Series Production of ITER TF Coil Winding Pack (WP) in Japan

N. Koizumi, K. Matsui, T. Hemmi, H. Kajitani, M. Nakamoto,
M. Yamane, K. Sakaguchi

National Institutes for Quantum and Radiological Science and Technology
(QST)

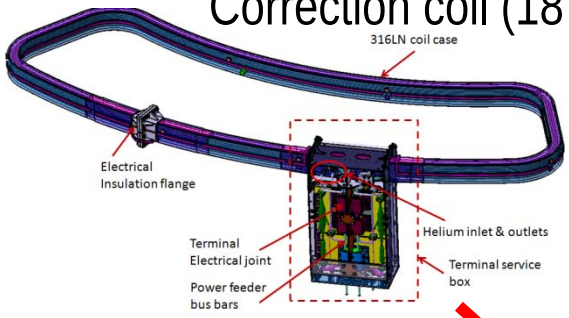
25th International Conference on Magnet Technology (MT25)
August 29, 2017
RAI-Amsterdam, Netherland

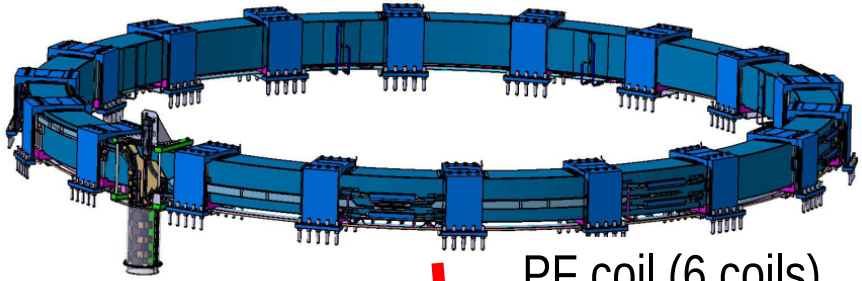
Outline

1. *Introduction*
2. *Double-Pancake (DP) fabrication process and its progress*
3. *Technical issues in WP fabrication*
4. *WP fabrication progress*
5. *Summary*

ITER Magnet System

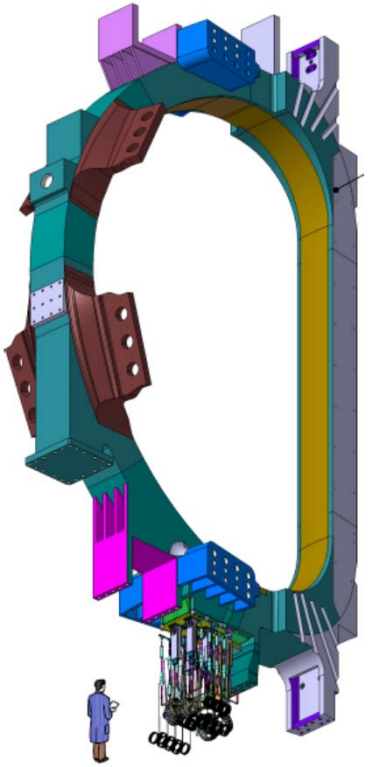
Correction coil (18 coils)

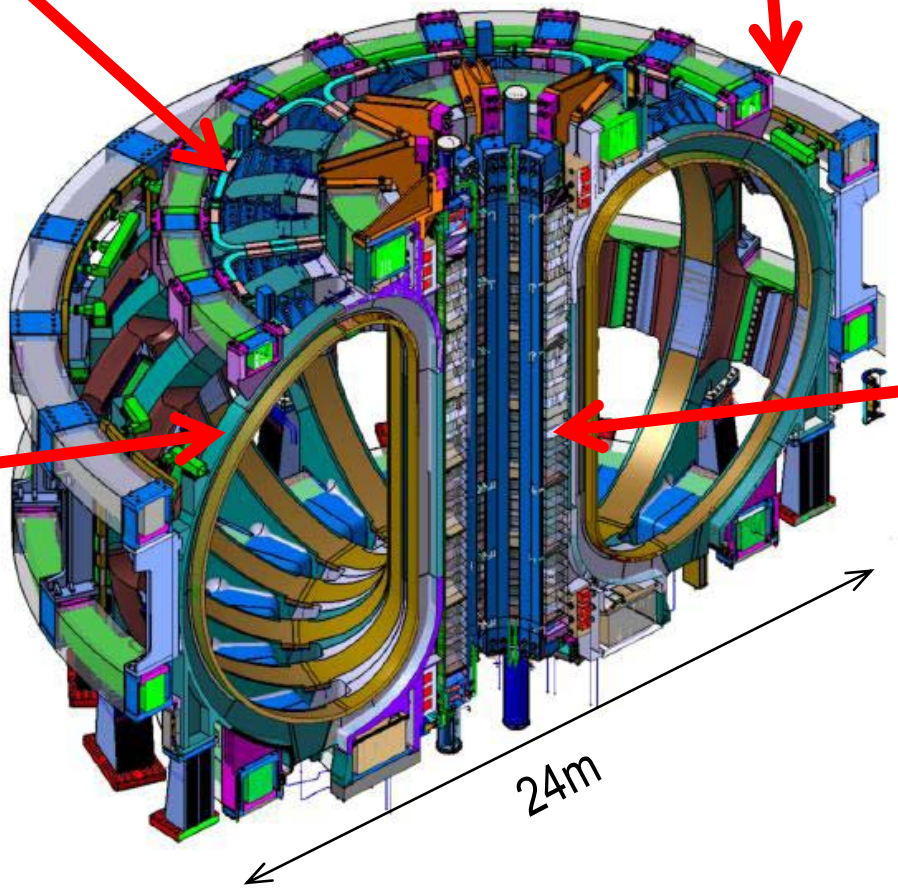


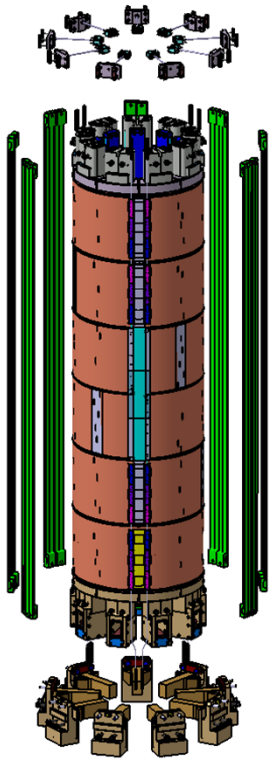


PF coil (6 coils)

TF coil (18 coils)

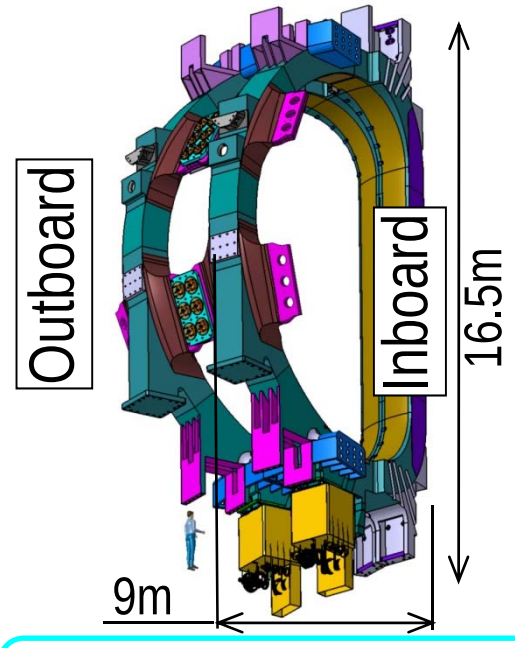




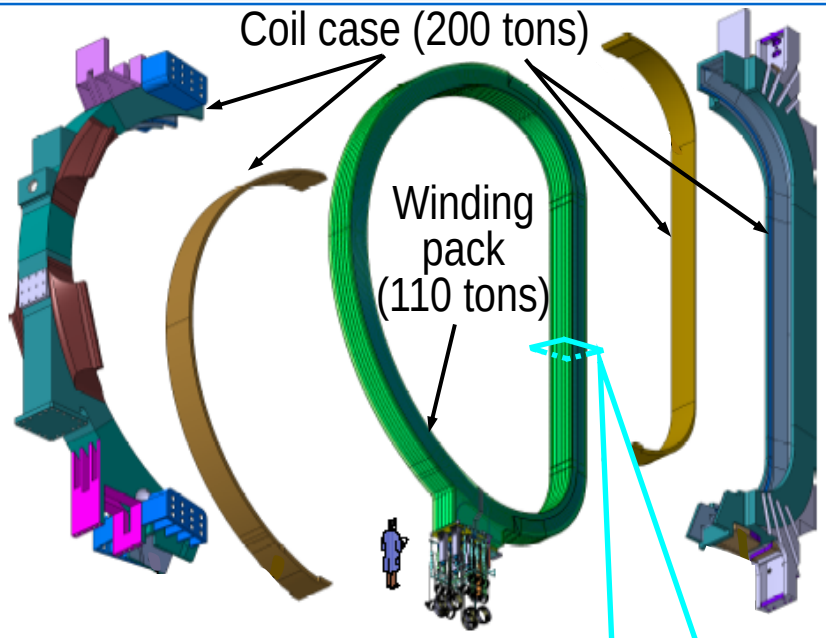


CS (6 modules)

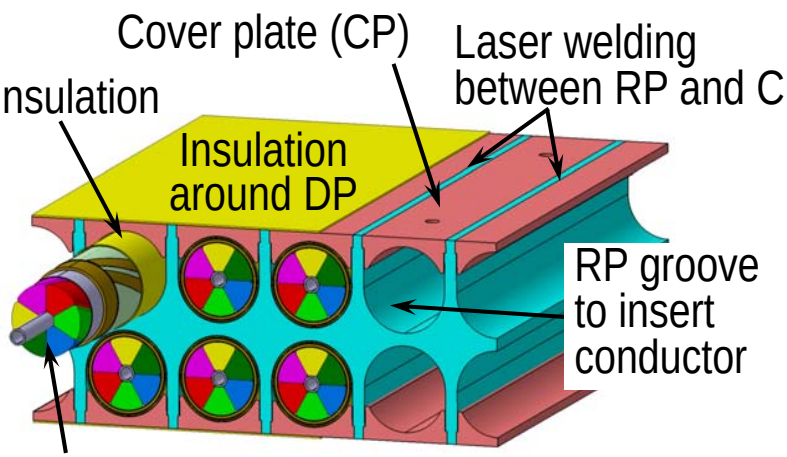
ITER TF Coil

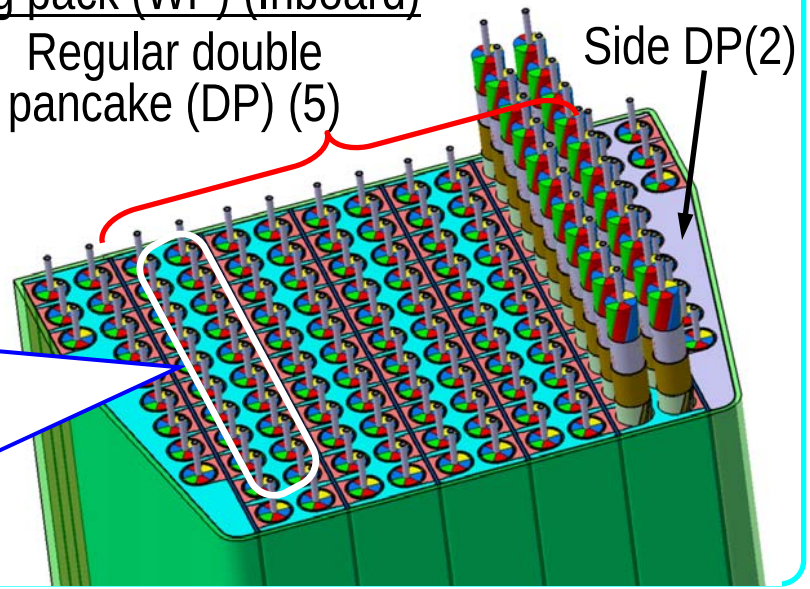


Nominal field
= 11.8T
Nominal current
= 68kA



Cross-sectional view of a TF winding pack (WP) (Inboard)

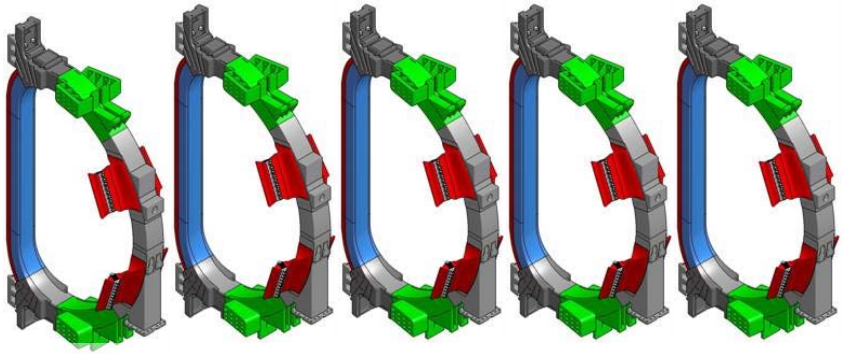




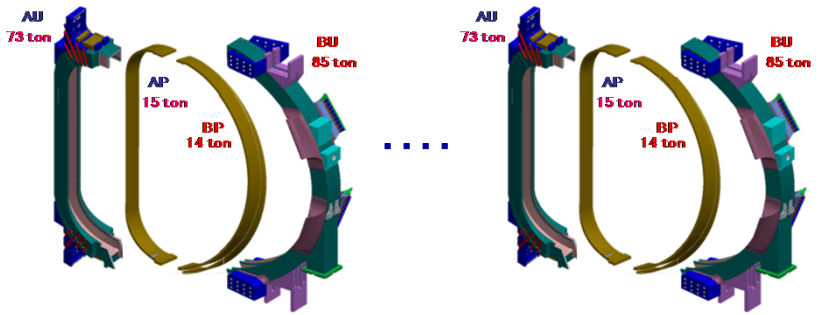
Scheme of TF coil procurement in Japan

QST

MHI with Melco & HHI

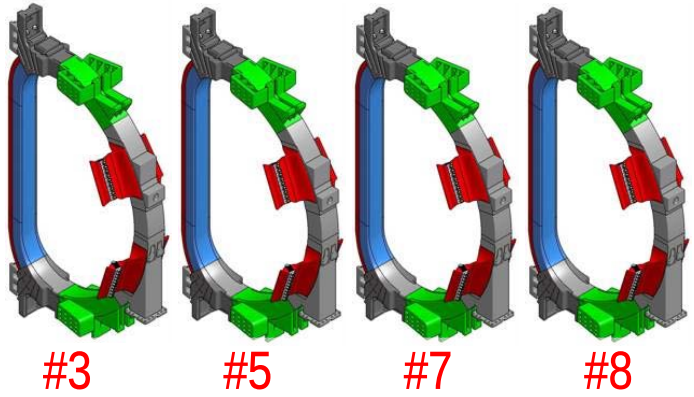


5 JA TF coils

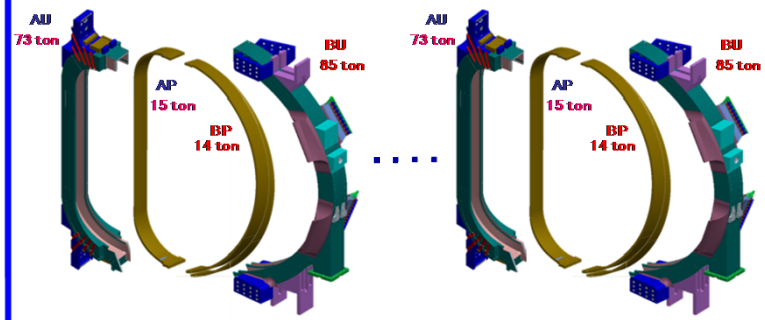


4 EU TF coil cases (TFCS)

Toshiba (TSB)



4 JA TF coils



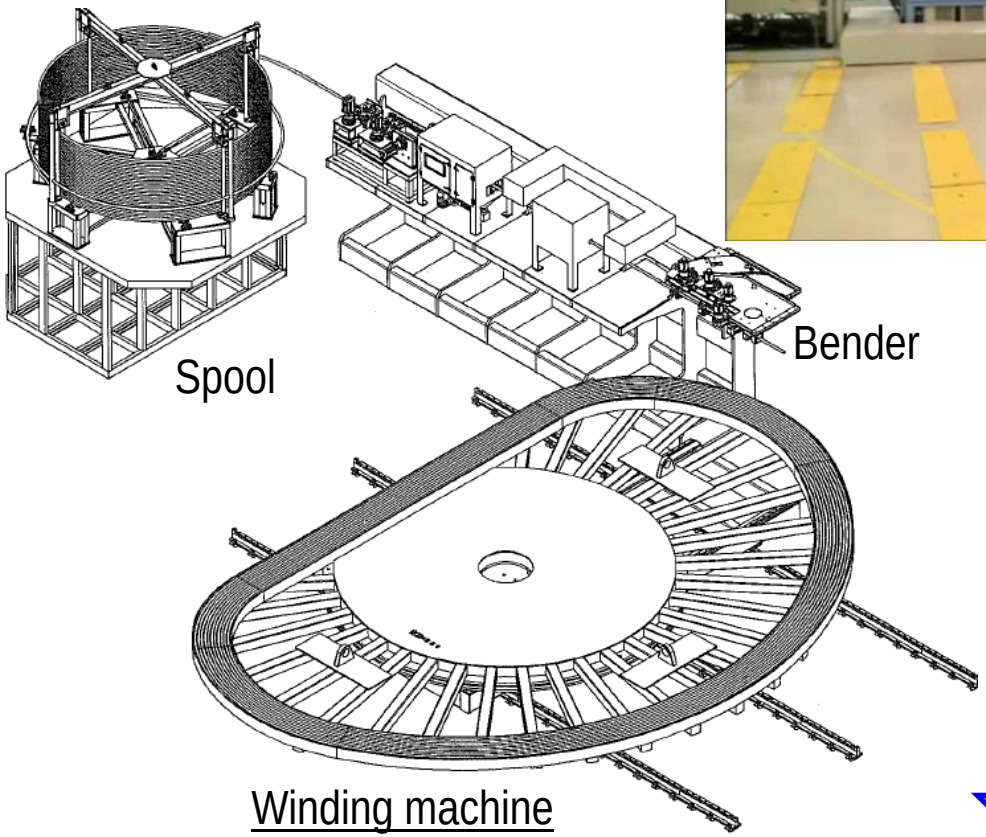
6 **EU TFCSs**

Outline

1. Introduction
2. Double-Pancake (DP) fabrication process and its progress
3. Technical issues in WP fabrication
4. WP fabrication progress
5. Summary

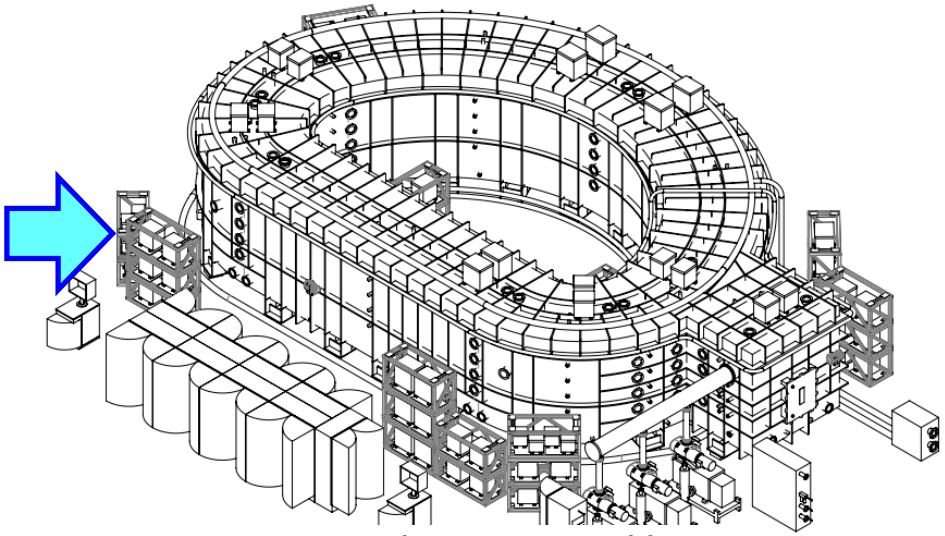
1) DP Winding

TF conductor:
CN, JA, KO



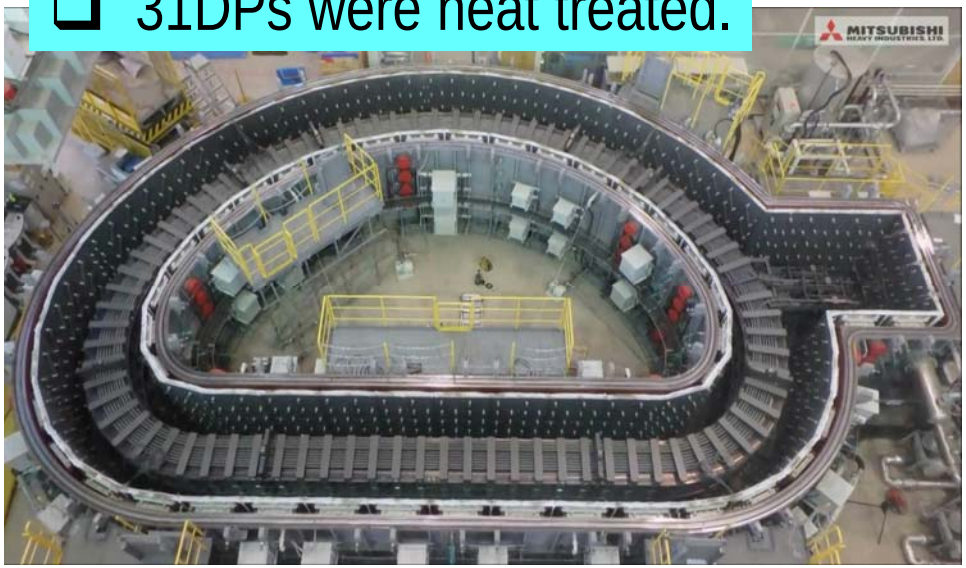
- Winding of 31DPs were completed.

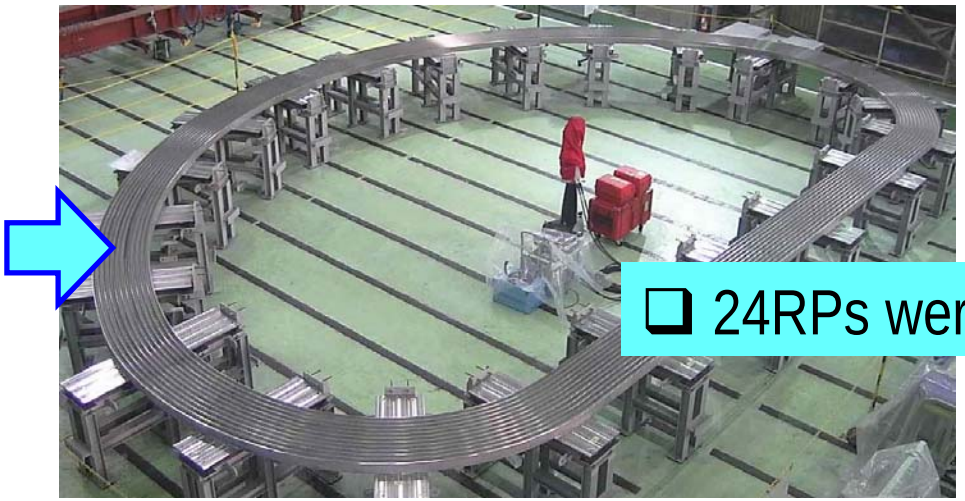
2) DP Heat treatment, 3) RP fabrication



Heat treatment (650°C, >100h)

❑ 31DPs were heat treated.



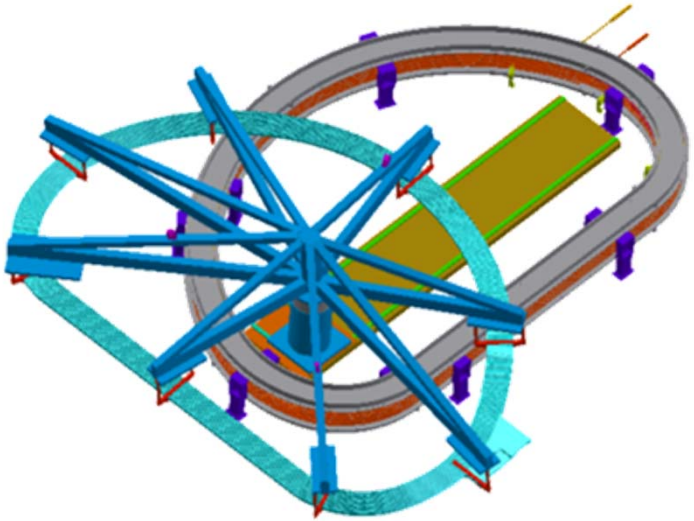


❑ 24RPs were completed.

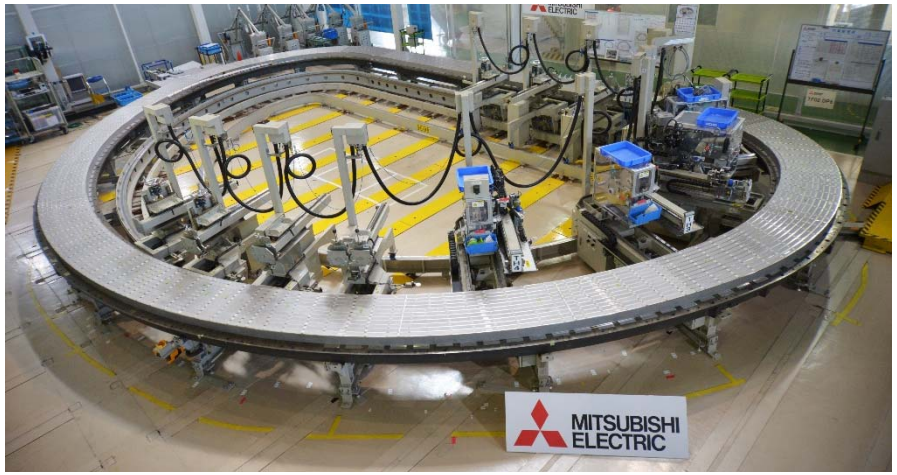
RP made by MHI

RP made by TSB

4) Transfer and turn insulation



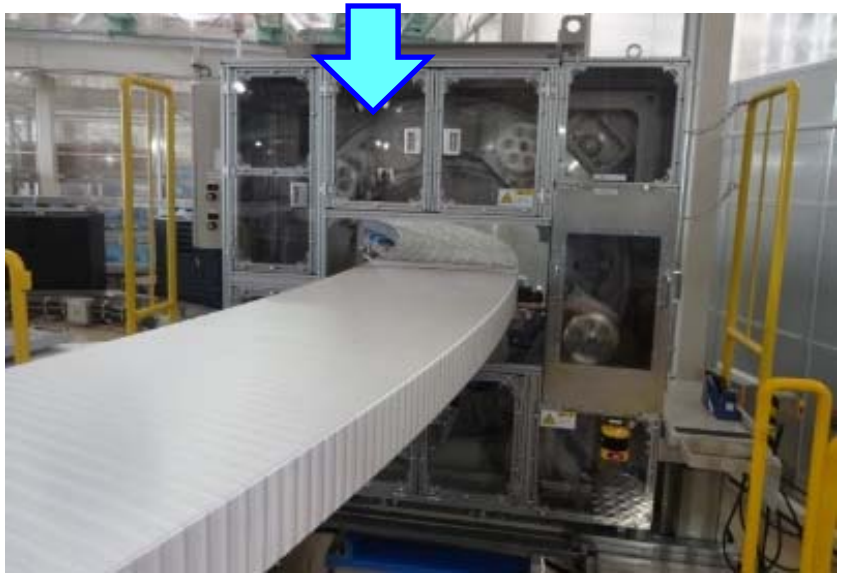
Transfer of conductor into RP groove



Turn insulation

- Turn insulation of 20DPs were completed.

5) DP insulation, impregnation



DP insulation

Completed DP

Impregnation of DP

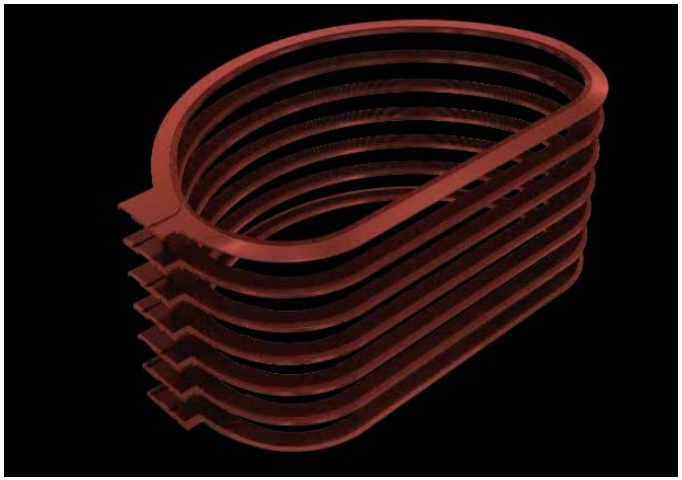
- 15DPs were completed.

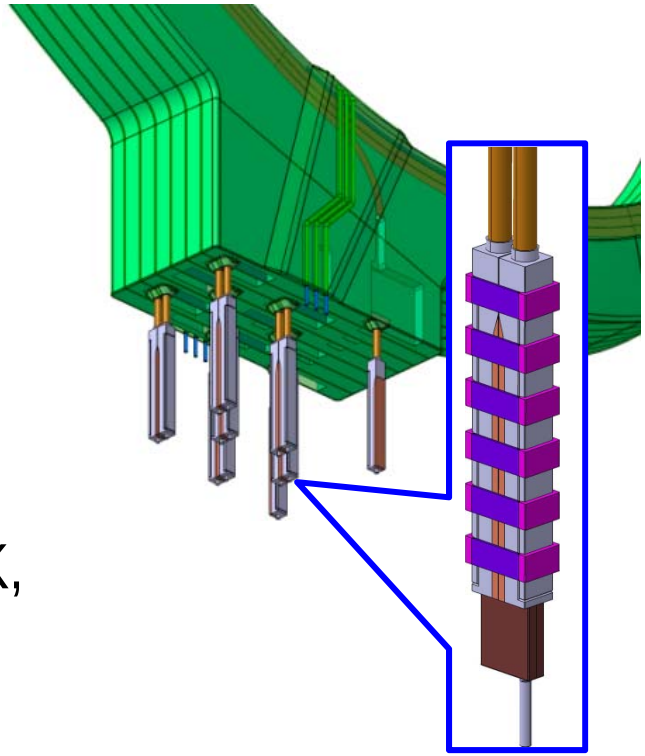
Outline

1. Introduction
2. DP fabrication process and its progress
3. Technical issues in WP fabrication
4. WP fabrication progress
5. Summary

WP manufacturing procedure

1. 7 completed DPs are stacked with inserting glass fabric between each DP in order to adjust position of DP and achieve good bonding between DPs;
2. 15 multilayer GK ground insulation tapes are wrapped around the stacked DPs;
3. electrical connections are established between adjacent DPs by means of an inter-DP joint;
4. the ground insulation is vacuum-pressure impregnated (VPI) with inter-DP glass fabric to form a rigid WP;
5. cooling pipes are assembled, and
6. final inspection of WP, including cold test at 80 K, is performed.

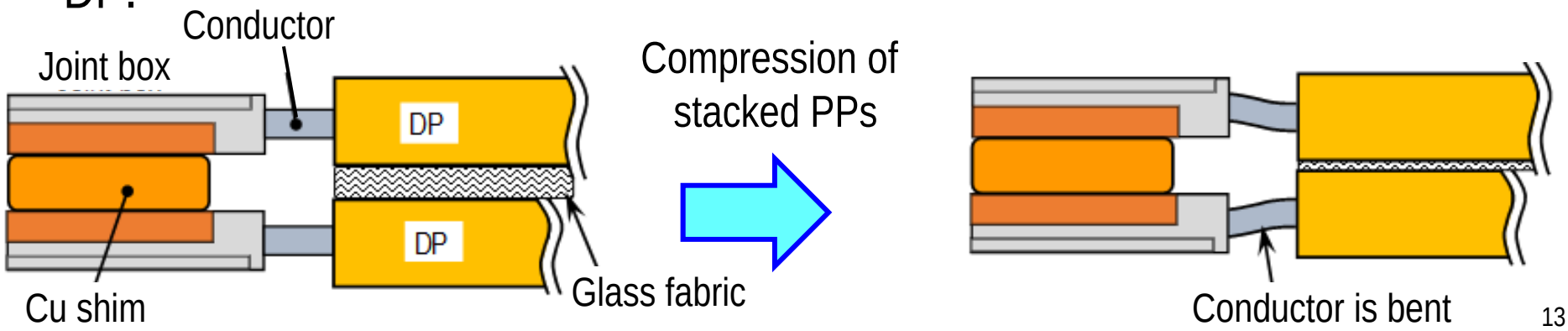




Technical issues in WP fabrication (1)

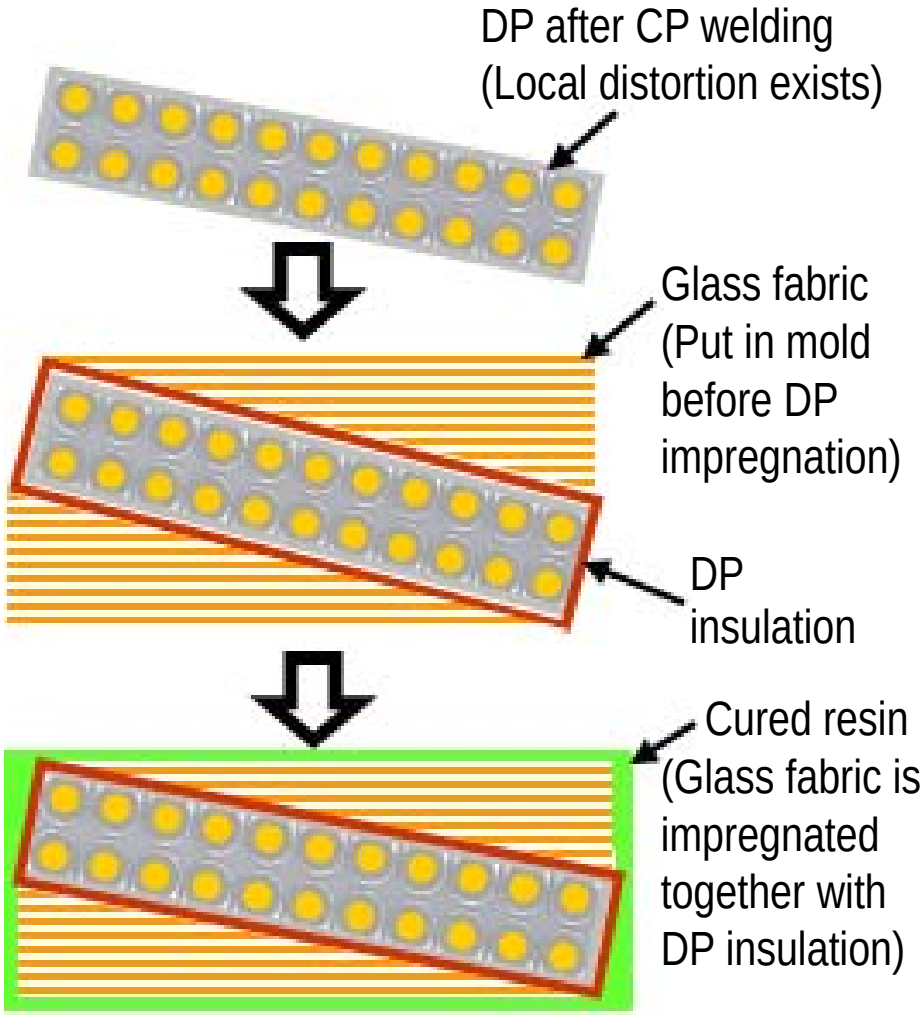
- Height of a WP is limited to be below only 3 mm thicker than the nominal, 824.6mm, to enable WP to be inserted into coil case with proper margin.
- DP height becomes higher due to distortion by CP welding and WP height is accumulated by seven DPs. 5 mm glass fabric layer exists between each DP to compensate this distortion in original manufacturing plan.
- Accordingly, compression of WP impregnation mold makes the glass fabric layer thinner. This may originate;

1. winkle of ground insulation tape wrapped around WP; and
2. degradation of conductor next joint and/or impregnated DP insulation at conductor outlet by local bending of the short conductor between joint and DP.

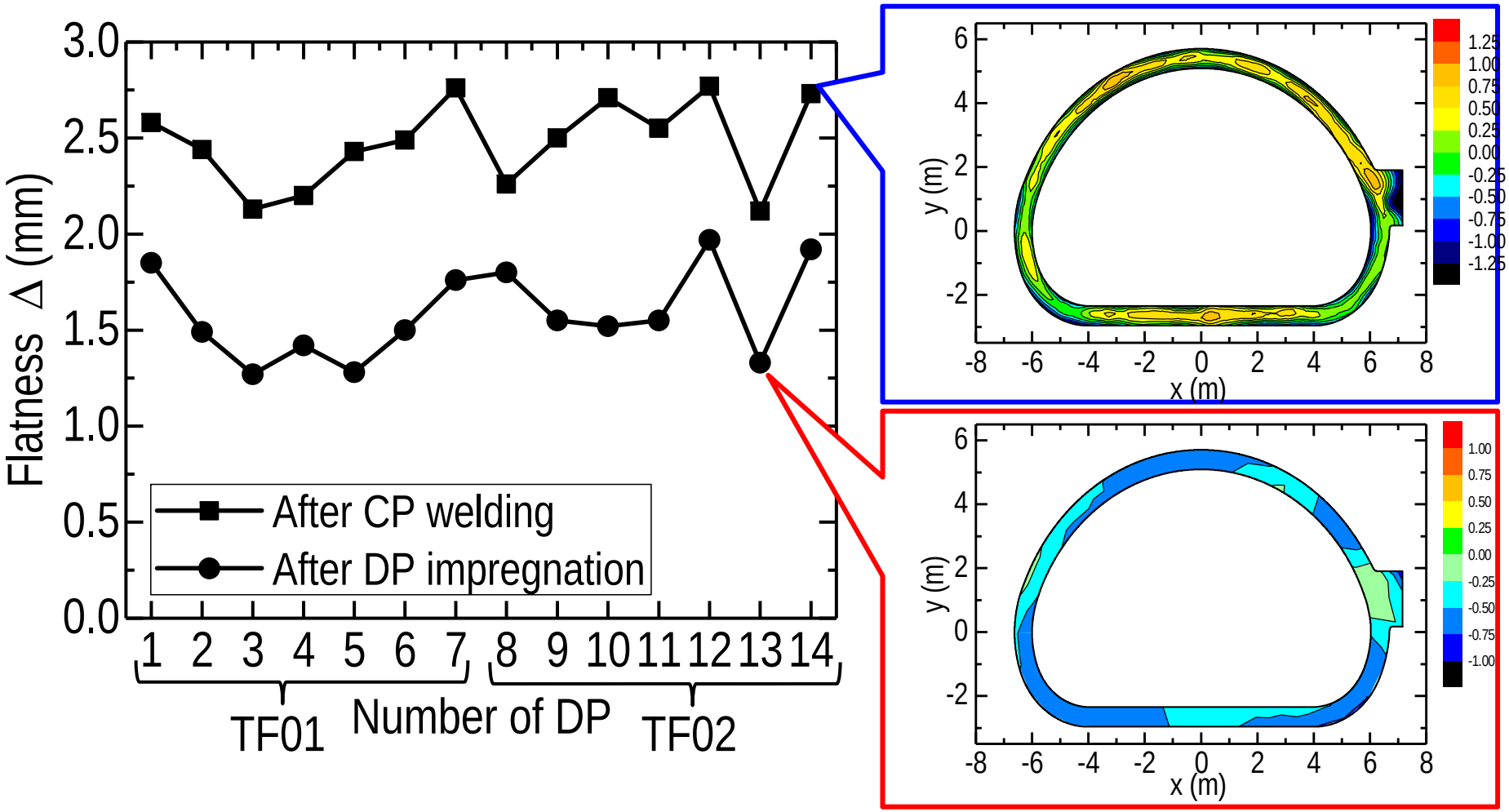


Measures to this technical issue

- Inter-DP glass layer thickness is made thinner, 2 mm instead of 5 mm, with compensating DP distortion by CP welding.
- WP ground insulation tapes are wrapped around WP with applying tensile force of 120 N by automatic taping machine.
- Cu shim between DP joints is soldered after compressing WP impregnation mold.



Flatness of DPs



- Flatness of impregnated DPs are within 2 mm as planned.
- Local flatness of impregnated DP is much better than those after CP welding.

Other technical issues in WP fabrication

- Current center line measurement.
  - ➔Tue-Af-Po2.03-06: M. Nakamoto, et al., “Current Center Line Measurement of ITER TF Coil”

- Joint resistance measurement at normal state
  - ➔MT25-Wed-Af-Po3.02-06 : H. Kajitani, et al. “New inspection method of joint resistance at room temperature for ITER TF Coil”

Outline

1. Introduction
2. DP fabrication process and its progress
3. Technical issues in WP fabrication
4. WP fabrication progress
5. Summary

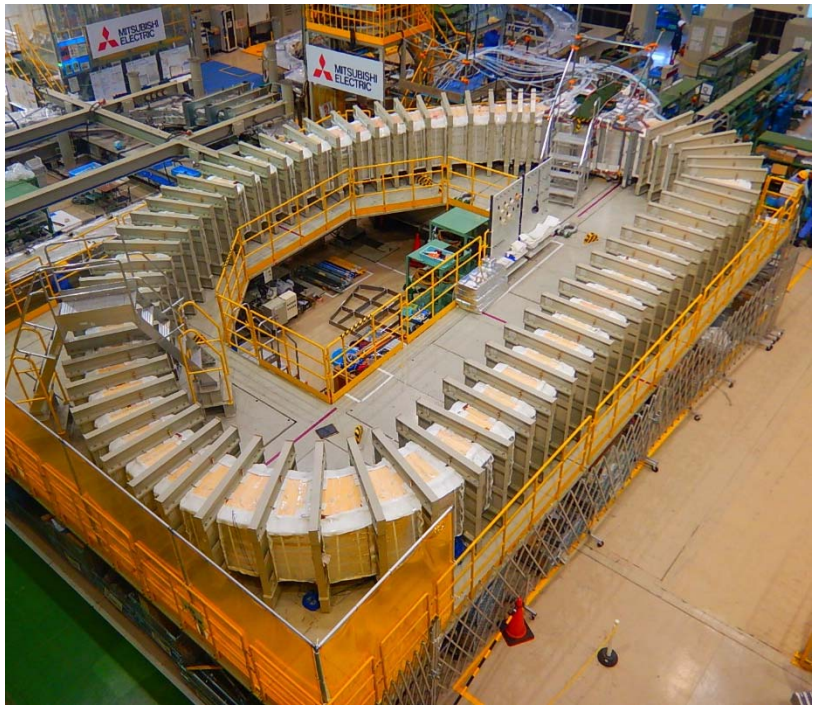
DP stacking

- DP stacking for 2 WPs was completed.

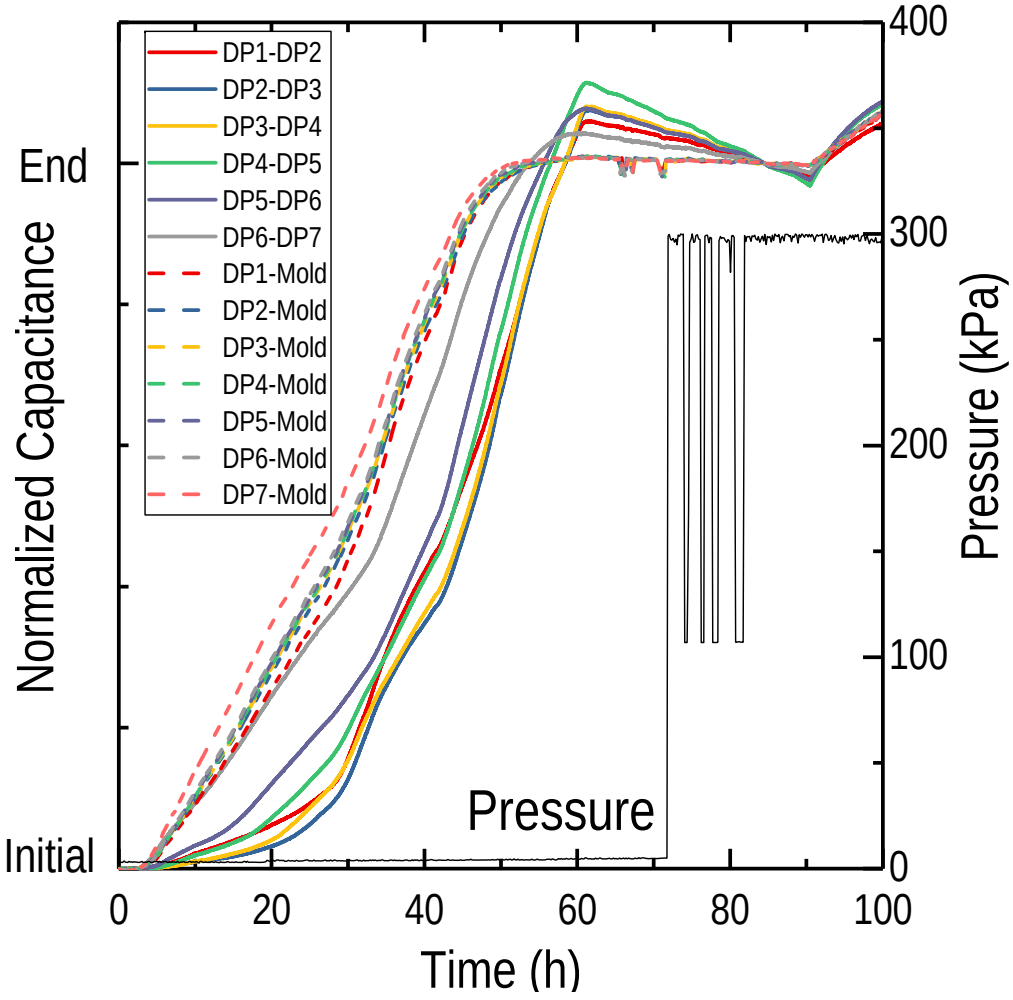
WP ground insulation

- 1st WP ground insulation was completed.

WP impregnation



- Curing of 1st WP is finished and WP is being cooled down.
- Capacity measurements between DPs and between DP and mold indicates good impregnation.



Normalized capacitance during WP impregnation

5. Summary

- Optimized manufacturing plan is established to solve the technical issues in DP and WP fabrication.
- As part of this purpose, DP flatness of 2 mm was achieved by putting glass fabric on locally distorted and/or dented area of DP surface during preparation of DP impregnation. This compensates local distortion, which is originated by CP welding, resulting in making DP stacking process much easier (positive to keep tight tolerance of WP height).
- The series production of DP and WP is in proceeded according to the optimized manufacturing plan and 31 DP winding, 20 DP transfer and turn-insulation, 15 DP impregnation was completed in Japan. In addition, curing of 1st WP impregnation is finished and WP is being cooled down.