R&D achievements for the full-size 1/8 Vacuum Vessel Towards CFETR construction

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Abstract: In order to solve the technical difficulties of ultra-large-scale precision assembly and welding in the assembly site of the future fusion reactor vacuum vessel sector, the Institute of Plasma Physics of Chinese Academy of Sciences carried out the final assembly and integration of 1/8 vacuum vessel sector in a vertical state based on the Comprehensive Research Facility for Fusion Technology (CRAFT) program. In December 2022, the full-size 45-degree sector consisting of two 22.5-degree sectors and the splice plates was completed, and the deviation of the 1/8 vacuum vessel was better than ±8mm. During the R&D of the 1/8 vacuum vessel sector, the following key technologies were developed. The technology of the three-dimensional precision control network for the on-site assembly based on the laser alignment measurement can meet the precise positioning of large-size components in a large field of view. The inversion technology of the splice plates based on reverse modeling can effectively solve the problem of complex surface matching. The real-time monitoring system of the dynamic posture based on multi-sensor fusion can achieve sub-millimeter precision control during the assembly process. The precision micro-deformation welding technology for the vacuum vessel sector can achieve low-stress precision welding of the 50mm thick ultra-low carbon stainless steel hyperboloid shell. The combination of digital ray and phased array ultrasonic testing methods can achieve non-destructive testing of the full volume coverage of the weld, and the detection accuracy has reached the international advanced level. The integrated application of these technologies provides a complete process solution for the engineering construction of the future fusion reactor devices.

Keywords: Vacuum vessel, On-site assembly, Precision measurement, On-site welding, On-site NDT