Magnet Technology in Europe, in particular Accelerator and Detector Magnets

Herman ten Kate

CERN, Geneva, Switzerland, & University of Twente, the Netherlands

Email: herman.tenkate@cern.ch

***Abstract*— A selection of remarkable superconducting magnets under design or construction in Europe is presented.**

For reaching the highest possible quasi-stationary magnetic field for physics research at the European Magnetic Field Laboratory (EMFL), facilities are being upgraded in Grenoble and Nijmegen for achieving 45 T with hybrid magnets for which wide bore 9 T (NbTi) and 13 T (Nb_3Sn) outset coils are under construction.

At the frontier of fusion, we see record size NbTi and Nb_3Sn based coils for the magnet system of ITER under construction, roughly 60% completed. In parallel NbTi based coils for the JT-60SA tokamak were realized. Beyond ITER, magnet design for the next step European DEMO has started. Most remarkably is the effort of the enterprise Tokamak Energy attempting to aggressively push the technology for ReBCO coated conductor based magnets to beyond the 20 T level for a spherical tokamak. Large quantities of ReBCO are purchased bringing cost down of which other magnet projects using ReBCO are greatly profiting.

Concerning accelerator magnets, a first successful 11 T Nb_3Sn dipole magnet for the High Luminosity LHC 11 T was approved for installation in the LHC tunnel. In parallel, the production of Nb_3Sn quadrupole magnets is progressing well. For the first time ever Nb_3Sn magnets will be incorporated in an operational accelerator. In parallel, a start was made with a push to develop the technology for a possible next machine, the Future Circular Collider, for which 15-16 T class Nb_3Sn magnets are to be developed in the next 20 years.

Apart from the development of high-field accelerators magnets for the FCC, also the design of the new detector magnets for the physics experiments at FCC and CLIC are in progress. A design study started in 2014 for a Future Circular Collider. A new 100 km ring-tunnel is foreseen as well as new particle detectors. Baseline designs for the detector magnets were developed and FCC's conceptual design report was issued in 2019. For FCC-ee detectors two variants exist: first, a 7.6 m bore, 7.9 m long 2T/600MJ solenoid surrounding the calorimeter; and second, a very challenging 4 m bore, 6 m long, ultra-thin and radiation transparent 2T/170MJ solenoid surrounding the tracker only. Demanding is the FCC-hh detector featuring a 14 GJ magnet system of three solenoids, comprising a 4 T main solenoid with 10 m free bore, 20 m long, in line with two 3.2 T forward solenoids with a 5.1 m free bore and 4 m long.

Also, detector magnets for non-colliding beam experiments are on the drawing table. Worth mentioning are unique designs for axions search like BabyIAXO, a 2.5T/10m long dual-bore common coil system operated by cryocoolers for seeking solar axions; and the very

challenging Madmax, a 9T/1.2m bore dipole magnet for searching axion dark matter. Last but not least we mention the initiative for the AMS-100 detector magnet system comprising, an ultra-thin and radiation transparent 1T/4m bore, 6 m long ReBCO based solenoid surrounded by a with 12 m diameter compensation coil for use in space and operating at some 50 K.

In 2019 the field test of ECOSWING, the first-ever 3 MW superconducting wind turbine comprising 40 ReBCO tape-based racetrack coils using 20 km of coated conductor, cooled by cryocoolers at 35 K, was successfully concluded.

***Keywords (Index Terms)* — Magnets, NbTi coils, Nb_3Sn coils, LHC, FCC, FCC-hh detector, accelerator magnets, detector magnets.**

IEEE CSC & ESAS SUPERCONDUCTIVITY NEWS FORUM (global edition), February 2020.
Submitted January 21, 2020; Selected January 29, 2020. Reference RP116; Category 5, 6.
Plenary presentation PT-3 given at ACASC/Asian-ICMC/CSSJ Joint Conference, 6-9 January 2020, Okinawa, Japan.