TESTS ON SUPERCONDUCTING DIPOLE MODULES: DISPLACEMENT AND DEFORMATION

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Introduction

The Survey & Alignment Group within the department NC-Magnets and Alignment is involved in the organization and development of measuring concepts and techniques for the future FAIR project. These tasks are based on the knowledge and the experiences obtained by works at the existing machine at the GSI. The measurements for the coming facility contain tests both for normal conducting and superconducting magnets. The following passage gives an overview about a test at a superconducting dipole from the Budker Institute of Nuclear Physics (BINP) in Novosibirsk in order to detect displacements and deformations of the cold mass versus the cryostat.

Two prototypes of the dedicated dipole were extensively tested during the last years. Concerning alignment aspects, one of the questions to be answered was the behavior of the dipole yoke with respect to its surrounding cryostat during pumping processes, thermal cycles and after transport.

Magnet movement and yoke deformation

For financial reasons there was for a start no explicit development of a totally new measuring system for monitoring the displacement of a (in operative phases) non-accessible magnet at temperatures of 4 K. In fact, an existing KERN E2 theodolite combined with a FARO SI.2 laser tracker and supplemented by suitable tools for lighting and sighting together with an appropriate measuring methodology were chosen in order to be able to detect movements and deformations of the magnet yoke at least in vertical and longitudinal direction as well as its roll and tilt angle.

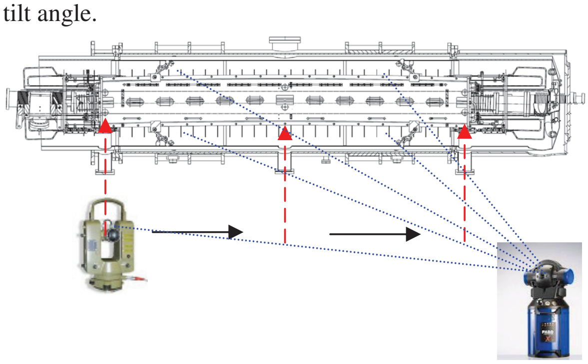

Figure 1: Measurement setup in front of cryostat and enclosed superconducting dipole with fit bores (top view)

The theodolite is placed rectangular to the magnets beam axis, each in front of the three cryostat windows in order to observe the 6 inside targets which are located next to the edges and at the center of the upper yoke half (fig. 1). Observations are possible in evacuated, cold condition of the superconducting dipole module as well as when the magnet has room temperature and the vacuum vessel is ventilated. Correction values for the glass window and the lighting unit with its semitransparent mirror are considered. The positions and orientation of the theodolite itself in relation to the outer cryostat fiducials are precisely determined by the laser tracker. As a result of fiducialisation measurements the relation between the magnets fit bores and the cryostat fiducials in warm condition with an opened cryostat is precisely known.

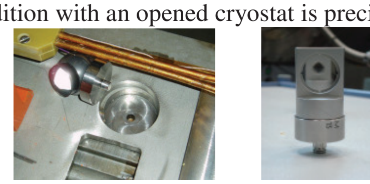

Figure 2 left: Fit bore in dipole yoke, right: Customized targets

This measuring procedure was performed at the same prototype in a total of 22 rounds during a period of 12 months, whereas 9 measurements - including fiducialisation - were carried out at warm (~297 K), 5 runs at cold (~10 K) and 8 runs at graded yoke temperatures from 18 K to 265 K. In doing so the tests were executed at very different condition of the module like opened (ventilated) and closed cryostat (under vacuum), with and without vacuum chamber and other mechanical fittings, after quenches.

Even after a number of thermal cycles the positions of the fiducial points that are placed on the surface of the upper magnet yoke are highly reproducible with mean standard deviations of ±0.06 mm. The data of the fiducial positions must not be seen as absolute displacements of the yoke but need to be corrected by appropriate material correction values in order to get real information about the movement of the magnet center axis. Doing this it can be stated that this investigated dipole remains at the edges in its axial position both in warm and cold condition within ±0.1 mm. An exception is the yoke center which shows a non-explicable bulge of +0.25 mm at almost operative temperature.

References

[1] A. Schnegg, “Bestimmung der geometrischer Veränderungen des BINP SIS100 Dipol“ (measurement report), 25.10.2011

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