Development of ITER PF6 Coil Assembly Tools and Mock-up Test

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1. Introduction

The ITER magnet system is mainly composed of 3 coil groups; (a) 18 toroidal field (TF) coils, (b) 6 poloidal field (PF) coils and (c) 18 correction coils (CCs). According to assembled position, 18 CCs are classified into 3 groups which are top CCs, side CCs and bottom CCs. The ITER Tokamak assembly tools are purpose-built tools to assemble the ITER components which include the cryostat and the components contained therein. Based on the design description document prepared by the IO (ITER international organization) [1,2], ITER Korea has carried out the conceptual design of assembly tools with IO cooperation [3,4].

PF6 and PF5 coils should be placed on the cryostat base before sector assembly. After completion of sectors assembly, PF6 and PF5 coils would be assembled with TF coils by assembly tools. For easy assembly, PF6 assembly tools should lift coil simultaneously without incline of horizontal level. Especially, PF6 assembly procedure and verified tools are very important because maintenance of tools is impossible due to assembled sector. Therefore, PF6 assembly tools should be designed to ensure that PF6 coil is lifted to final position by the 6 synchronized hydraulic cylinders without incline of coil. And this synchronized system should be verified by its mock-up test.

In this paper the conceptual design of PF6 assembly tools is introduced about function, structure and mock-up manufacturing and its test are also described for verification of design.

2. Design and Mock-up

2.1 Tool Function

The function of the PF6 assembly tools is, as shown Fig. 1, is to support temporarily until completion of assembly of 9 sectors and to lift PF6 coil to final assembly position. Due to PF6 coil weight up to 360 tons, PF6 assembly tools should be designed to withstand heavy load of PF6 coil.

The PF6 coil is temporarily placed, on 6 sets of adjustable PF6 assembly tools mounted on the cryostat base. After sector assembly is complete, PF6 coil is raised on the assembly tools in 12 stages using vertical hydraulic jacks and H-beam segments. H-beam segments are bolted together for stability during positioning work. The horizontal positioning is done by the bottom square plate which has 4 hydraulic jacks to push the vertical column of support in two directions. Low-friction sliding pads are provided between the upper plane of the bottom square plate and the bottom plane of vertical column.

Considering smooth lifting of PF6 coil and narrow assembly clearance, synchronized system should be equipped for assembly tools. PF6 assembly tools have interface with cover plate PF6 coil. Other surface of PF6 coil is thin plate.

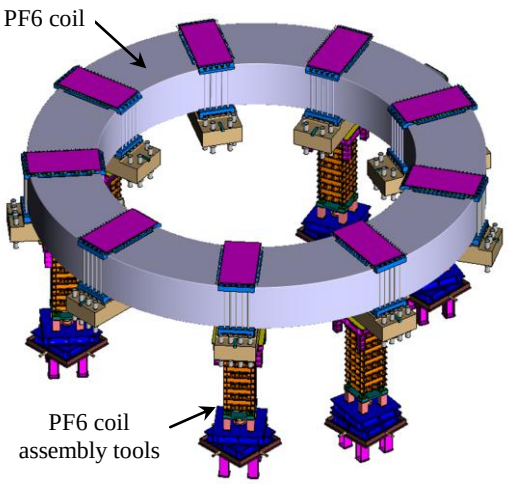

Fig. 1. Configuration of PF6 coil and assembly tools.

2.2 Tool Structure

PF6 assembly tools consist of 6 temporary supports with lifting system with hydraulic cylinder. These 6 hydraulic cylinders are controlled by solenoid valve respectively. Moreover, this hydraulic system is operated by linear scale sensor and their feedback equipped with displacement control.

A temporary support is required to locate each of the lower PF coils at an appropriate height, determined as the minimum height necessary to provide vertical clearance to the coil terminal boxes, during assembly. Shown in Fig. 2, the support comprises a rigid frame, ~ 2 m in height and with a footprint of 1 m x 1 m. The supports may be fabricated in carbon steel, and protected via non-powdering epoxy paint. However, the adjustable interfaces with the cryostat base and PF coils must be clad in stainless steel. In principle, the supports interface only with the cryostat base and the PF6 coil.

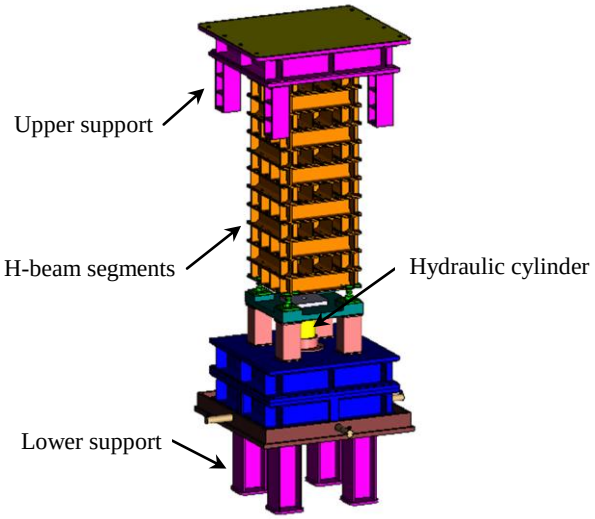

Fig. 2. Configuration of PF6 assembly tool including H-beam segments.

2.3 Mock-up Manufacturing

For verification of design and check feasibility of assembly procedure, this tools should be tested using mock-up. Mock-up of PF6 assembly tools fabricated in 1:5 scale as shown in Fig. 3. Also PF6 coil dummy made for mock-up test. Hydraulic cylinders with linear scale sensor are used for lifting PF6 coil dummy. These cylinders are controlled by solenoid valve respectively. All structures are made of structural carbon steel.

Fig. 3. Mock-up of PF6 coil assembly tool

2.4 Mock-up Test

In this test, values between linear scale sensor and real measurement using vernier calipers are compared for reliability of tools. This test carried out the times and height of lifting is 200 mm. heights of all position are measured and recorded. Test results are shown Table 1. This result indicates that design of PF6 assembly tools is feasible to support and lift PF6 coil safely without any incline.

Table I: Height Values from Linear Scale Sensor and Vernier Calipers Measurement

Cylinder Position	Linear Scale Sensor (mm)	Vernier calipers (mm)
C1	200.0	200.3
C2	199.9	200.0
C3	199.9	200.3
C4	200.2	200.1
C5	200.2	200.5
C6	200.3	200.4
Average	200.1	200.2

3. Conclusions

The conceptual design of PF6 assembly tools has been developed by ITER Korea to satisfy ITER assembly procedure and technical requirements for PF6 coil. For verification of design of PF6 assembly tools, mock-up test carried out to secure that these tools maintain performance of synchronized system for assembly feasibility of PF6 coil. And this mock-up test results show that conceptual design of PF6 assembly tools is feasible to assemble PF6 coil. Detailed design work continues by May 2012.

REFERENCES

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