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Mechanical Characterization of Low-Carbon Steels for High-Field Accelerator Magnets: Application to Nb3Sn Low-β Quadrupole MQXF

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In the quest of higher field accelerator superconducting magnets, essential parts of their design are the so called yokes, which are traditionally made of low –carbon magnetic steel. In currently used magnets, they are typically found in the form of fine –blanked laminations, or machined from laminated heavy plates. The material's choice is made based on a compromise between the high saturation field, providing a return path for the magnetic flux, and the mechanical robustness conferred to the magnets'cold masses.
This paper describes the mechanical characterization of low –carbon steel, and applies several approaches for the design and validation of the material from the structural point of view, applicable to a Nb3Sn quadrupole: MQXF. Tensile tests at room and cryogenic temperature, together with fatigue and fracture toughness at cryogenic temperature have been performed. Calculations based on the obtained material properties and results of extensive non-destructive examination (ultrasonic testing) have been implemented in order to ascertain the structural limits of low –carbon steel for its use in the fabrication of high field accelerator superconducting magnets.

Primary authors: AVILES SANTILLANA, Ignacio (CERN); VALLONE, Giorgio (Lawrence Berkeley National Lab. (US)); IZQUIERDO BERMUDEZ, Susana (CERN); Mr BONNIN, Simon (CERN); CROUVIZIER, Mickael Denis (CERN); SGOBBA, Stefano (CERN); WEISS, Klaus-Peter (KIT, Institute for Technical Physics); BAGRETS, Nadezda (KIT); HUANG, Chuanjun (Technical Institute of Physics and Chemistry, Chinese Academy o); Prof. LAIFENG, Li (CAS)

Presenter: AVILES SANTILLANA, Ignacio (CERN)

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