Effect of Microstructure on Joint Properties of Multi-pass Welds of Highly Corrosion-Resistant Titanium Alloys

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Gr.12 and Gr.13 are newly developed in the chemical industry, marine power generation, seawater purification facilities, submarines, etc. Compared with G7, G17, G30, and other titanium alloys, Gr.12 alloy has higher wear resistance in the non-acid environment. On the other hand, Gr.13 has good performance in various acid environments. Because of the addition of Ni, Ru, and other elements, the Gr.13 alloy has excellent corrosion resistance in the caustic soda solution environment. In addition, since both Gr.12 and Gr3 alloys are added with cheap alloying elements, these two materials have apparent price advantages compared with other alloys. However, the weldability of both materials also exhibits certain limitations. The performance of these two materials is lower than that of the base metal after TIG welding. It shows that cracks appear before reaching the bending when the welded Gr.12 titanium alloy is subjected to a bending test (5TR 180°), which means Gr.12 and Gr.13 titanium alloy cannot meet the design requirements of some more complex structures. Therefore, in this study, we will try to find why two of the materials welded by TIG welding show lower performance in the bending test. Gr.12 titanium alloy and Gr.13 titanium alloy were used as test materials. Microstructural analysis by EBSD/EPMA and microstructural observation and hardness test were attempted on the TIG-welded specimens. Through electron microscopy, we confirmed that the abnormal structures of Widmanstätten + acicular structures were observed in multi-pass TIG-welded specimens; also, coarse crystal grains have been observed in the weld metal. Furthermore, by EBSD analysis of these species, we found that the constituent phase of all sample materials in each area is the α phase. Similar sample materials were analyzed by EPMA, which demonstrated no segregation of elements, and no precipitate was formed in all areas. Although we found tissue hardening in this experiment, it is believed that it will not directly impact the workpiece's properties due to the small degree of tissue hardening. Therefore, refining the grains is a key point to solving the problem. The prevention and control measures of coarse grains are mainly in the following aspects： Adding an external energy field during the welding process, such as high-frequency electric and magnetic fields, will produce thermal effects, force effects, and ultrasonic effects and cause forced flow of liquid metal in the molten pool and magnetic oscillation.