Fine tuning of MCBXF design

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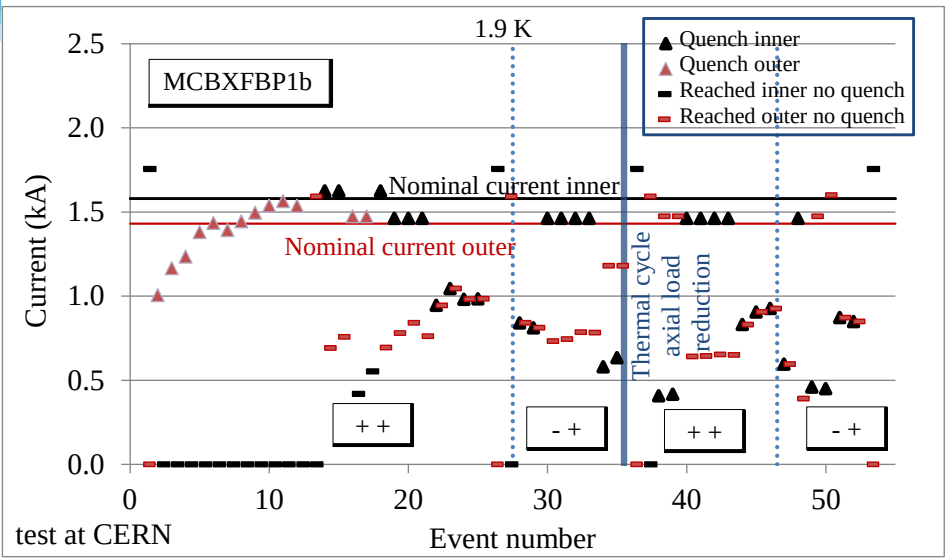
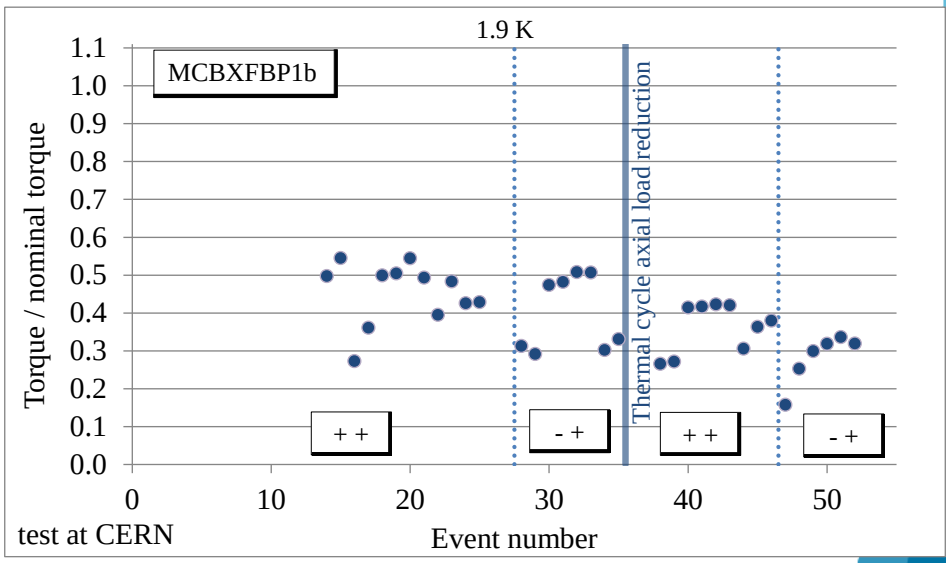
RESULTS OF FIRST PROTOTYPE

- First assembly reached ultimate current in each plane individually (March 2019) ☺
  - With no retraining after thermal cycle
- With simultaneous powering, the magnet reached 30% to 55% of torque
  - Note that reaching 50% of the torque means operating at 71% of the current (torque is proportional to the square of the current
- The release of axial load confirmed the limitation due to the torque in the heads

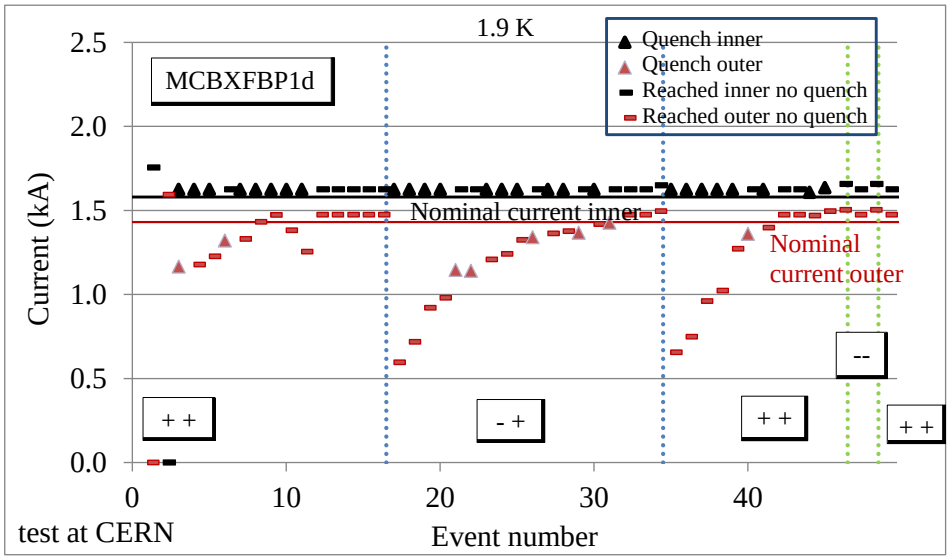


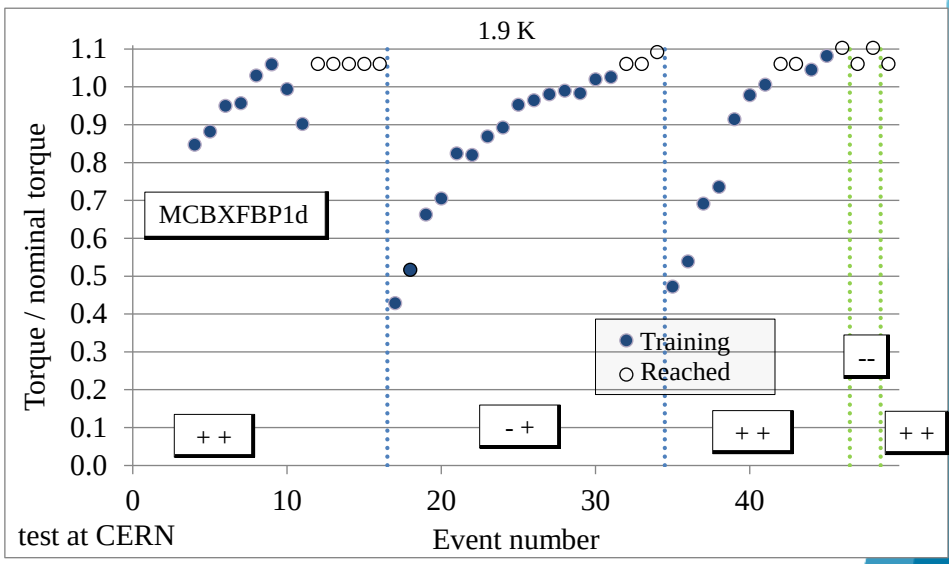


Training of MQXFBP1b (left) and maximum torque reached (right)
(G. Willering et al.)

RESULTS OF FIRST PROTOTYPE

- Third iteration on the assembly reached nominal torque (August 2019) ☺
  - The changes was a shimming in the coil heads
  - This shimming of coil heads is a critical part of the assembly and should be carefully followed and agreed with CIEMAT
- … but retraining when changing the sign of the torque, starting from 40%

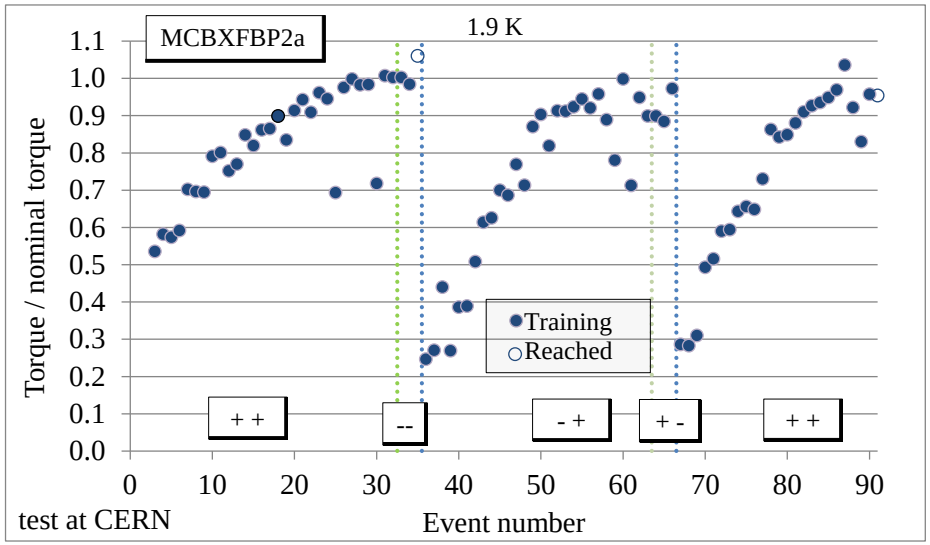


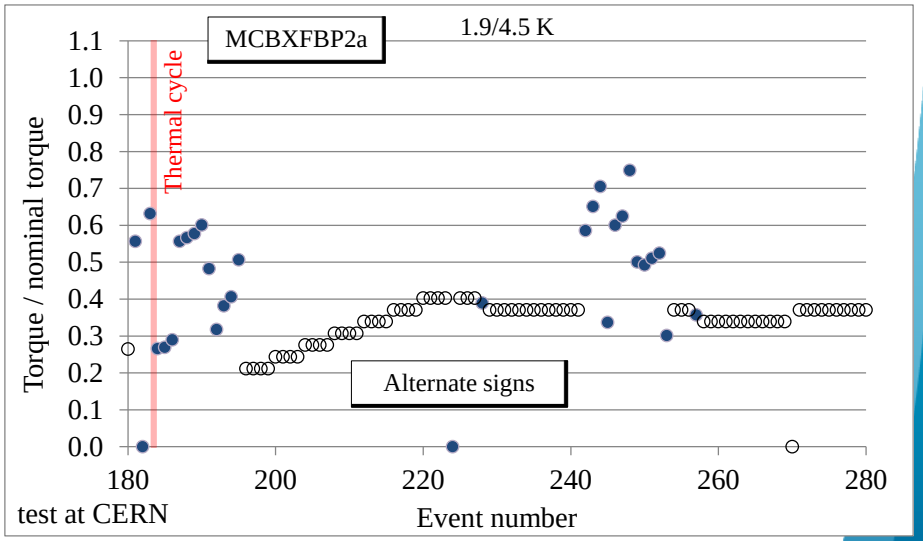


Training of MQXFBP1d (left) and maximum torque reached (right) (G. Willering et al.)

RESULTS OF THE SECOND PROTOTYPE

- Reproducibility: second prototype MCBXFBP2
  - Similar behaviour: nominal torque reached, retraining needed when changing torque, all signs accessible when torque is limited to 35%
    - Some erratic behaviour around nominal

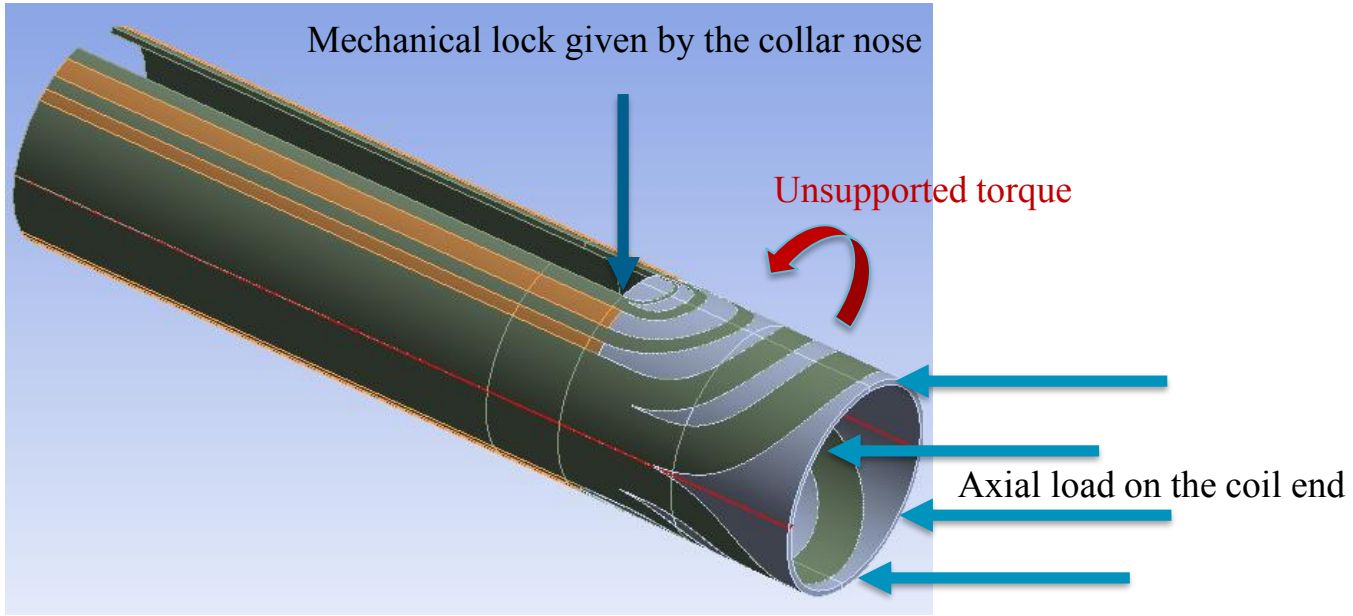




Maximum torque reached in MCBXFBP2 (S. Ferradas Troitino et al.)

FINE TUNING OF DESIGN

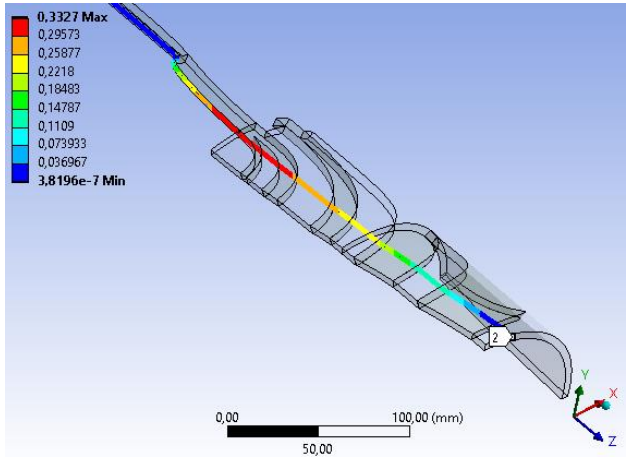
- Fine tuning of design
  - CIEMAT team proved that a fine tuning of the magnetic length of the inner dipole would decrease the displacement induced by the unsupported torque in the head by order of 30% - and possibily improve the retraining limitation
  - This fine tuning corresponds to reducing the magnetic length by 10% (about 10 cm over 1.2 m) and aligning the inner layer head with the outer layer head
  - This change is transparent for the production



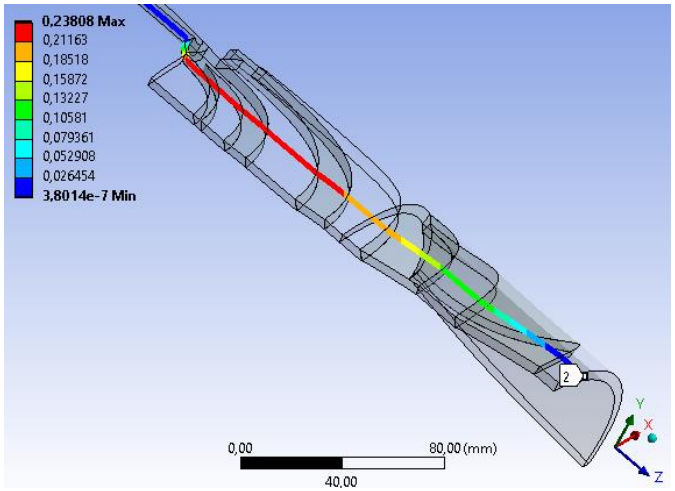
Design principles to steer torque in MCBXF heads (F. Toral, et al.)

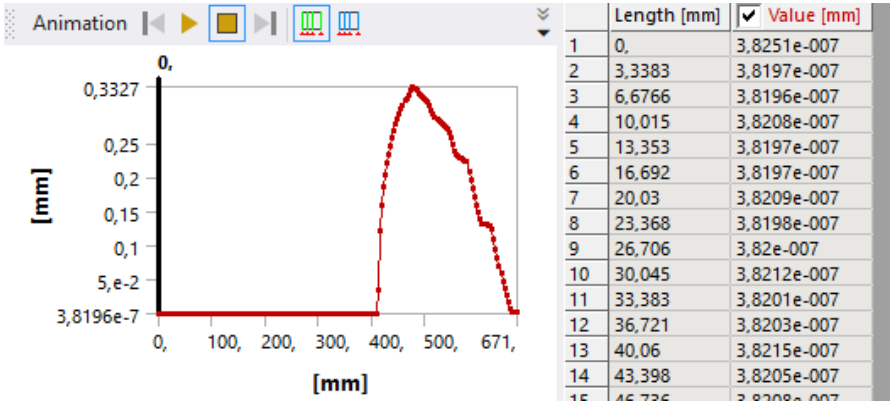
ITERATION ON THE MAGNET

Baseline

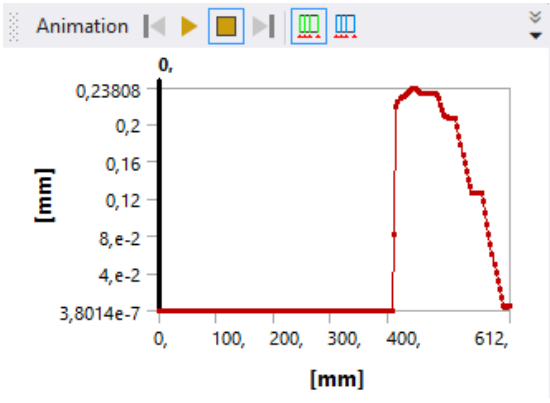


Proposed improvement





	Length [mm]	Value [mm]
1	0,	3,8251e-007
2	3,3383	3,8197e-007
3	6,6766	3,8196e-007
4	10,015	3,8208e-007
5	13,353	3,8197e-007
6	16,692	3,8197e-007
7	20,03	3,8209e-007
8	23,368	3,8198e-007
9	26,706	3,82e-007
10	30,045	3,8212e-007
11	33,383	3,8201e-007
12	36,721	3,8203e-007
13	40,06	3,8215e-007
14	43,398	3,8205e-007



	Length [mm]	Value [mm]
1	0,	4,2765e-007
2	3,0448	4,2707e-007
3	6,0896	4,2701e-007
4	9,1343	4,2702e-007
5	12,179	4,2709e-007
6	15,224	4,2711e-007
7	18,269	4,2702e-007
8	21,313	4,27e-007
9	24,358	4,2703e-007
10	27,403	4,2712e-007
11	30,448	4,2704e-007
12	33,493	4,2698e-007
13	36,537	4,2697e-007
14	39,582	4,2702e-007

Iteration on the design to minimize displacement in the end region due to torque (J. Garcia Matos, et al.)

ITERATION ON THE MAGNET

- Design improvements
  - The change involves the construction of a new specific tooling for the winding of the inner layer
  - The current in the inner dipole increases by 15%, but the magnet proved to be able to reached this field level in dedicated tests (there is a 50% loadline margin in the straight part)
  - It is implemented on MCBXFB01, to be tested in June
  - The change is reversible (we can go back to previous design) – if successful it will be implemented in the baseline
- Consequences for beginning of production
  - Start with winding the MCBXFB outer layer
  - Use the shorter coil tooling if the test is successful for the inner layer winding