has 2 sets of front positioning device, 2 sets of central positioning device, 2 sets of tail positioning device, 2 sets of front positioning support, 2 sets of central positioning support, 2 sets of tail positioning support. At the same time, clamping device designed by the vehicle body welding fixture clamping selection principles mainly has 2 sets of front swing arm positioning locking device, 2 sets of tail swing arm positioning locking device, 2 sets of shear positioning locking device, and 2 sets of dynamic positioning locking device. Followed by four kinds of vehicle body parameters and welding process requirements, designing fixture mixed line main control device includes two-position five-way valve, check valve, dynamic positioning locking device lifting limit valve, dynamic positioning locking device locking limit valve, pump, cylinder, pneumatic connection valve, work platform, body support, adjustable type support base and so on. Schematic diagram of underbody repair welding fixture for combined light vehicle (see Figure 1).
4.2. Control working principle of mixed line welding fixture
Select manual and vehicle models by control panel. Control corresponding pneumatic circuit based on the selected models, and implement electric operation according to the different pneumatic circuit. So it can realize the different models of mixed production line of flexible welding. Welding fixture pneumatic circuit consists of three kinds of using state. Pneumatic system diagram (see Figure 2) and two-position five-way valve and stroke valve location and movement situation (see Table 1). The specific method is as follows:

Figure 1. Fixture for repair welding of combined light vehicle underbody.

Figure 2. Schematic diagram of control air pressure loop.
Table 1. Energized and positional table for the valves of control circuit

| Vehicle type                  | P1   | P2   | P3   | P4   | P5   | Stroke valve 3 | Stroke valve 4 | Cylinder 5   | Cylinder 6   | Cylinder 7   | Cylinder 8   | Cylinder 9   |
|------------------------------|------|------|------|------|------|---------------|---------------|-------------|-------------|-------------|-------------|-------------|
| Before welding               | lef t| lef t| lef t| lef t| lef t| up and impassable | up and impassable | up          | down        | down        | down        | down        |
| After welding                | -    | -    | -    | -    | -    | -             | -             | -           | -           | -           | -           | -           |
| Light bus                    | lef t| lef t| lef t| lef t| lef t| up and impassable | up and impassable | up          | down        | down        | down        | down        |
| Welding                      | rig ht| rig ht| rig ht| rig ht| rig ht| -             | -             | -           | -           | -           | -           | -           |
| After welding                | -    | -    | -    | -    | -    | -             | -             | -           | -           | -           | -           | -           |
| Half row Light vehicle       | lef t| lef t| lef t| lef t| lef t| up and impassable | up and impassable | up          | down        | down        | down        | down        |
| Welding                      | rig ht| rig ht| rig ht| rig ht| rig ht| -             | -             | -           | -           | -           | -           | -           |
| After welding                | -    | -    | -    | -    | -    | -             | -             | -           | -           | -           | -           | -           |

4.2.1. The first type is suitable for single-row and double-row light vehicle, and the working loop is: Two-position five-way valve P1 turn to right, and the light vehicle switch to a single row and double row state. Mount workpiece, two-position five-way valve P3 turn to right, two-position five-way valves P2, P4, P5 are left, stroke valve 3 and stroke valve 4 are impassable, two-position five-way valve P3 turn to right, which make the tail swing arm positioning locking device lock cylinder 9 and the front swing arm positioning 8 lock cylinder lock workpiece. After welding, two-position five-way valve P3 turn to left, and open the tail swing arm positioning locking device lock cylinder and the front swing arm positioning locking device lock cylinder. Remove the workpiece for getting ready for the next workpiece.

4.2.2. The second type is suitable for the light bus, and the working loop is: Two-position five-way valve P1 turn to left and switch to the half row vehicle state. Two-position five-way valve P2 turn to left and switch to the light bus. Mount workpiece, two-position five-way valve P3 turn to right and make the tail swing arm positioning locking device lock cylinder 9 and the front swing arm positioning lock cylinder 8 lock workpiece. Two-position five-way valve P4 turn to right and make the shear positioning locking device lock cylinder 7 lock workpiece. Two-position five-way valve P5 turn to left, stroke valve 3 and stroke valve 4 are impassable. Mount workpiece, two-position five-way valve P3 turn to right and make the tail swing arm positioning locking device lock cylinder 11 and the front swing arm positioning locking device lock cylinder 10 lock workpiece. After welding, two-position five-way valve P3 turn to left, and open the tail swing arm positioning locking device lock cylinder and the front swing arm positioning locking device lock cylinder. Two-position five-way valve P4 turn to left and open the shear positioning locking device lock cylinder 9. Remove the workpiece for getting ready for the next workpiece.

4.2.3. The third type is suitable for the working loop of half row light vehicle: Two-position five-way valve P1 turn to left and switch to the half row light vehicle state. Two-position five-way valve P2 turn
to right and switch to the half row light vehicle state. Lifting position of lifting dynamic positioning locking device lifting lock cylinder is controlled by stroke valve 3. Mount workpiece, two-position five-way valve P3 turn to right and make the tail swing arm positioning locking device lock cylinder 9 and the front swing arm positioning lock cylinder 8 lock workpiece. Two-position five-way valve P5 turn to right and make the dynamic positioning locking device lock cylinder may retract and lock workpiece. Retract dynamic positioning locking device lock cylinder 6 by stroke valve 4. After welding, two-position five-way valve P3 turn to left and open the tail swing arm positioning locking device lock cylinder and the front swing arm positioning locking device lock cylinder. Two-position five-way valve P5 turn to left and open dynamic positioning locking device lock cylinder. Remove the workpiece for getting ready for the next workpiece.

5. Conclusion
Light vehicle body mixed line welding parameters and four kinds of fixture is analysed, which is designed and manufactured. Actually, debug and carry out trial production in the vehicle factory, and make sure that the reliability and precision of welding through the actual vehicle welding inspection which improve the efficiency of the welding production and reduce the cost. And provide the manufacture and design referential basis of fixture for other vehicle mixed lines.

References
[1] Yinhu Q and Chunyan Z 2010 Design and simulation of carrosserie fixture based on CATIA J. Mechanical Design and Manufacturing. 6 236-238.
[2] Zhigang H 2005 Prediction and control of welding deformation of thin plate structure D. Dissertation full-text Database of Huazhong University of Science and Technology Library.
[3] Yueqing L and Yiyuan M 2005 Basic conditions for ensuring the design of welding fixture of carrosserie J. Tooling Design. 2 34-37.
[4] Jing Z and Junhua Z 2007 Introduction of automobile welding production line and welding fixture J. Modern Manufacturing Technology and Equipment. 1 51-53.
[5] Xin 'an F 2005 Machinery Manufacturing Equipment Design M. Machinery Industry Press.
[6] Sumei L 2008 Design of Welding Assembly Platform for D150 Minicar J. Equipment Manufacturing Technology. 42 67-69.
[7] Zhanying L, Xueshan N and Yingwang W 2010 Planning and Application of Flexible Welding Line of Carrosserie J. Automotive Technology and Materials. 9 17-20.