Metallographic Analysis of ITER Strands and SULTAN-Tested ITER Cable-in-Conduit-Conductors

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Introduction

ITER, the magnetic confinement fusion reactor being built in France, requires high magnetic fields to contain, control and heat the plasma and these high field magnets require Nb_3Sn strand in quantities that far exceed previous world production capacity. Multiple manufacturers are required to produce the strand and the result is very different designs chosen by manufacturers to meet ITER design specifications, as illustrated in Figure 1. Even though the strands meet individual strand performance specifications, they behave differently to each other when manufactured into cable and tested under cyclic loading [1]. Thus it is important, as both a diagnostic and a record of construction, to fully characterize the cable and the production strands. At the Applied Superconductivity Center a complete metallographic analysis has been performed on all strands and selected cable-in-conduit-conductors have been analyzed after extensive fatigue testing in the SULTAN facility under conditions designed to simulate ITER operating conditions. Individual strands have also been tested after electromechanical testing at the University of Twente.

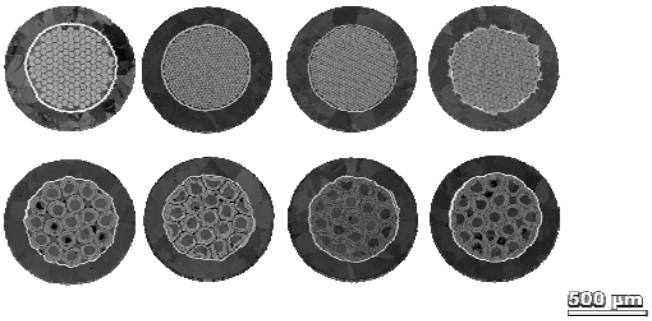

Figure 1 – A wide variety of composite designs are used in the production of superconducting Nb_3Sn strand for ITER. On the top row we show cross-sections of strands based on the "bronze process" and on the bottom row strands based on the internal Sn process as produced for the ITER TF coils.

Experimental

The components of the individual strands and cables were geometrically characterized using FESEM and scanning laser confocal imaging of transverse cross-sections.

Results and Discussion

A complete report on the ITER production strands has been created as a record for future analysis of magnet performance. Analysis of the Sultan tested cables shows that short 1st-stage twist pitches minimize excess strand bending that can lead to localized filament fracture if strands are able move too freely within the cable-in-conduit. Our analysis of the strands deformed using TARSIS at the University of Twente show that different strand designs influence the resistance of strands to bending and filament fracture. [2]

Conclusions

Understanding the role of strand design and the impact of cyclic testing on the full ITER cables allowed firm conclusions about how to optimize cable design for good performance under ITER operating conditions.[3]

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References

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