

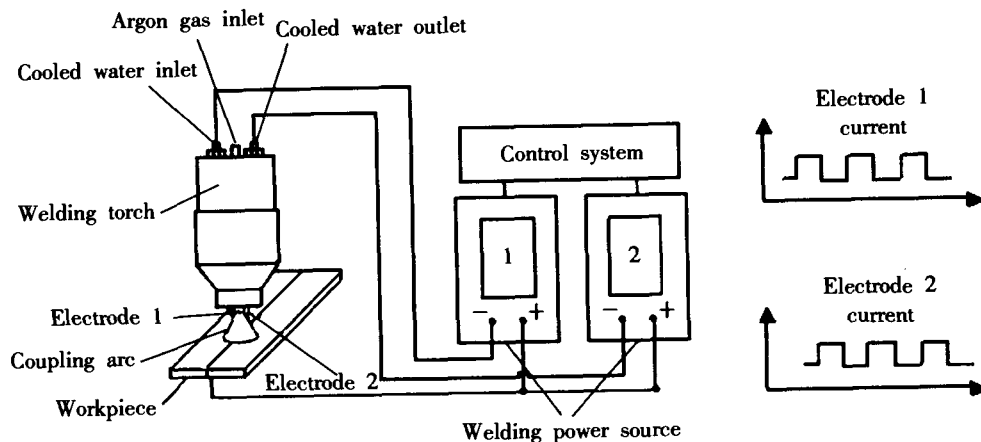


Fig. 1 Schematic diagram of T-TIG welding system

distance between electrodes' tip) is regulable within the range from 1 mm to 6 mm. When $D \leq d$ (the diameter of the electrode), we must use slanting electrode showed to adjust the distance. The two shapes of electrode are shown in Fig. 2, and θ is the tip angle of a electrode including slanting and normal shapes.

For working in high current, the welding torch is equipped with a cooled water circulating system. During the welding process, the two arcs generated from their own electrodes pull each other according to Lorentz force, and synthesize into an integrated coupling arc. After the half-year use, this welding torch has been proved to stable in capacity. Each current can be strong up to 400 A and meets the needs of research and application.

2 T-TIG coupling arc pressure

2.1 Distribution of T-TIG coupling arc pressure

Arc pressure is significant one of arc physics fea-

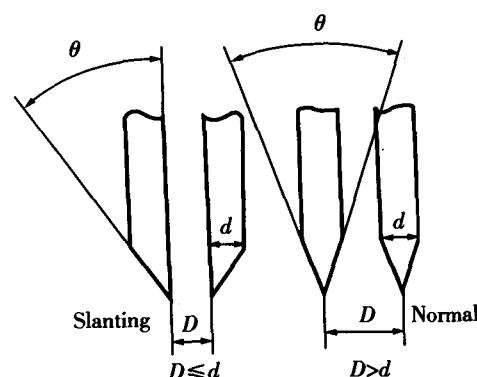


Fig. 2 Different shape electrodes

tures. Excessive arc pressure can bring unstable welding process and many defects^[8]. In this paper, the distribution of T-TIG coupling arc pressure and conventional TIG single arc pressure were measured by using the static small-hole method.

The welding parameters are tabulated in Table 1.

Table 1 Welding parameters of single and coupling arc

	Current/A	Arc length/mm	Distance/mm	Diameter/mm	Tip angle (°)	Shape of electrode
Single arc	200	3	—	3	30	Normal
Coupling arc	100 + 100	3	4	3	30	Normal

Fig. 3 shows that single arc pressure becomes larger with the increase of current value. Its distribution curve falls abruptly in the range near the center, and is basically in concordance with the hyperbolic curve^[9]. The coupling arc pressure distribution showed in Fig. 4 is quite differ-

ent. In the peak value area, the pressure falls slowly, and the form shifts from the "pinnacle-shape" of the single electrode to "platform-shape". It is not until when radius reaches the distance 1.5 mm from the center that the pressure value falls abruptly. Meanwhile, it is evident that the

peak value of coupling arc pressure with 100 A + 100 A is lower than that of single arc with 200 A, and is approximately equal to single arc 100 A. So we can get this important characteristic that coupling arc pressure can be suppressed a low level compared with single arc.

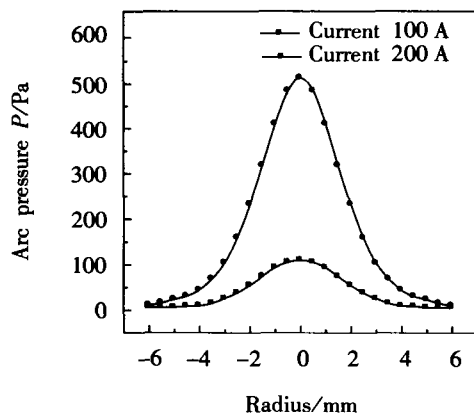


Fig. 3 Single arc pressure distribution

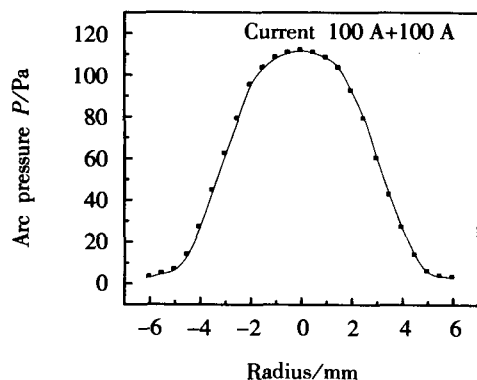


Fig. 4 Coupling arc pressure distribution

2.2 The reason for T-TIG coupling arc pressure reducing

Fig. 5 shows the shape comparison between single and coupling arc under the same light exposure using a CCD camera. Slanting electrode is used in coupling arc, the distance is 2 mm, other welding parameters are the same as that in Table 1. The anode is cooled water copper block. From these figures, we can find that the shape of coupling arc is different from that of single arc. The profile near the cathodes is approximately two times wider than that of single arc, where the current density is lower than

single arc. But it nearly has the same profile as single arc near the anode. This change results in decrease of electromagnetic force difference between the region near the anode and the cathode^[10]. Therefore the arc pressure is held down according to the change of electromagnetic force.

Since arc pressure can be suppressed, T-TIG welding can be achieved in the high current region without excessive arc pressure. This characteristic lays the physical foundation for T-TIG to be applied in high efficiency welding.

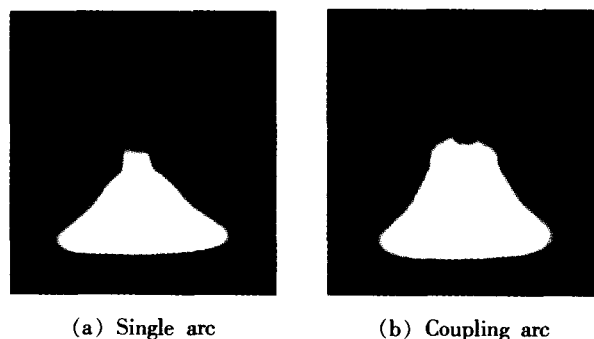


Fig. 5 Comparison of the visible profiles between single arc and coupling arc

3 Preliminary welding experiment

From the above research, T-TIG welding arc can keep high current with its less arc pressure. So preliminary experiment of thin plate welding is designed in this paper. In this experiment, the mode of high current and high speed is selected because deposition is not most important for thin plate. The material of workpiece is Q235 steel, the size is 200 mm × 100 mm × 2 mm. The distance of two electrodes is 2 mm, the current is 150 A + 150 A, welding speed is set at 600 mm/min. As a comparison, conventional TIG is designed with the same welding parameters. Fig. 6 and Fig. 7 show the welding results. From the two photos, we can realize that the weld of T-TIG method is sound under high current, but the workpiece using TIG method has the defects of undercut and burn through because of high welding speed and high arc pressure brought by high current. So with the new T-TIG welding method, welding speed can be increased, welding efficiency is improved in thin plate welding.



Fig. 6 Welded workpiece with conventional TIG with high welding current



Fig. 7 Welded workpiece with T-TIG with high welding current

4 Conclusions

The conclusions in the present paper are summarized as follows.

(1) We verify that T-TIG welding is achieved through a coupling arc generated by two independent arcs pulling each other according to Lorenz force by using self-designed welding torch.

(2) The coupling arc has lower arc pressure than single arc under the same current. So it can be loaded with higher current to achieve good weld without the flows such as burn through and undercut.

(3) The preliminary welding experiments prove that T-TIG welding method can be applied in high speed and high current welding of thin plate.

Acknowledgements

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References

- [1] Sugitani Yuji, Kanjo Yoshihiro, Ushio Masao. High efficiency processes in automatic welding. *Welding Research Abroad*, 1999, 45 (4): 32 - 37.
- [2] Jiang Lipai, Jiao Xiangdong, Xue Long, et al. Key points of high efficient automatic welding technique for large scale spherical steel tank. *Journal of Mechanical Engineering*, 2003, 39 (8): 146 - 150. (in Chinese)
- [3] Sykes I, Digiacomo J. Automatic hot wire GTA welding of pipe offers speed and increased deposition. *Welding Journal*, 1995, 74 (7): 53 - 56.
- [4] Yang Chunli, Lin Sanbao, Liu Fengyao, et al. Research on the mechanism of penetration increase by flux in A-TIG welding. *Journal of Materials Science and Technology*, 2003, 19: 225s - 227s.
- [5] Zhang Y M, Zhang S B, Jiang M. Sensing and control of double-sided arc welding process. *Journal of Solar Energy Engineering, Transactions of the ASME*, 2002, 124 (3): 695 - 701.
- [6] Kobayashi, Yamada. Practical application of high efficiency twin-arc TIG welding method (SEDAR-TIG) for PCLNG storage tank. *IIW Doc. XII - 1669 - 01*.
- [7] Kobayashi, Nishimura. Development of high efficient twin-arc TIG welding method. *IIW Doc. XI - 783 - 03*.
- [8] Zhao Xihua. *Welding methods and mechatronics*. Beijing: China Machine Press, 2001. (in Chinese)
- [9] Wu C S, Ushio M, Tanaka M. Analysis of TIG welding arc behavior. *Computational Materials Science*, 1997(7): 308 - 314.
- [10] Yang Chunli, Lin Sanbao. *Arc welding base*. Harbin: Harbin Institute of Technology Press, 2003. (in Chinese)