FIP/1-3

Full-scale trial results to qualify optimized manufacturing plan for ITER Toroidal Field coil winding pack in Japan

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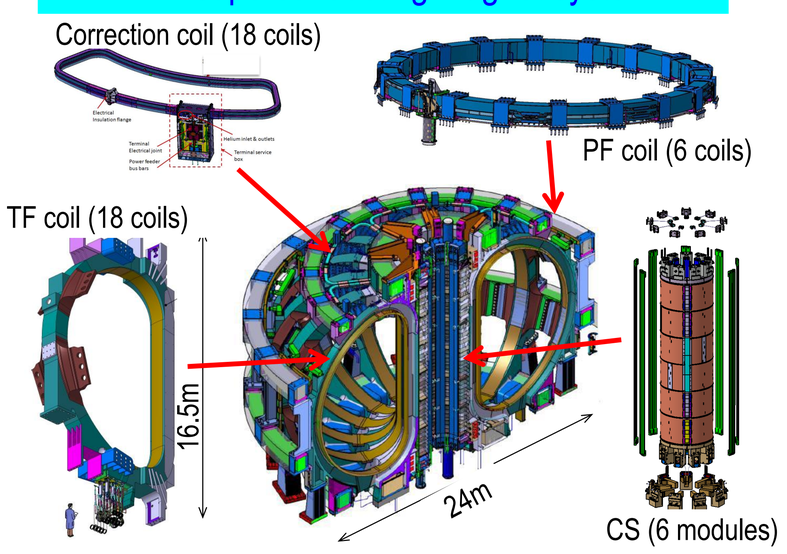
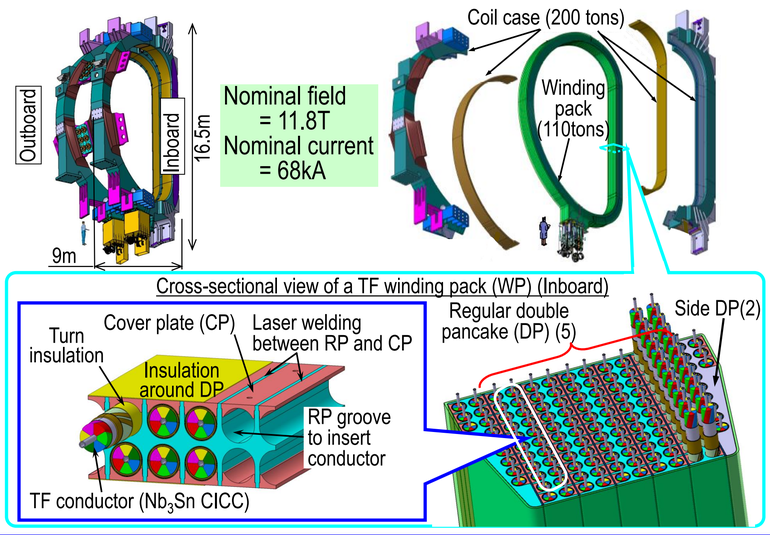
1. ITER TF coil and its procurement in Japan

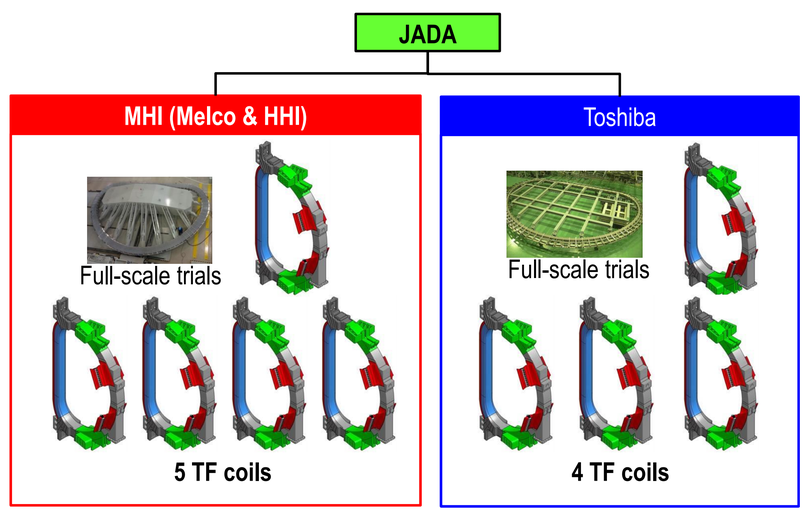
ITER superconducting magnet system



ITER Toroidal Field (TF) coil



Scheme of TF coil procurement in Japan



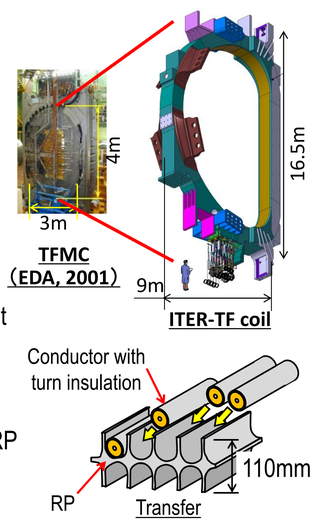
2. Technical issues and optimized manufacturing plan

Challenge in TF coil WP manufacture

- Basic technique of TF coil manufacture was demonstrated by TF model coil (TFMC) development during ITER-EDA.
- TF coil ≈ 3.5 X TFMC, but tolerances of TF coil ≈ those of TFMC.
- Allowable strain of TF superconductor <0.1%
  - ➔ Tight tolerance is challenging.

Most critical challenge (Transfer)

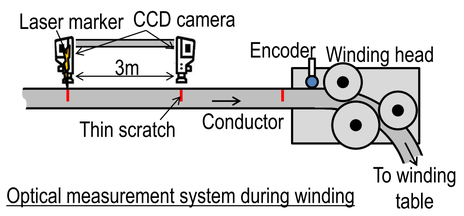
- TF conductor elongation after heat treatment ≈0.05%
- Other sources originating error; Winding, RP and dimension measurement
- Gap between conductor turn insulation and RP groove surfaces = 1mm or 1.5mm
- Original tolerance ≈ ±**0.02%** in length



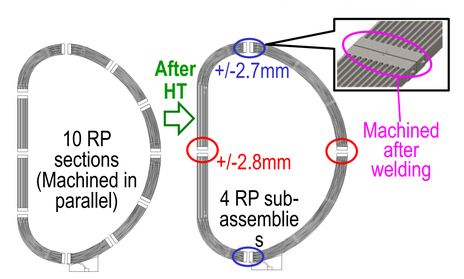
Challenge in TF coil WP manufacture

- To enable transfer, manufacturing plan is optimized.

1. High accuracy winding technique using optical measurement system. (Target accuracy = ±**0.01%**)
2. Highly accurate prediction of conductor elongation by heat treatment (HT). (Target accuracy = ±**0.02%**)
3. 4 RP sub-assemblies are assembled to fit RP groove length to heat-treated winding length. (Relaxed tolerance in conductor length ≈±**0.04%**)

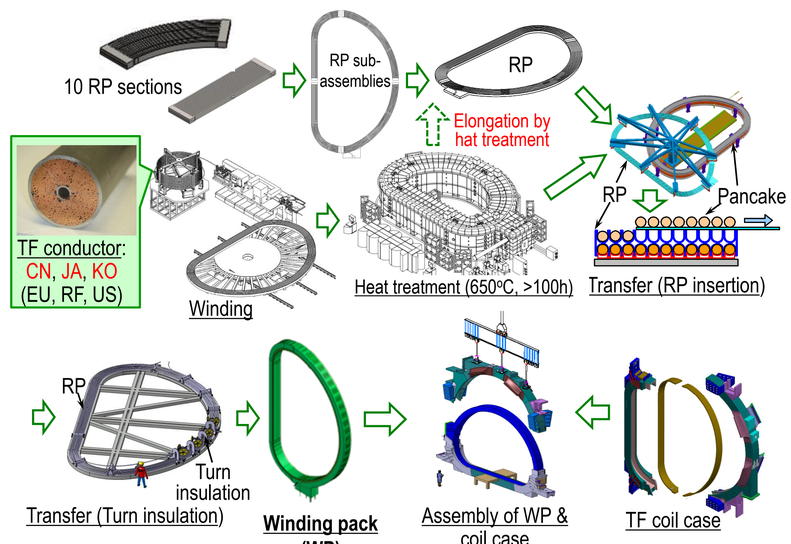


Optical measurement system during winding



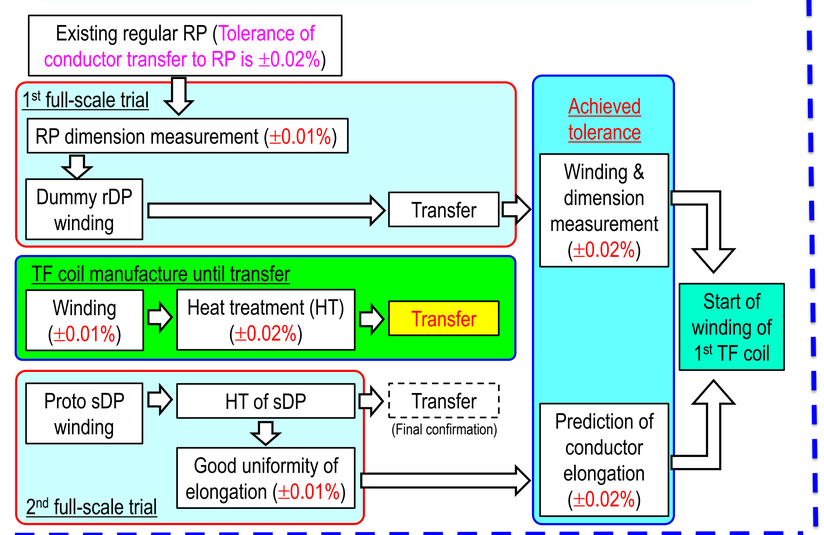
New RP manufacturing procedure

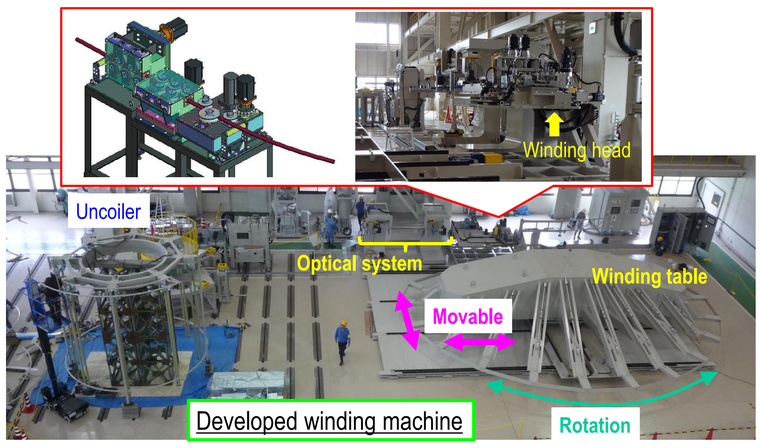
Optimized TF coil manufacture procedure



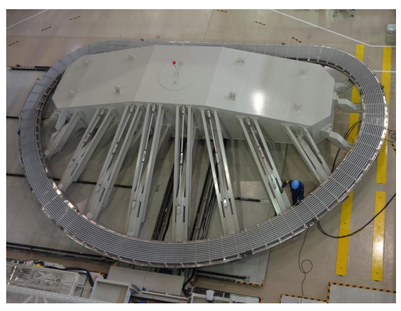
3. Full scale trials for TF coil winding pack manufacture

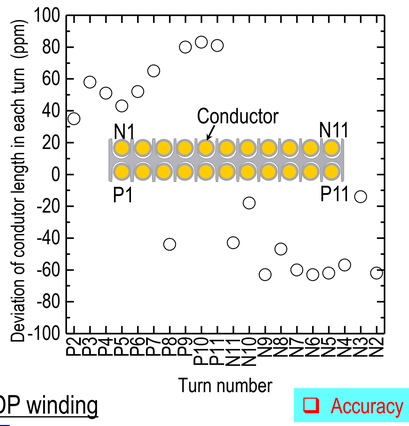
Strategy to accelerate full-scale trials



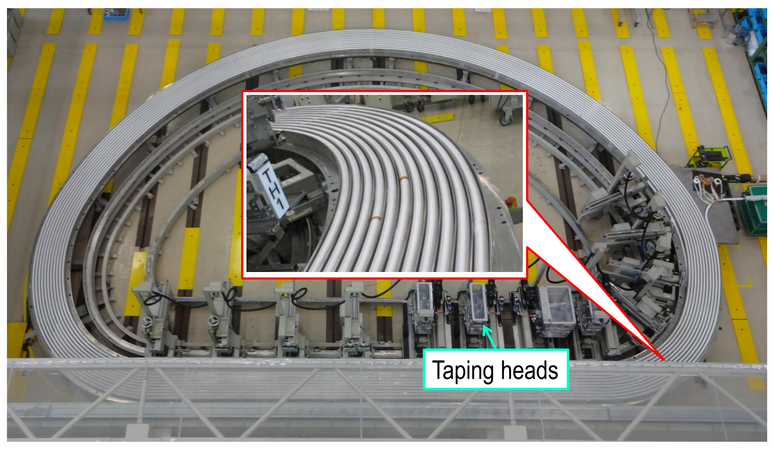


1st full scale trial





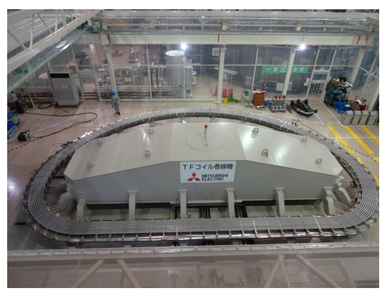
Dummy rDP winding

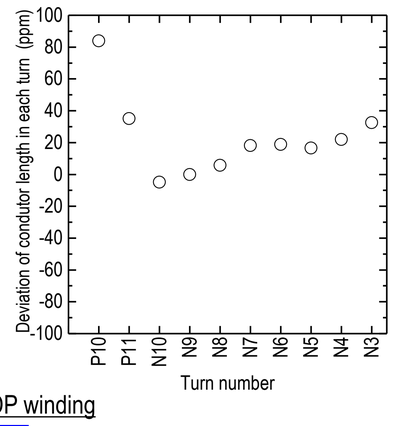


Dummy rDP transfer

❑ Accuracy of winding <0.01%

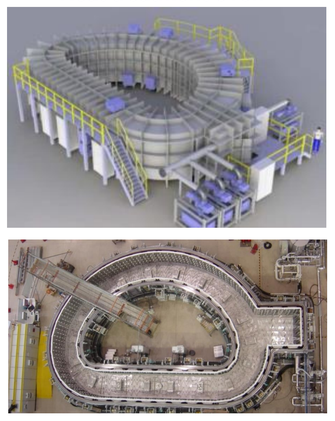
2nd full scale trial





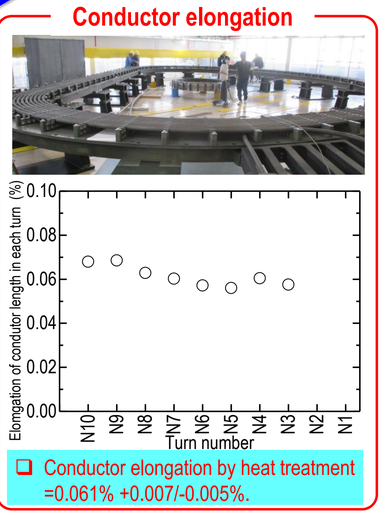
Proto sDP winding

Heat treatment oven



- ❑ Dedicated oven was fabricated.
- ❑ ±5 ºC at 650ºC was demonstrated.

Conductor elongation

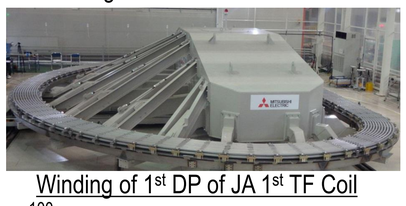


- ❑ Conductor elongation by heat treatment =0.061% +0.007/-0.005%.

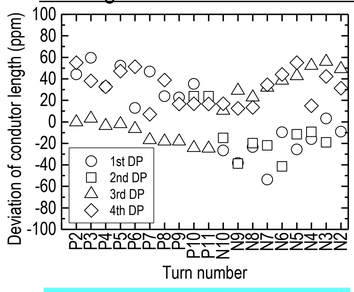
Proto sDP heat treatment

4. Progress in TF coil series production

- ❑ Winding of 5 DPs for the 1st TF coil was completed.

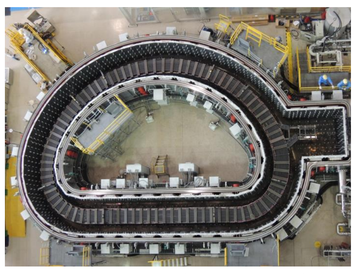


Winding of 1st DP of JA 1st TF Coil



Accuracy of winding <0.01%

- ❑ 1st DP was heat treated.



Heat treatment of 1st DP of JA 1st TF coil
(Elongation = 0.07% +0.006/-0.008%)

Elongation < Prediction(0.061%)±0.02%

5. Summary

Full-scale trials are performed to qualify the optimized manufacturing plan of ITER TF coil WP manufacture in Japan. The major achievements and progress are as follows:

- ❑High accuracy of winding to control conductor length with ±0.01% was demonstrated.
- ❑Heat treatment oven was developed with highly accurate temperature control and conductor elongation is predicted to be 0.06% ± 0.02%.

From these successful achievements, JADA started series production of TF coil. The present achievements are as follows:

- ❑5 DP winding was completed with satisfying target accuracy of ±0.01%.
- ❑1st DP was heat treated and elongation of conductor was within target accuracy of ±0.02%.

In addition, the delay from 2011 is being recovered.