Characterization of High J_c Nb_3Sn Strands for the Series-Connected Hybrid Magnet

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Introduction

The series-connected hybrid magnet takes advantages of the recent development of high J_c Nb_3Sn superconducting wire. However, it is a concern that the high J_c Nb_3Sn wire may be more strain sensitive. Nb_3Sn strain sensitivity is especially a concern in the application of cable-in-conduit conductor (CICC) where significant J_c degradation has been associated with localized strains from large transverse Lorentz force [1]. In order to predict the performance of the CICC and to identify and analyze the possible degradation in the CICC tests results, the characterization of J_c versus strain is crucial.

Experimental

The 0.8 mm J_c = 2400 A/mm^2 Nb_3Sn wire made by Oxford Superconducting Technology is heat treated at 210 °C/48h + 400 °C/48h + 640 °C/50h in Ar. A Walters spring probe (WASP) at the University of Geneva and a straight pull device developed at the NHMFL are used for investigation of J_c strain sensitivity and the irreversible strain limit as a function of heat treatment temperature respectively.

Results and Discussion

The J_c vs. axial strain at three different temperatures is shown in Fig. 1. The thermal pre-strain is determined to be -0.26%. The data in Fig. 1 are fitted with a deviatoric strain scaling law as shown in solid lines. The fitting parameters are C1 =5.35x10^4 AT ; B_{c2m0} = 28.5 T; T_{cm0} =16 K, C_{a1} = 60; C_{a2} = 24; ε_{0a} = 0.25%.

Fig. 2 shows the measured irreversible strain as a function of sample heat treatment temperature. It is evident that irreversible strain increases monotonically with heat treatment temperature. This result seems to be in contrary to an intuitive belief that under-reacted Nb_3Sn may be less strain sensitive, because the unreacted Nb core in a Nb_3Sn wire makes it more ductile. Our results suggest that cracks in Nb_3Sn may be initiated from the interface between unreacted Nb core and the Nb_3Sn layer around it.

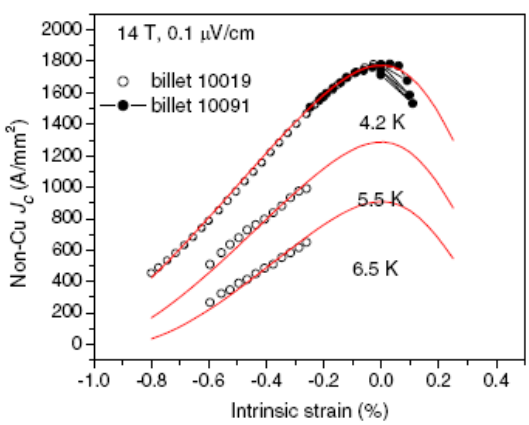

Fig. 1 Nb_3Sn J_c vs. strain measured at 14 T, 4.2 K

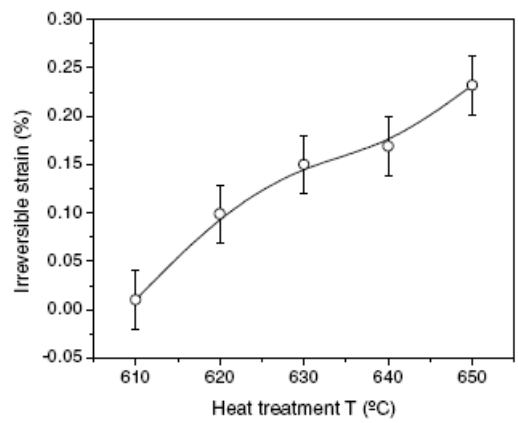

Fig. 2 Effect of heat treatment temperature on irreversible strain of Nb_3Sn

Conclusions

As an important part of the series-connected hybrid material testing program, the J_c versus axial strain curves are measured by a straight pull device and a WASP device. The data are fitted by the deviatoric strain scaling law. The results are comparable with data in the literature. A study of irreversible tensile strain shows that the irreversible strain increases with the sample heat treatment temperature.

Acknowledgements

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Reference

[1] Zhai, Y.H., *et al.*, IEEE Trans. Appl. Supercond., **18,** 1127-1130 (2008).