Technology

Practical Application of DS-TIG Advanced Torch for High Efficient Prefabricated Piping Construction

TATSUMI Kosuke*　　YASUDA Shuhei**

1. Introduction

In order to reduce the workload of on-site external piping in the construction of the air separation unit, we have been working on unitizing part of the external piping and expanding the scope of its fabrication in the factory. For this reason, the amount of welding carbon steel piping performed in the factory has increased compared to the past, which poses a challenge to improve the efficiency of this work. Most of the welding work of unit piping is welding of pipes and fittings, and in the past, these were processed and welded by hand, which was a factor that prolonged the construction. So, this time, we introduced the DS-TIG advanced torch, which was developed by our development department, to thereby performing automatic welding of unit piping, aiming to improve the efficiency of work in the factory.

2. Features of DS-TIG advanced torch [1)]

In single-side butt gas tungsten arc welding (TIG) for a plate thickness of 4 mm or more, both plate edges to be butt welded are generally beveled to form a V-shaped bevel. On the other hand, plasma welding does not require beveling because deep penetration can be obtained therefrom. Plasma welding is a welding method that increases the energy density by squeezing the arc generated from the electrode through a water-cooled restraint nozzle. This high energy density arc penetrates the base material and creates a keyhole, resulting in deep penetration and enabling back bead (full penetration) welding. However, plasma welding requires a dedicated welding machine and many consumable parts around the torch, and has other drawbacks such as its narrow welding margin in spite of the complicated parameters of welding conditions.

The “SANARC® DS-TIG Advanced Torch” commercialized by our development department is a special torch that solves the above-mentioned problems of plasma welding (Figure 1). This torch uses a unique water-cooling method to cool the electrode near the arc-generating region more intensely, thereby achieving a thermal pinch effect and enabling keyhole welding without the need for beveling. Unlike plasma welding, consumables such as water-cooled restraint tip are not used, and general-purpose TIG welding machines can be used. In addition, this torch can select high current and high speed conditions and thus can further shorten the welding time.

Keyhole welding can provide stable penetration without a root gap, thus reducing the number of welding passes. In addition, the distortion of the weld is small, and post-processes such as correcting the distortion can be omitted. Figure 2 shows comparison of the torch internal structures for each welding method.

Figure 1　Schematic illustration of DS-TIG advanced torch

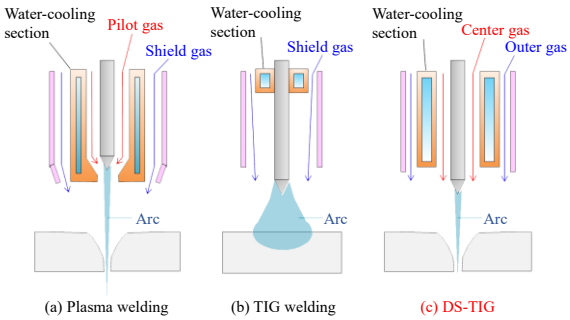

Figure 2　Comparison of torch internal structures for each welding method

* Production Technology Section, Design Department, Design & Production Management Division, Plant Engineering Center
** Plant Design Section, Design Department, Design & Production Management Division, Plant Engineering Center

3. Challenges associated with practical application of DS-TIG advanced torch

Fittings used for piping are JIS (Japanese Industrial Standard) products and commercially available in beveled shapes. In the process of putting the DS-TIG advanced torch into practical application, the DS-TIG advanced torch was designed for single bevel groove welding without beveling the pipe side in order to further improve the fabrication efficiency. In this case, the problem is that, when keyhole welding, which is well-suited for a square bevel groove, is applied to a single bevel groove, it results in asymmetric bevel welding, which increases the risk of burn-through. In addition, a misalignment between a pipe and a fitting tends to be large, so a welding margin that can deal with a misalignment of up to 2 mm was needed. In order to address these issues, the welding conditions were optimized.

Figure 3 Applicable welds (pipe and fitting)

4. Optimization of welding conditions

In order to achieve stable welding in a single bevel groove by the DS-TIG advanced torch, not only the welding heat input conditions but also the torch target position and the shielding conditions were optimized. In particular, the torch target position contributes greatly to welding stability, and it was effective to tilt the torch movement angle to an appropriate angle, as shown in Figure 4. By optimizing the welding conditions this time, stable welding was made possible even in the case of a single bevel groove or a misaligned bevel groove. As a result, good back bead welding without internal defects was achieved with a diameter of 150 A to 400 A and a plate thickness of 7.3 mm to 12.7 mm in actual construction piping as well (Figure 5).

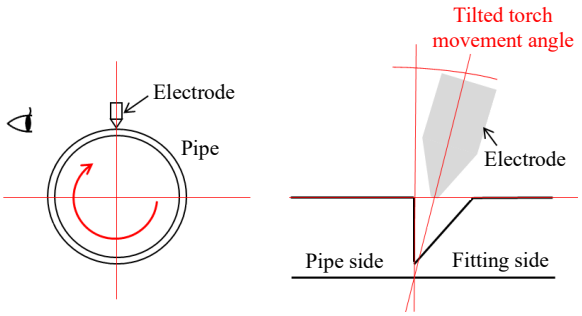

Figure 4 Optimization of torch target position

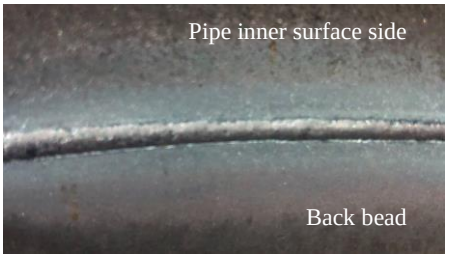

Figure 5 Example of back bead external view

5. Productivity improvement effect brought by practical application of DS-TIG advanced torch

The practical application of the DS-TIG advanced torch has enabled keyhole welding with a general-purpose TIG welding machine, reducing the number of welding passes and significantly shortening the welding time. In addition, by optimizing the welding conditions for single bevel groove welding, beveling work has become unnecessary. These effects reduced the time required for a series of welding-related work (including beveling and temporary welding) by about 65%, as shown in Figure 6.

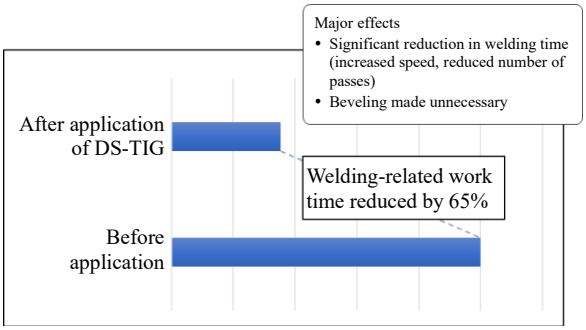

Figure 6 Reduction in welding-related work time

As one of the construction results, we were able to shorten the time from pipe cutting to the completion of prefabricated piping from six weeks to four weeks in the fabrication of the unit as shown in Figure 7. The number of workers involved was also reduced from four to two, resulting in a 60% or more reduction in fabrication man-hours.

Further, the automation of welding led to stabilization of weld quality. In addition, cost reduction of grinders and other consumables and welding materials was also achieved.

Figure 7 Example of in-factory unit

Reference

1) Wada, Katsunori and Tomoaki Sasaki, Development of "SANARC® DS-TIG Advanced Welding Torch" for Keyhole Welding, *Taiyo Nippon Sanso Technical Report* No. 39, 2020