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Evaluation of Electrical and Mechanical Characteristics for a Twisted Soldered-Stacked-Square (3S) HTS Wire with 1 mm Width

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Introduction

- In actual applications, owing to the high width-to-thickness ratio of the 2G HTS tape, the design of the HTS device including various cables and coils are seriously restricted.
- To improve application flexibility of the 2G tape, a novel 3S wire, which has a square cross-section composed of several 2G narrow tapes with 1 mm width, is suggested and developed through narrowing, stacking and soldering processes.
- In large-scale conductor for high current applications, a twist structure is inevitable during the cabling process.
- Therefore, in this study, to study twist structure of the 3S wire, several twisted 3S wire samples are fabricated. And the electrical and mechanical characteristics of the twisted samples are measured, including twist pitch, critical current under external magnetic field, self-field AC loss, bending diameter and tensile force.

Twisted 3S HTS Wire

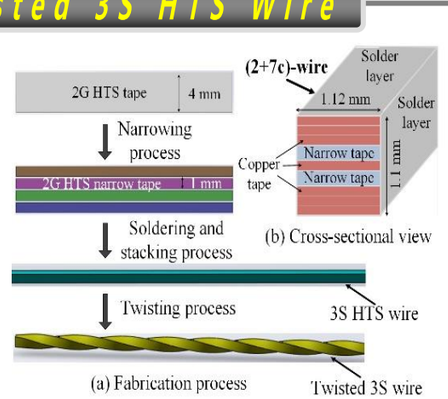

Fig. 1. (a) Fabrication process and (b) cross-sectional view of twisted soldered-stacked-square (3S) HTS wire.

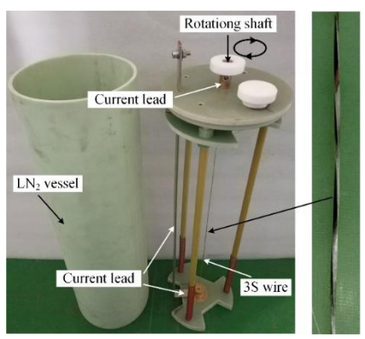

Fig. 2. Photograph of an equipment used to twist soldered-stacked-square (3S) HTS wire.

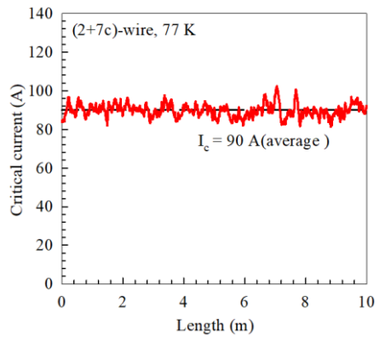

Fig. 3. Uniformity along length direction of critical current distribution for soldered-stacked-square (3S) HTS wire, (2+7c)-wire, applied to fabricate twisted samples.

TABLE I
SPECIFICATIONS OF TWISTED 3S HTS WIRES

HTS Narrow tape	
Width and thickness	1.0 mm × 0.15 mm
Critical current, average, self-field	45 A @77 K
Thickness of superconducting layer	~1.3 μm
Thickness of silver layers	~1 μm
Thickness of substrate layer (including buffer)	~108 μm
Thickness of copper plating layer, each side	~20 μm
Twisted 3S (2+7c)-wire	
Width and thickness of 3S wire	1.12 mm × 1.10 mm
Width and thickness of brass tape	1.0 mm × 0.1 mm
Critical current, self-field	90±10 A @77 K
Twist pitch	100 mm
Number of narrow tape layers	2
Number of copper tape layers	7

Electrical and Mechanical Characteristics

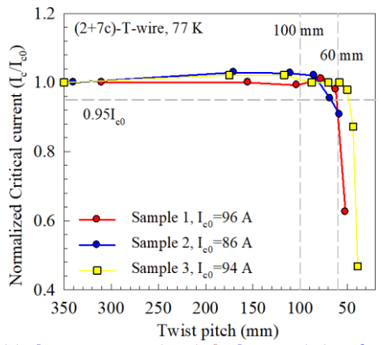

Fig. 4. Critical current vs. twist pitch characteristics of twisted soldered-stacked-square (3S) HTS wire samples, (2+7c)-T-wire.

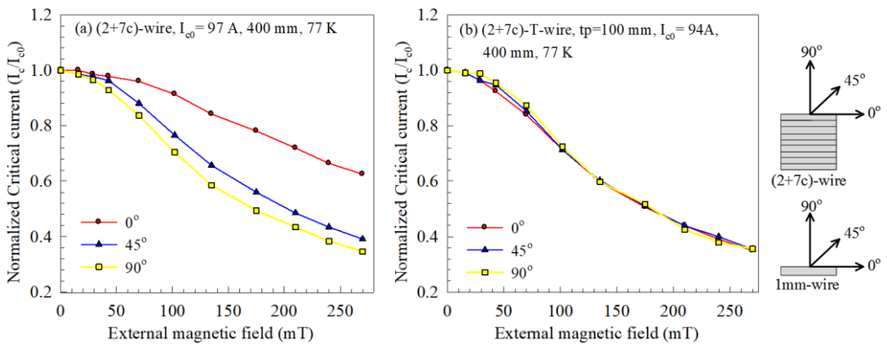

Fig. 5. Critical current vs. external magnetic field characteristics of soldered-stacked-square (3S) HTS wires with or without twist structure, (a) (2+7c)-wire and (b) (2+7c)-T-wire.

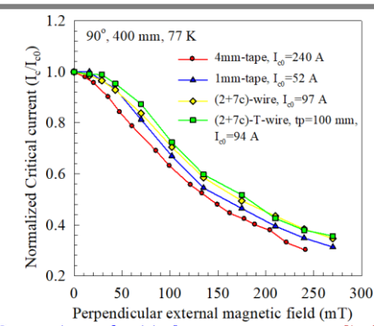

Fig. 6. Comparison of critical current vs. perpendicular (90°) external magnetic field characteristics for various HTS samples

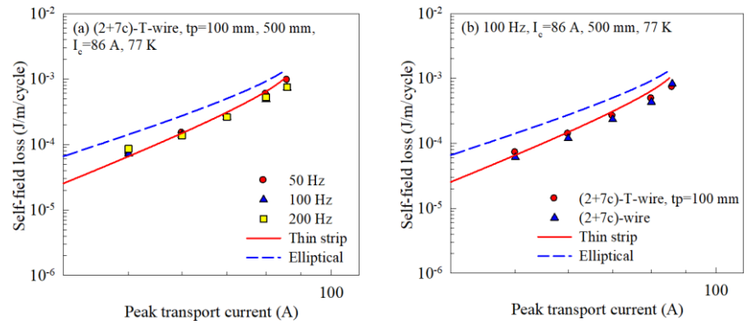

Fig. 7. Self-field loss characteristics of twisted soldered-stacked-square (3S) HTS wire, (2+7c)-T-wire: (a) frequency dependence, (b) comparison with non-twisted 3S wire.

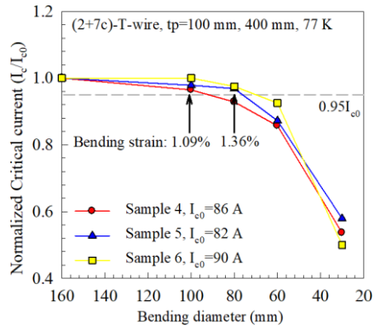

Fig. 8. Critical current vs. bending diameter characteristics of twisted soldered-stacked-square (3S) HTS wire samples, (2+7c)-T-wire.

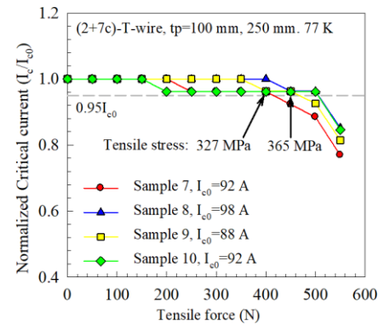

Fig. 9. Critical current vs. tensile force characteristics of twisted soldered-stacked-square (3S) HTS wire samples, (2+7c)-T-wire.

Conclusion

- The critical current distribution for the (2+7s)-wire is relatively uniform at the average value of 90 A, and twist pitch of the (2+7c)-T-wire is approximately 60 mm.
- The critical current of the (2+7c)-T-wire is isotropy, and the curves of critical current for the both (2+7c)-wire and (2+7c)-T-wire are almost overlapped.
- The self-field losses are independent of frequency that means the eddy-current loss in the (2+7c)-T-wire can be ignored. The losses of the (2+7c)-T-wire and the (2+7c)-wire are identical, and are good agreement with the thin strip equation.
- The minimum bending diameter for the (2+7c)-T-wire is approximately 80 mm, and allowable tensile force is above 400 N.

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