

## **Trackless Movement and Full Penetration Arc Welding**

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### **Introduction**

Conventional arc welding processes for fabrication of large steel structure, which employ giant and expensive welding equipment with a track and beveling of steel plate edge and multi-pass welding method to perform full penetration welding, suffer from low productivity and high cost. The key reason is that full penetration welding and seam tracking as the critical technique problems in conventional arc welding have not been solved and improved. Currently, either one-sided or both-sided full-penetration welding a butt joint using conventional arc welding processes requires multi-pass weld. On the other hand, conventional automatic arc welding equipment employs a track for making a long weld, hence seam tracking plays a critical role in generating sound welds in many automatic welding applications. Weld line tracking technique, however, cannot be widely used in welding production currently due to its low reliability and high cost. Therefore, the obvious expense of the conventional arc welding has been forcing engineers to explore new technologies for possible cost savings and increase of productivity in welding of large steel structures.

The proposed project was aimed at the development of trackless movement and full penetration welding methods, in which full penetration welding and seam tracking are integrated and was to provide a flexible, portable, light, and affordable welding apparatus for fabrication of large steel structures. A basic prototype of the Trackless Movement and Full Penetration (TMFP) apparatus was designed according to requirements of arc welding production. Based on this apparatus the flux-cored wire plasma arc welding process was developed for high-strength steel (DH-36). The preliminary experimental demonstrated that the proposed TMFP apparatus and process was able to perform trackless movement and full penetration welding. This technology can be used for fabricating butt joints of thick metal plates for large structures.

### **TMFP Apparatus**

The basic idea of this present innovation is that an apparatus with the trackless movement and full penetration functions will be assembled with a butt joint based on a pre-existing gap (3mm-10mm) of a weld line. To perform trackless movement, the pre-existing gap of the weld line is used to act as a "guide slot" and a guide wheel unit to track the gap is designed in this apparatus. In the innovation, the guide slot through the pre-existing gap and

the guide wheel unit can save an external track and a seam-tracking device, and increase the accuracy and reliability to track a weld line. An electric or manual winch can serve as a driver to drag the welding apparatus to move along a weld line, irrespective of the length, configuration, and other factors of a butt joint.

A movable weld backing is held against the underside of the weld by a spring tensioning system to support liquid metal and form backside bead to make a full-penetration weld. Therefore, the full penetration welding and seam tracking can be integrated in the TMFP apparatus. This innovation provides a flexible, portable, light, and affordable welding machine for fabrication of large steel structures.

### **TMFP Plasma Arc Welding Process**

Based on this apparatus, flux-cored wire plasma arc welding can perform a one-side full penetration welding a butt joint with single pass. In the process, the flux-cored wire as a filler metal can be added to the leading edge of the weld puddle using a mechanized wire feeder and a layer of liquid slag between the moveable backing and the liquid metal of the backside weld pool may act as a “lubricant” to increase the sliding ability of the moveable backing and act as a very efficient heat “insulator” to protect the backing from the high temperature of plasma arc, and provide a shielding layer for the weld pool.

Preliminary trials of square butt joints with pre-existing gap for the TMFP flux-cored plasma arc welding were conducted on 3/8 in. thick plates of high-strength steel (HSS) DH-36, which is used in naval and commercial ship structural application. In this study, E71T-1 flux-cored wire is used. The preliminary experimental results demonstrated that the proposed TMFP apparatus and based on this apparatus the flux-cored plasma arc welding process can implement trackless movement and full penetration welding for HSS materials. These trials also proved that flux-cored plasma arc welding made a sound, crack-free and porosity-free weld for HSS steel materials.

### **Advantages of TMFP Welding Process**

Advantages of the process over conventional arc welding methods will be obvious to fabricators: consistent quality welds for long welds; significant welding time and cost saving; a light, portable, flexible, and affordable machine (less than 20lb in the TMFP apparatus weight) for welding of large steel structures to save equipment investment; adjustable deposition rate of the weld metal for improvement of mechanical properties of a weld.

## **Conclusions**

A new one-side welding technique for fabrication of large steel structures, trackless movement & full penetration apparatus and based on this apparatus flux cored wire plasma arc welding process, has been demonstrated. The following conclusions can be drawn from the results of this work:

1. The new technique can perform trackless movement and seam tracking using the pre-existing gap as a guide slot and a guide wheel unit, and full penetration welding for a butt-welded joint using a moveable backing.
2. The innovation substantially simplifies automatic arc welding equipment. A light, portable, and flexible TMFP welding machine is useful and economical for fabrication of large steel structures.
3. A layer of liquid slag between the moveable backing and the backside weld pool acts as a “lubricant” to increase the sliding ability of the moveable backing and a efficient “heat insulator” to protect the backing from the high temperature of plasma arc, and a “shielding film” for the weld pool.
4. Flux-cored wire plasma arc welding makes a sound, crack-free, and porosity-free weld for HSLA steel materials.
5. Compared with conventional arc welding methods, the new process significantly saves welding time and production cost, and insures consistent quality welds in welding of large steel structures.
6. Adjustable deposition rate of the weld metal will improve mechanical properties of a weld.