Activated Flux for Welding Duplex Stainless Steel

1. Merchandise Name:

Activated Flux for Welding Duplex Stainless Steel

2. The info of Development Teammate

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3. The Idea of Development

Welding is a critical technology for joining metals in manufacturing industries. Arc welding is undoubtedly one of the most common and important joining techniques used today. Gas tungsten arc welding, also known as tungsten inert gas (TIG) welding, produces an electric arc between a tungsten electrode and the workpiece to be welded. The tungsten electrode, the molten metal, and the filler metal are protected from atmospheric contamination by an envelope of inert gas (such as argon or helium) during welding. The TIG welding is commonly used for high-quality joining of stainless steels, aluminum alloys, and titanium alloys. However, its application is limited to thin section metals welded by a single-pass operation. The highest penetration depth in stainless steel TIG weld that is achievable in a single-pass operation is limited to 2.5 mm. The low productivity of TIG welding can be traced to a greater number of passes required to fill the groove joint for thick section metals. Fig. 1 shows the effect of welding parameters on the size of stainless steel weld. By increasing the welding current in an attempt to improve the penetration capability of TIG welding, the width of resultant weld becomes excessively wide with a relatively slight gain in its depth. Improvements in productivity of TIG welding have long been sought in the welding community.

Penetration capability of TIG welding can be significantly improved by applying a thin layer of activated flux with a paint-like consistency to the surface of the workpieces to be welded. The use of the flux that increases the penetration depth of the TIG welds was developed by the E. O. Paton Electric Welding Institute (Ukraine) in the mid-1960s, and was termed activated TIG welding. A key technique for activated TIG welding is the ingredient of an activated flux. It should note that the ingredient of an activated flux must be selected according to the materials of workpieces to be welded. A commercial flux has been developed by the NPUST, Taiwan. The commercial ingredient of an activated flux used in TIG welding of stainless steels has three key features: a high penetration, low distortion, and no slag. Fig. 2 shows that the commercial flux ingredient of stainless steel activated TIG welding was developed by this study.

Fluid flow dominates the transfer of heat in a welding pool, and thus, determines the geometry of the resultant weld. The fluid flow in a welding pool is driven by the buoyancy force, the electromagnetic force, the surface tension gradient, and the drag force induced by plasma jet (Fig. 3). The dominant force that drives fluid flow is the surface tension gradient (dγ/dT). If the surface tension gradient is non-zero, then fluid flows from lower surface tension regions to higher surface tension regions. Furthermore, surface tension gradient is dependent on the concentration of oxygen in the welding pool. When using the TIG welding without activated flux, the temperature coefficient of surface tension in the welding pool generally exhibited a negative value. This indicated that the surface tension gradient introduces centrifugal Marangoni convection in the welding pool. In this condition, the molten metal flows from the center to the edges, resulting in a wide, shallow weld (Fig. 4a). When the TIG welding with activated flux is used, the temperature coefficient of surface tension in the welding pool changed from a negative value to a positive value. This indicated that the surface tension gradient introduces centripetal Marangoni convection in the molten pool. In this condition, the molten metal flows from the edges to the center, resulting in a narrow, deep weld (Fig. 4b).

Fig. 5 shows the procedures of technical development for activated TIG welding, which include oxide grinding, oxide sieving, oxide/methanol weighing, oxide/methanol mixing, oxide/methanol stirring, flux coating, and TIG welding. Prior to welding, the oxide was mixed with a methanol and stirred with a glass rod until the mixture attained a paint-like consistency. The activated flux paste was then applied onto the surface of the steel plate with a paintbrush. The methanol was allowed to evaporate, leaving a thin coating layer of the flux attached to the surface of steel plate. Moreover, the weight per unit area of the flux coating layer was 2.24±0.12 mg/cm2. The commercial flux ingredient of stainless steel activated TIG welding was developed by the present study which makes it possible to intensify conventional TIG welding for joining thickness of 8–10 mm by single-pass operation. Moreover, the sensitivity of the geometry of stainless steel TIG welds to variations in the chemical composition of the base metals can be also reduced when using this flux ingredient.

4. Technological Competition and Industrial Application

Commercial flux ingredient of stainless steel activated TIG welding has been successfully developed by the present study. The activated flux used in the TIG welding of stainless steel has positive effects on the engineering technology: 1. increasing the penetration depth of welded joint; 2. reducing the distortion and residual stress of weldment; 3. saving time of pre-operation work; 4. saving time of post-treatment work; 5. instead of multi-pass procedures; 6. avoiding the heat-to-heat variations in the geometry of the resultant weld. The activated TIG welding technology can be widely used in the industry fields of the machinery, power, construction, shipbuilding, and petrochemical manufacture.

5. The Statement of Achievement of Merchandise

Fig. 6 shows the effect of welding current on the shape and size of stainless steel TIG welds. The results show that significant variation in the penetration depth and bead width of the TIG welds occurred. When the welding current of conventional TIG welding increased from 125 to 225 A, the penetration depth of the welds increased from 0.80 to 2.85 mm, and its bead width increased from 6.47 to 11.02 mm. This indicates that conventional TIG weld exhibit a wide, shallow shape. However, when the welding current of activated TIG welding increased from 125 to 225 A, the penetration depth of the welds increased from 2.51 to 7.08 mm and its bead width increased from 4.88 to 6.92 mm. This indicates that activated TIG weld exhibit a narrow, deep shape. Fig. 7 shows effect of welding current on depth-to-width ratio of stainless steel TIG welds. The results show when the current is 175 A, the depth-to-width ratio of stainless steel weld can be increased to a maximum of 500%.

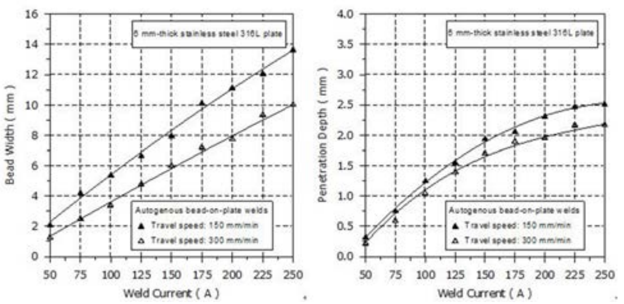

Fig 1 ：Effect of welding parameter on size of stainless steel weld.

Fig 2 : Commercialization of activated flux for welding duplex stainless steel.

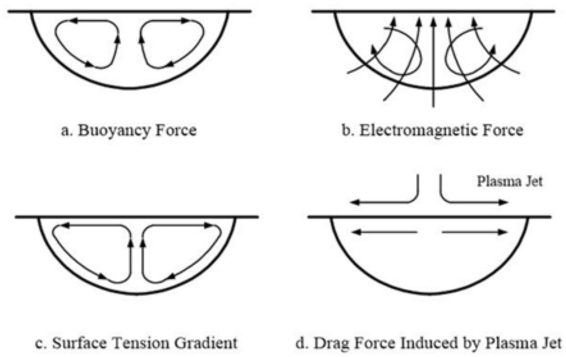

Fig 3：Driving forces for fluid flow in welding pool.

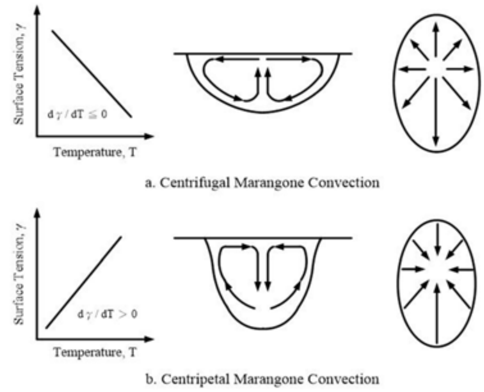

Fig 4：Relationship between temperature coefficient of surface tension and convection of molten metal.

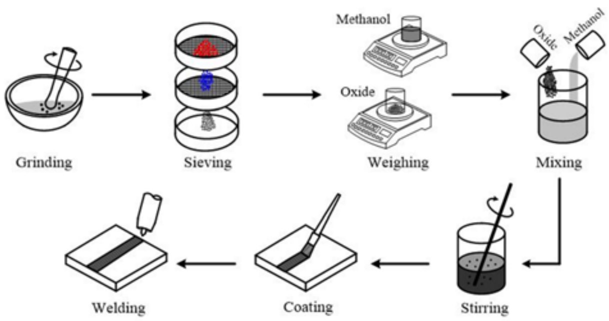

Fig 5：Procedures of technical development for activated TIG welding.

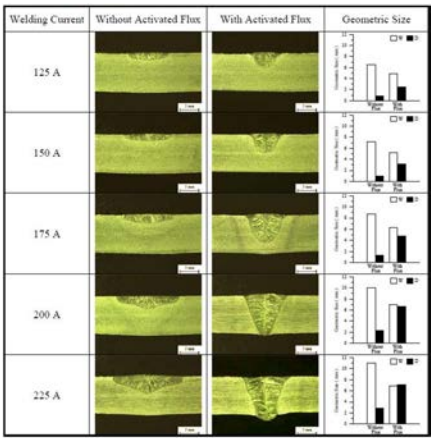

Fig. 6 : Effect of welding current on shape and size of stainless steel TIG welds.

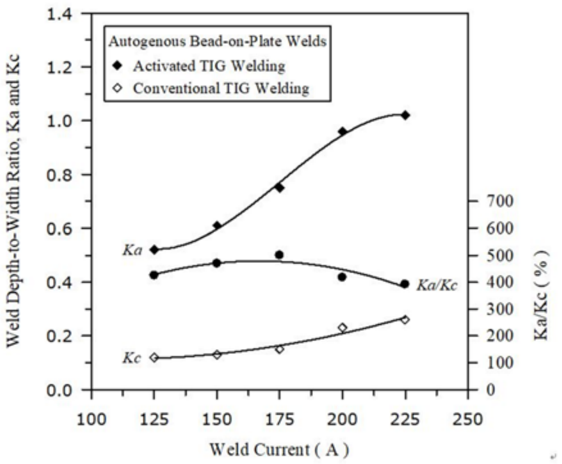

Fig. 7 : Effect of welding current on depth-to-width ratio of stainless steel TIG welds.