RRP Nb_3Sn Sub-Element Shear Dependence on Hexagonal Sub-Element Stack Orientation and the Strand's Position within a Rutherford Cable

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Abstract

Superconducting strands built into Rutherford cables undergo high deformation at the cable edges. This deformation negatively impacts subelement integrity and subsequently the Residual Resistivity Ratio (RRR) of the stabilization Cu in Nb3Sn strands after heat treatment due to compromised diffusion barriers [1]. Rutherford cables for the high luminosity upgrade of the LHC at CERN (HL-LHC) use Restack Rod Process (RRP) Nb3Sn wires with a 108/127 sub-element stack. Numerous cross-sectional samples from the US' inner-triplet quadrupole magnets' ("HL-LHC AUP") cables have been mounted, polished, and analyzed with light microscopy. The number of sheared subelements within a strand was seen to depend not only on a strand's position in the overall cable (i.e., center vs. edge), but also on its specific position within the cable edge. Moreover, the rotational angle of the subelement hexagonal stack within a strand (related to the strand twist pitch plus planetary motion during cable fabrication) relative to the cable's centerline plane (and thus the shear force directions) appears to play a role. There is a need to understand these dependencies, as they might impact the applicability of the established criterion of < 15% sheared subelements often imposed to ensure acceptable RRR degradation. By gathering data across many HL-LHC AUP cables and utilizing a more statistical approach, we aim to establish more accurate success criteria for future R&D cables using RRP wire, when the available cable runs (and thus samples) are limited. Moreover, we present a new method for estimating the extent of cabling damage at the cable edge by biaxial rolling of wire triplet, which is well suited for small production runs of R&D Nb3Sn wires.

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Refereces:

[1] Sumption, M. D., Nazareth, V., Barzi E. *et al*. (2008). MEASUREMENTS OF RRR VARIATION IN STRANDS EXTRACTED FROM Nb[sub 3]Sn-TYPE RUTHERFORD CABLES. AIP Conference Proceedings, 986(2009), 277–284. https://doi.org/10.1063/1.2900356