Design of a New Type of automatic welding for saddle-type intersecting line

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Abstract. A new type of pipe-to-pipe intersecting line welding device uses a large and small cam structure and a circular arc-shaped sliding track of the welding gun frame, which ensures that the welding gun rotates with the workpiece to coordinate the lifting movement and the corresponding adjustment of the welding gun’s position. Production practice shows that the movement’s position is precise, there is no accumulation of transmission errors, and the welding gun’s movement has high reproducibility and precision. It has a low-cost automated special welding equipment for pipe-to-pipe intersections.

1. Foreword
Steel pipes have good mechanical properties, easy to manufacture and are widely used in industry. At present, the automation and semi-automation rate of pipe welding is still not high, and the traditional manual welding requires the welder to have good operating experience, stable operation level, and poor welding labor conditions; such as too much smoke and dust, large heat radiation, and high risk factor. In actual production, due to the influence of the welder’s technical level, work mood and other objective factors, it is difficult to guarantee the processing quality and processing accuracy, the product consistency is poor, and the welding efficiency is relatively low.

Whether it is a bicycle frame tube or a boiler head takeover, its welding line is a saddle curve. Since the 1990s, research on automatic welding of this type of saddle-type intersecting line has been carried out home and abroad [1-2]. However, because only one cam is used to control the welding gun lifting and lowering in the study, the gun position of the welding gun cannot be adjusted accordingly; there are certain restrictions on the quality of welding. With the development of computer technology and control technology, the multi-axis controller PMAC [3] and robot [4-6] are used to control the welding trajectory of the welding torch. Many studies have focused on how to describe the saddle-type trajectory [7], and few researchers have considered it [8-9]. Welding gun’s position changes with different welding positions. In order to more accurately describe the saddle-type curve trajectory, the trajectory was modeled and stimulated [10], and 5 degrees of freedom welding robot was designed [11]. As pointed out by some scholars [12-13], the system interference phenomenon where robot joint coupling and welding gun posture change is more common.

This article uses a dual cam structure to control the lifting of the welding torch and the adjustment of the welding torch angle. Not only can it more accurately fit the saddle curve, but it can also more accurately adjust the welding angle of the welding torch to suit the quality of the weld. Quality meets production need.
2. Structure, composition and working principle of the welding device

Figure 1 is a schematic diagram of the composition and working principle of the welding device. The device is composed of two parts: the welding piece bearing device and the welding gun actuating device. The entire system has only one motor (not shown in the figure 1, set on motor base 13). The welding device bearing device is a worktable and two Z-shaped top pieces fixed by the bolt. The worktable co-operates with the main shaft and is connected to the motor through the bearings of the upper and lower panels, which drive the workpiece to be rotated by the motor. The two welded pipes are positioned and fixed on the worktable by a Z-shaped top piece, so they can rotate synchronously with the worktable driven by the motor.

The welding torch actuating device is shown in figure 2. The large and small cams are driven by the spindle to rotate synchronously with the table. After the rotation, the cam shafts also rotate synchronously. The small cam (Figure 1, component 10) pushes the roller frame and the slider mounted on the roller frame, the welding torch holder and other components make vertical, reciprocating movement, so that the welding torch can be welded to the workpiece. The trajectory of the vertical movement of the welding gun is obtained, according to the outer contour of the small cam to simulate the trajectory of a saddle-shaped weld. The large cam rotates and pushes the roller post (component 5 shown in Figure 2) for vertical lifting movement, and causes the top bearing to roll in the track of plate 4. The triangular top plate is driven by the roller column to drive the welding gun. The base and the welding torch make circular movements in the welding torch holder, so they can obtain the corresponding adaptive adjustment of the welding gun position.
Figure 2. Schematic diagram of welding torch actuating device.

3. Main design features

In the welding device, a single motor is used to directly connect the worktable through a reducer to rotate the workpiece (the speed can be set according to the welding requirements and production efficiency). The bevel gear is used to change the motion transmission direction to drive the large cam and the small cam to rotate at the same time. Through the calculation and design of the outer contour of the small cam, the welding torch is moved up and down following the workpiece rotation to fit the saddle type welding of the pipe joint intersection line. The torch holder on which the welding torch is mounted slides in a specially designed arc-shaped (the center of which is exactly the apex of the welding torch) welding torch holder, so that the welding torch can make a certain angle of rotation around the apex of the torch.

While the small cam drives the welding torch to move up and down in a straight line, the large cam drives the welding torch to make the angle between the welding torch and the welding point within a reasonable range, so that the welding torch always divides the angle between the two connecting pipes. That is, the angle $\beta$ always divides the angle between the two pipes as shown in figure 3, to ensure that the two pipes being welded are evenly heated, and the thin-walled pipe is not completely welded on one side and insufficiently welded on the other side.

Figure 3. Welding gun position adjustment

The saddle-shaped welding seam formed by the welding torch of this device is based on the dual cam mechanism for trajectory simulation and adaptive change of the welding gun position. It is not
only easy to adjust, but also the movement position is accurate, and avoids the accumulation of transmission errors, improve the reproducibility of the welding gun and welding quality.

4. Production application effect
This design has been widely used in factories, as shown in figure 4, the production efficiency is greatly improved compared to manual welding; welding is completed in about every 10 seconds, high automation efficiency, high welding quality and efficiency suitable for unity mass production, stable welding quality, high repeatability, fully meets the production requirements. The device does not require the welding level and welding experience of the workers, only loading and unloading is needed, coupled with the low cost of the device, which brings good economic benefits to the enterprise.

Figure 4. Actual product

5. Conclusion
The saddle-type intersecting line seam automatic welding device for pipe joints designed and developed in this paper has the following characteristics.

(1) Adopting dual cam structure, this new device has novel and clever design, simple structure, reliable operation and high repeat accuracy.

(2) The rotary motion of the workpiece to be welded and the welding torch movement are transmitted by the same motor through motion, and the welding gun position can be adjusted with different welding positions to ensure that the welding torch is placed at the bisector of the two pipes to be welded to achieve high-quality automatic welding of saddle-type seams.

(3) The actual production application proves that the welding machine greatly improves the production efficiency and the welding quality is stable and reliable.

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