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Viewpoint

Performance test of REBCO CICC sub-cables with l0 kA current under 20 T background field

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This is a viewpoint on the letter by Huan Jin *et al* (2023 *Supercond. Sci. Technol.* **36** 12LT01).

Following the successful achievements of pancake winding made by high temperature superconductors (HTS) rare-earth barium copper oxide (REBCO) tapes as small insert solenoids, the fusion magnet community is engaged in the past decade in an effort to develop high current conductors based on REBCO tapes to wind large high field magnets [1, 2].

Several cable layouts are proposed by the research groups. A popular topology uses stacks of tapes in various arrangements, either twisted or non twisted, soldered or non-soldered, for insulated or non-insulated windings. In an alternative layout, inspired by power transmission cables, the tapes are wrapped in several layers around a central core.

So far, the target of fully preserving the tape transport properties in high current cables could not be achieved. The invoked reasons for the performance loss are always linked to some mechanical damage of the tape, either during conductor assembly or due to the operating loads. Further on, the performance loss worsens upon electromagnetic load cycles, what is obviously a big concern for the magnet designers.

The recent letter on SUST reports the tests of two 10 kA prototype conductors in the background field of 20 T [3]. The layout of the cables is 'wrapping multi-layers of tape around a core'. The prototypes are intended to be sub-components for a larger cable, where six such elements are arranged around a central channel [4]. The most significant and novel achievement is the range of combined operating current and background field. Indeed, most tests at 20 T background field have been so far for small conductors, with operating current up to 1 kA. The test reported in [3], at 20 T background field and up to 10 kA is to my knowledge a world record for HTS cables with this layout. Only the SPARC Model Coil [2] has a larger combination of operating field and current, but it is based on a different technology, 'non-insulated, soldered stacks of tapes'.

In the letter, the authors report 85% of the tape performance retained in the prototype 'A' and ≈75% in prototype 'B', which further degrades upon few load cycles. Both conductors show low n-index, which is evidence of irreversible degradation. The results are in line with other tests carried out on prototype cables made by similar layouts [4–6].

Based on post-mortem examinations, the authors suggest that the cable parameters, e.g. the spacing between turns, should be improved to provide better mechanical support under high electromagnetic (transverse) load. A similar conclusion is drawn in [7] from a finite elements' mechanical analysis.

The REBCO cable layout consisting of multiple layers of tape wrapped around a core (sometime quoted as CORC and STAR) was tested in several prototypes by various research groups. So far, the R&D results are not sufficient to reliably predict the conductor performance in a magnet. The technology is not considered mature for commercial applications. After a decade of trials and errors, now it is time to make good use of the lesson learned and build a representative prototype with stable and predictable performance, to become a reference for magnet designers.

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