Full Scale Mock-up Trial Fabrication of B3 Segment for ITER-TF Coil Structures
ITER TFコイル構造物　実機大B3セグメント試作

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Full scale mock-up of B3 segment of TF coil structures has been fabricated to investigate welding deformation. B3 segment has complicate welding deformation because of the complicate cross sections along welding. The full penetration weld, one side weld has been performed by narrow gap Tungsten Inert Gas (TIG) weld using pressing to control the deformation. As the result, the control procedure of welding deformation are obtained for the fabrication of the actual B3 segment.

1. Introduction
ITER Toroidal Field coil (TF coil) consists of a winding pack and structures [1]. The dimensions of the structures are 16.5m in height, 9m in width, and the weight is about 200 ton, made of stainless steel FM316LN [2]. The seven segments of the structures are A1-A3, B1-B4 and two plate segments of AP, BP as shown in Fig.1. As the fabrication of a full scale mock-up, B3 segment which is 5.8m in curved length, 2.7m in width, 35 ton in weight, has been selected to investigate the weld deformation.

This paper describes the results of trail fabrication of B3 segment, in which an attempt to control the deformation was tried.

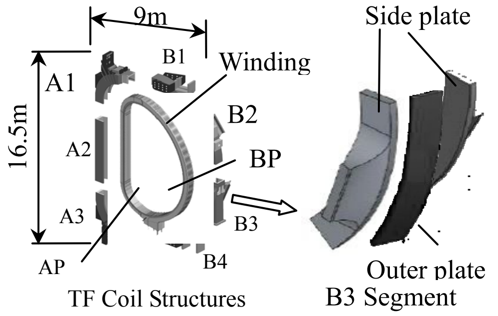


Fig.1. TF Coil

2. Full Scale Trial Fabrication of B3 Segment
2.1 *Composition of B3 Segment*

B3 segment has two side plates and one outer plate. The side plates were welded at the both edges of the outer plate, witch is shown in Fig.1. Outer surface of the side plate has a massive structure called “wing” to join to neighboring TF coils. Typical width of B3 segment is 1065mm, and the maximum width between the wing edges is 2740mm, as shown in Fig.2. The side plates including the wings were manufactured by forging and outer plate by bending a flat plate.

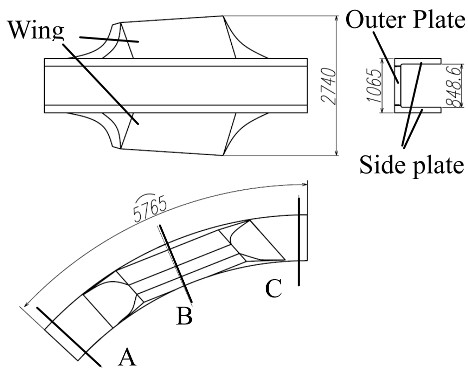
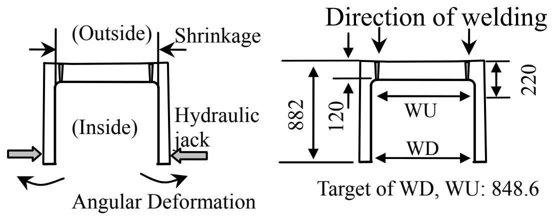


Fig.2. B3 segment

2.2 *Welding Method*

Welding of B3 segment is full penetration of 120mm in depth and about 5800mm in curved length. One side weld was selected because of the narrow space inside B3 segment inside. Narrow gap TIG welding and simultaneous welding of two side plates are used for controlling welding deformation which includes shrinkage and angular deformation.

To compensate the estimated shrinkage, the width of outer plate was widened. For the angular deformation, the off-set displacement was given to the side plates by hydraulic jack, as shown in Fig.3 a. The pressure of hydraulic jack was adjusted at every pass, comparing the estimated spring back after release of welding jig and the measured deformation during welding.



a) Welding deformation and pressing b) Cross section

Fig.3. Outline of cross section and welding restraint

2.3 *Full Scale Trial Fabrication of B3 Segment*

Before the trial fabrication, curved mock-up of 1m length was manufactured to investigate the shrinkage and the angular deformation. The shrinkage (Δ WU) was the difference at WU between before and after welding, as shown in Fig.3 b. The difference between WU and WD, which is described by Δ WD, was used as a measure of the angular deformation.

From the result of the curved mock-up, the width of the outer plate was widened by 6mm for the shrinkage, and the off-set displacement given to the side plates edges was 10mm.


a) Welding between Side plate and Outer plate b) After welding and release of welding jig

Fig.4. Fabrication of B3 Segment

Welding deformation in the trial fabrication were measured at the both the edges (A, C) and at the center (B), as shown in Fig.2. The welding was performed from position A to position C, measuring the welding deformation at every weld pass. The angular deformation (Δ WD) reached about -10mm at 12th pass. Then the hydraulic jack was removed and the side plates were constrained by welding jigs. Up to 12th pass, deformation was measured after welding each pass by releasing jack press

2.4 *Result*

The results of the welding deformation are shown in Table I. Comparing values of shrinkage, Δ WU at A is smaller than those at points B, C. The long length and the curvature of B3 segment cause the constraint at point C which is the welding end. Δ WD at point B is smaller than the others. This is because stiffness of wing constraints welding deformation. This shrinkage is about the same as the estimated value, though shrinkage varies in the longitudinal direction.

Table I. Δ WU and Δ WD after release of welding jig (mm)

Measured point	Initial distance between side plates	Shrinkage Δ WU	Angular deformation Δ WD
A	855.2	3.9	15.0
B	855.0	5.4	12.5
C	854.3	6.0	13.8

Measured angular deformation changes at every weld pass and those at constraining by jigs are shown in Fig.5. For first 12 passes, deformations with and without hydraulic jack were measured. The angular deformation from 1st to 12th pass can be controlled well because the deformation is lower than zero. After 12 pass, the deformation gradually increases due to insufficiency constraint of jigs. The angular deformation after release of the welding jig at the completion of welding is up to 15mm. However the angular deformation could be reduced by the sufficient constraint of welding jig, when the jig controls the value of the angular deformation as much as the compensation for the spring back.

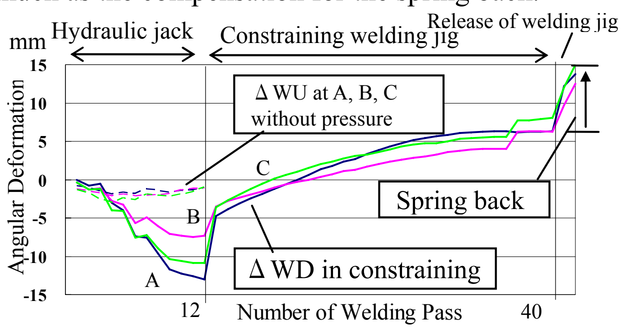


Fig.5. Welding angular deformation

3. Conclusion

Full scale mock-up of B3 segment for ITER-TF coil has been fabricated by full penetration one side weld with hydraulic jack and jig restraining, measuring welding deformations. The welding shrinkage was controlled to be almost the estimated value. The angular deformation was controlled by hydraulic jack and welding jig. Although the sufficient constraint of welding jigs is necessary to compensate the spring back, the control method of welding deformation was demonstrated for the fabrication of the actual segment.

References

[1] M.Iguchi, et al., Development of structures for ITER Toroidal Field Coil in Japan, MT-22, to be published

[2] Codes of Fusion Facilities -Rules on Superconducting Magnet Structure -, JSME, JSME S KA 1-2008, Maruzen (2008)