Development of Internal-Tin Processed Nb_3Sn Superconducting Wire for Fusion Application

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Introduction

There has been an increased need for further improved superconducting materials, which can operate in higher field for the next generation of fusion and accelerator magnets. However, those materials required for fusion application in particular, such as International Thermonuclear Experimental Reactor (ITER), should be produced and available with long lengths at a reasonable production cost, while performing under the stable and reliable operating condition.

Each conductor required for both toroidal field (TF) and central solenoid (CS) coils for ITER has been fabricated according to the strand specifications. The strands for these conductors were designed in order to maintain individually separated filaments after reaction to keep the ac losses as low as possible while the critical current was pushed up to a target value. For internal-tin processed Nb_3Sn, it seems that the strand design required to perform the ac losses below 600 mJ/cm^3 tends to cause the non-copper J_c to be limited to around 1100 A/mm^2 at 12 T.

Experimental

The non-copper critical current densities of the materials made for the TF and CS have been fully characterized [1]. The TF strand utilized 37 subelements and the CS used 19 subelements in each design, respectively. Figure 1 shows the non-copper J_c values of those materials including the data from two different reaction heat treatment conditions for the CS strand. The average non-copper J_c value for the TF strand was measured 1180 A/mm^2 at 12 T with corresponding ac losses of 980 mJ/cm^3 for ±3T cycle. For the CS wire, the extended heat treat condition significantly improved J_c value over 970 A/mm^2 while maintaining ac losses of 514 mJ/cm^3. In addition, strain behavior of the CS material exhibited a quite favorable level of sensitivity with around 0.6% of intrinsic irreversibility as shown in Fig.2 [2].

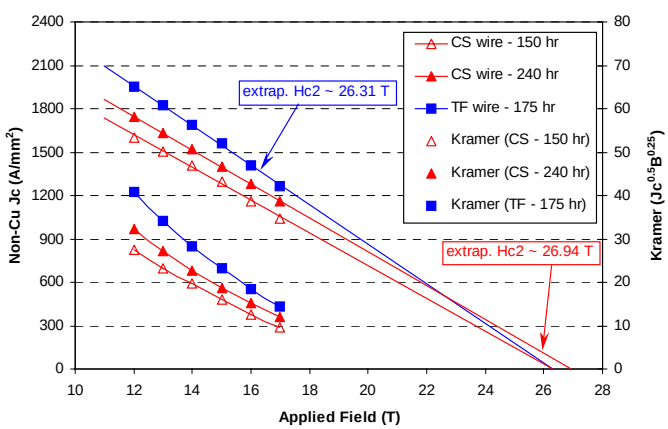

Fig. 1. Magnetic field dependence of J_c for the TF and CS strands.

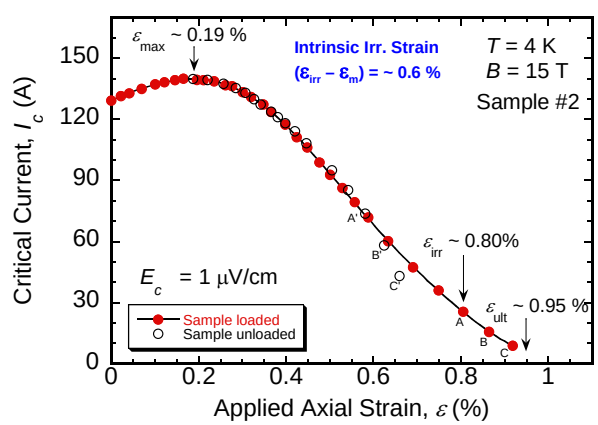

Fig. 2. Axial strain irreversibility of the CS strand.

Results and Discussion

The strand performance required for the TF and CS has been achieved. However, further improvements are necessary to increase the property margins. It is also suggested that more extensive heat treatment study needs to be investigated as a small change in reaction condition could make a significant effect on the strand properties.

References

[1] Pyon, T., *et al.*, *IEEE Transactions on Applied Superconductivity*, **Vol. 17**, No. 2, 2568-2571 (2007).
[2] Cheggour, N., *et al.*, *Applied Superconductivity Conference*, paper presented # 3LW06, (2006).