MT25

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Fabrication of the 7.3 m long coils for the prototype of MQXFB, the Nb_3Sn low-β quadrupole magnet for the HiLumi LHC

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Background

As part of the HiLumi Project at CERN an upgrade of the interaction region in the period 2024-2026 is planned in order to achieve a peak luminosity of $5 \cdot 10^{34}$ $cm^{-2}s^{-1}$, and to reach 3000 fb^{-1} integrated luminosity about 12 years after the upgrade. The components to be upgraded include the inner triplet (or low-β) quadrupole magnets, named Q1, Q2a, Q2b, and Q3. The MQXFB with a magnetic length of 7.15 m will be inserted in a single cold mass and the cryostat for the Q2a and Q2b. Two MQXFB magnet prototypes will be manufactured at the LMF at CERN until 2019.

Objectives

- Coil production for the assembly of the first MQXFB prototype magnet;
- Status of production, qualification measurements of production and tooling fabrication for the assembly process in the CERN Large Magnet Facility.

Conclusion

An overview about the successful coil impregnation process is presented. Three long MQXFB coils were impregnated so far, electrical qualification tests carried out on the low performance coils have indicated the robustness of the resin insulation. The procurement of tooling for the prototype magnet assembly has been launched.

- Results from electrical testing and geometrical inspection are shown;
- An overview about the successful coil reaction and impregnation process is presented;
- Three long coils were impregnated so far, electrical qualification tests carried out on the low performance coils have indicated the robustness of the resin insulation;
- The procurement of tooling for the prototype magnet assembly has been launched;
- The production outline aims to a first functional and full performance prototype assembly in the first quarter of 2018.

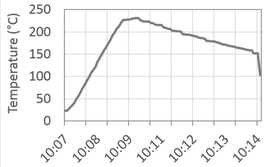
Production schedule

Coil ID	Conductor	Status	Date
CR101	RRP-low grade	Impregnated	March 2017
CR102	RRP-low grade	Impregnated	July 2017
CR103	RRP	Damage after RHT	June 2017
CR104	RRP	Wound and cured	July 2017
CR105	RRP	Wound and cured	August 2017
CR106	RRP	Cable received	August 2017
CR107	RRP	Cabling	August 2017

In 2016 two copper practise coils were produced, followed by two coils made from low performance Nb_3Sn RRP conductor. The production is currently continuing on the RRP full performance conductor. Table above represents the status of this coil production for the first prototype. Coil CR104 will be reacted in September 2017 followed by the vacuum impregnation. The winding and curing of coil CR105 have been launched in the beginning of August and will be finalized after the production duration of three working weeks.

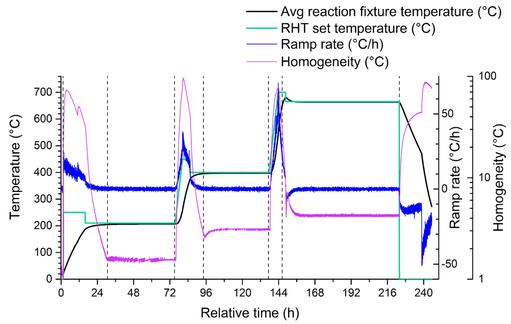
Splicing

Splicing tool



Reaction Heat Treatment

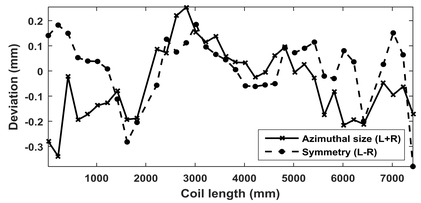
The GLO10000 furnace is used to perform the heat treatment. It was specified to achieve a temperature homogeneity of ±3°C along the 7.15 m long coil during temperature plateaus at 210°C, 400°C and 665°C. For this purpose, the furnace provides the control of 16 heating zones.



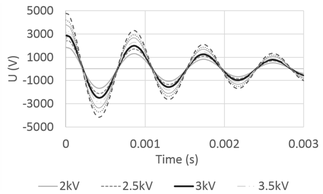
Results

Geometrical and electrical qualification

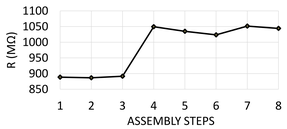
Geometrical qualification:



Discharge test:



The cross-section is measured each 200 mm over the coil length. The graph shows a variation in the total arc length of up to 100 µm creating a minor asymmetry of maximum 300 µm. This is given mainly by the assembly tolerances on the impregnation fixture.



The electrical resistance measurement with a current of 2 A throughout the coil production. The reaction fixture assembly and bolting (assembly step 1 to 3) do not show a major impact on the resistance values. After the RHT (step 4) the coil resistance value is increasing which can be explained by the pollution of copper during the RHT.

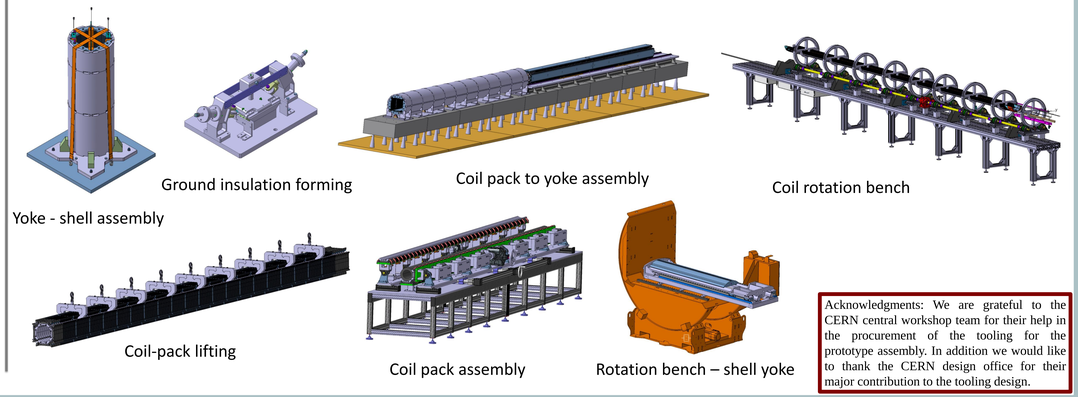
Total pole gap during steps of fabrication:

Coil ID	Before winding [mm]	Before heat treatment [mm]	After heat treatment [mm]
CR101	17.6	12.5	6.6
CR102	17.6	10	1.8
CR103	13.6	7.9	0
CR104	16	*	*
CR105	16	*	*

The distribution of the titanium pole gaps before winding operation is crucial to achieve a closed pole gap after the RHT. The titanium pole of the MQXFB coils is divided into seventeen parts which are assembled on the winding mandrel. Each production step is followed by an electrical qualification test at low current.

Tooling for the prototype assembly

The design of all required assembly tooling was finalized and the procurement launched. The tooling commissioning will start in autumn 2017. The first assembly trials will be based on low performance and copper coils.



Acknowledgments: We are grateful to the CERN central workshop team for their help in the procurement of the tooling for the prototype assembly. In addition we would like to thank the CERN design office for their major contribution to the tooling design.