SPECIAL ED. - HFML POSTER

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A novel clamping method for resistive magnets

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HFML Science in High Magnetic Fields

EMFL European Magnetic Field Laboratory

Radboud University Nijmegen

NWO Netherlands Organisation for Scientific Research

Introduction

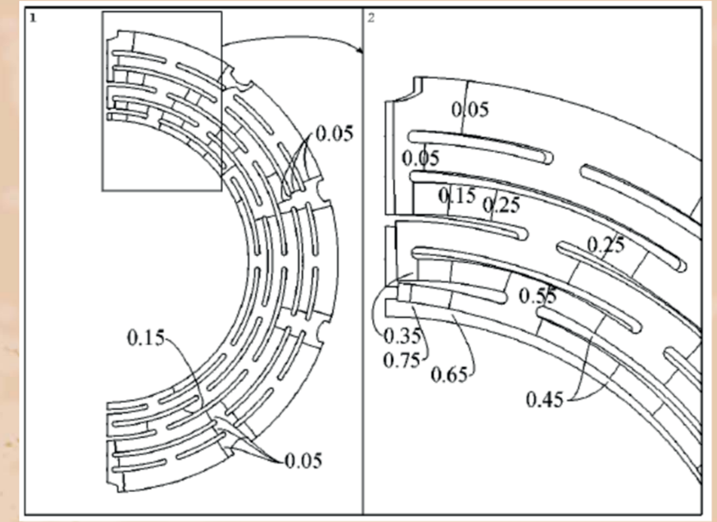
Bitter magnets are constructed by stacking hundreds of individual Bitter plates together in a coil. This loose stack of disks needs to be clamped together with tie rods that are pretensioned for several reasons:

1. the coil should be a 'rigid' object that can be handled
2. the coil should have a stiffness against internal rotations
3. to keep the end turn disks in position despite the large forces on these turns

THE END TURN ISSUE

Earlier studies (literature)

Disks at the ends of the coil are free to move on one side of the slit. Such movement lead to partial blockage of the cooling holes and is a major problem in Bitter disk design, especially in the design of hybrid insert magnets where the field at these end turns is significantly larger due to the superconducting outsert.



From:
End Effects in the NHMFL 45 T Hybrid Resistive Insert
Iain R. Dixon, Mark D. Bird, and Scott Bole
IEEE TRANS. APP. SC, VOL. 12, NO. 1, MARCH 2002

B. The Endforces

The endforces are at present of major concern. The endforce is a force that balances the discontinuity of the winding at the ends of a coil

$$F_E = \sigma(b)A \quad (1)$$

and generates a torque of

$$T_E = F_E(a_1 + a_2) \quad (2)$$

with $\sigma(b)$ the integrated stress over the conductor cross-section A at the end b of the coil, a_1 and a_2 the inner and outer radius of the coil, respectively. For the innermost coil of the NHMFL hybrid magnet an endforce of 125 kN (!) results.

From:
Generation of the Highest Continuous Magnetic Fields
Hans J. Schneider-Muntau, Jack Toth and Huub W. Weijers
IEEE TRANS. APP. SC, VOL. 14, NO. 2, JUNE 2004

PRE-TENSIONING THE TIE RODS

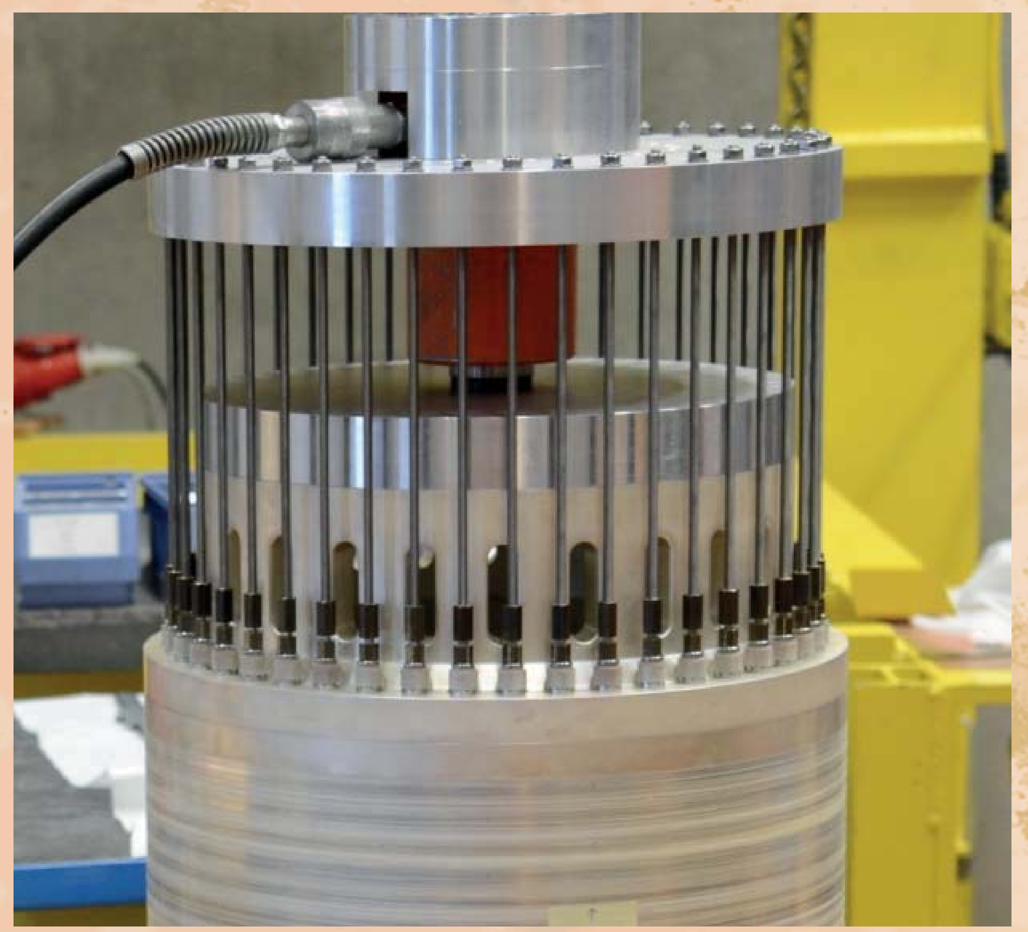
Method & Tools

A hydraulic press and a special made tool are used to pull on the tie rods.

Initially the coil is compressed by several millimeters. Once fully compressed the tool will start to pull on the tie rods. When the set point pressure is reached, the nuts on the tie rods are hand-tightened and the hydraulic pressure is relieved.

Typically we can apply 50-90% of the yield stress to the tie rods in this manner

The clamping force on the coil is then in the range of 1 to 10 MPa. Higher values for smaller coils.

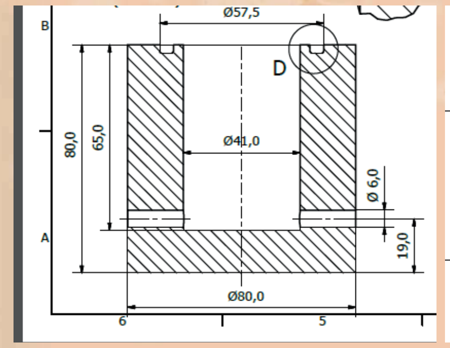


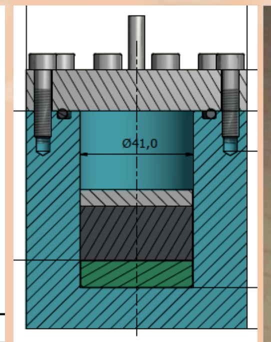
A NOVEL METHOD FOR CLAMPING

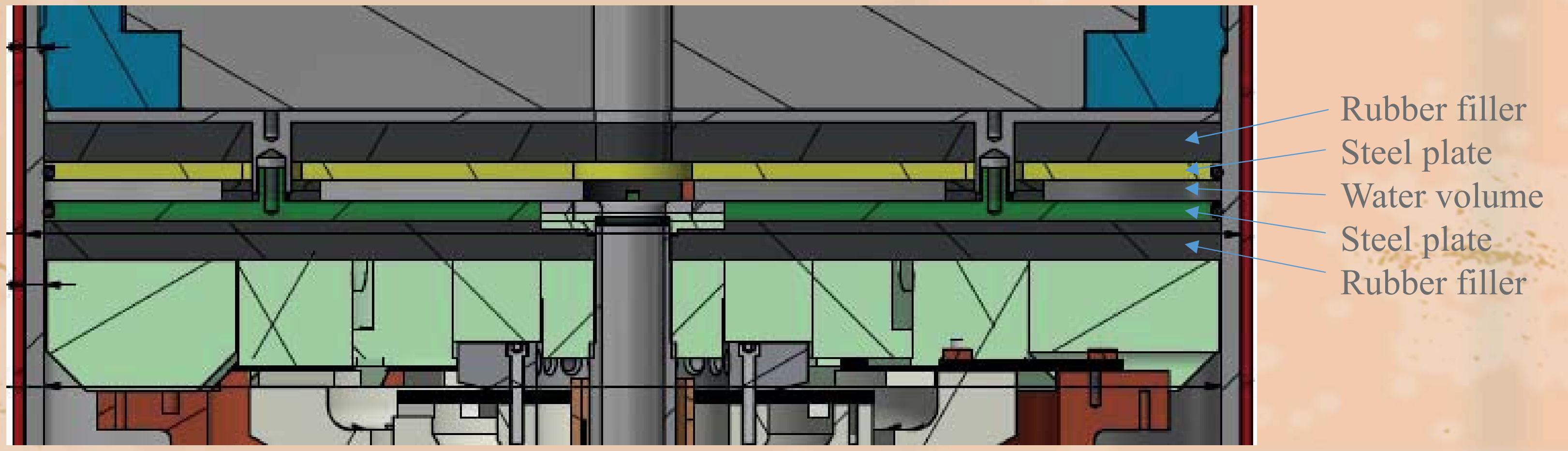
Fresh ideas

We modified the top construction of the insert magnet for the 45 T hybrid magnet at HFML to use a water-filled, pressurised bellow to provide an in-situ and controllable compressive force on the coils.

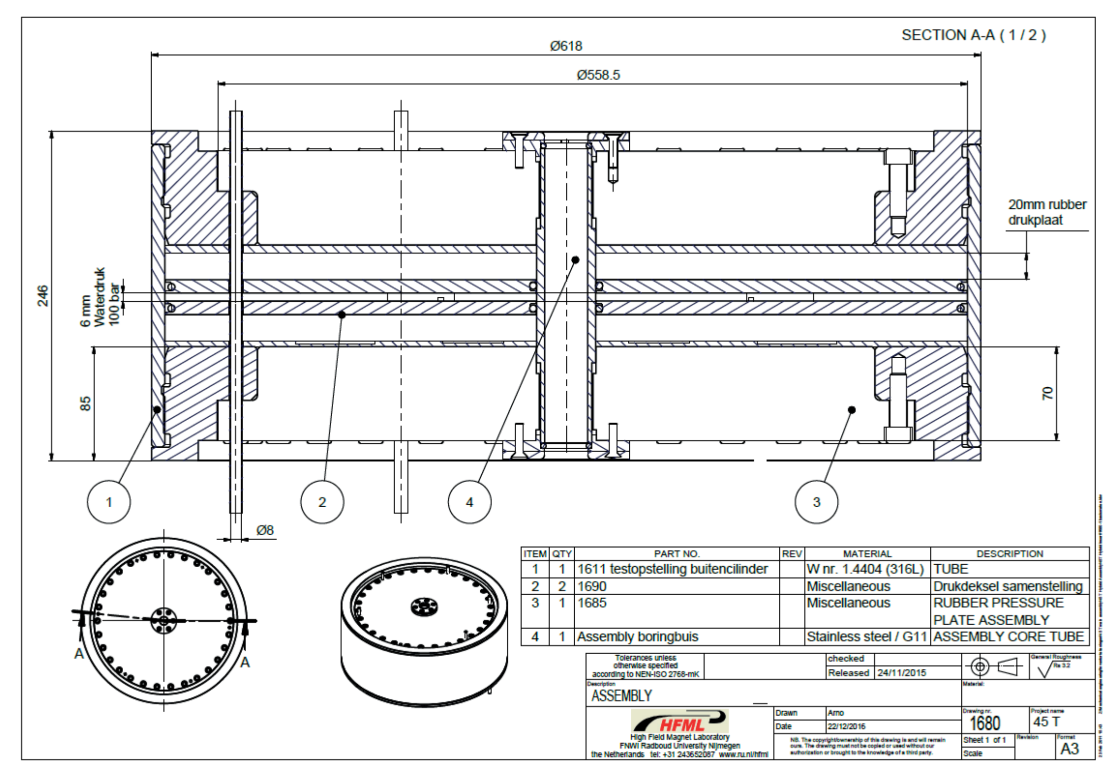
The construction is designed such that a compressive force of 10 N/mm^2 can be applied to each coil.







FULL SCALE MOCK-UP & TEST



Put to test

A full scale mock-up has been designed and manufactured and is currently being prepared for testing. The bellow is leak-tight on the ID/OD, additional measures are needed to ensure leak tightness around the feedthroughs.

FINAL WORDS

The proof of the pudding…

A novel method to clamp Bitter coils is under development. Initial tests on a small scale have confirmed that the system is leak-tight on the ID and OD of the bellow.

A full scale mock-up has been manufactured and will be put to the test soon. We expect the rubber filler to follow movement of the coils, thus ensuring that each coil will at all times be under a compressive stress of 10 N/mm^2.

Initial calculation indicated that such a compressive stress will provide sufficient friction on the end turns to prevent movement of the disks.