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Transverse Stress Effect on the Critical Current of Internal Tin and Bronze Process Nb_3Sn Superconductors

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The effect of transverse stress on the critical current density, J_c, has been shown to be significant in bronze process Nb_3Sn, with the onset of significant degradation at about 50 MPa.[1] In an applied field of 10 T, the magnitude of the effect is about seven times larger for transverse stress than for axial tensile stress. In a subsequent study,[2] similar results were observed in another bronze process Nb_3Sn conductor made by a different manufacturer.

Because axial tensile stress on typical magnet conductors is usually greater than transverse stress, the effect on J_c of the two types of stress will be comparable in importance in magnet engineering. The main effect of transverse stress will be to place limits on the conductor thickness in the direction of the Lorentz force. This can be particularly significant in cabled conductors where stress concentrations can occur at strand crossover points.

In bronze process wires, the magnitude of the effect has been observed to be the same for round strands as for flattened strands (round strands that were flattened prior to reaction) except that there is a small peak in the J_c vs. compression curve for the flattened sample due to anisotropic precompression of the filaments.[1]

The mechanism accounting for the transverse stress effect and its large magnitude compared with the axial tensile effect is still the subject of speculation. In an attempt to better understand the nature of the effect, we have undertaken a series of experiments to determine whether the transverse stress effect depends on the grain morphology of the Nb_3Sn reaction layer in the superconductor.

To do this, we have measured the effect in an internal tin conductor with excess tin, which yields a more equiaxed Nb_3Sn grain morphology than for bronze process Nb_3Sn, where the grains are more columnar.[3]

The results for the effect of transverse compression on the J_c of a round bronze process Nb_3Sn wire are shown in Fig. 1.[1] Fig. 2 shows the results for a round internal tin superconductor. A comparison of the two sets of results shows nearly the same transverse stress effect in each within the limits of error. The unloaded values of J_c recovered more for the bronze process Nb_3Sn than for the internal tin Nb_3Sn, probably because the yield strength of the matrix may have been greater for the bronze process wire, retaining more residual transverse stress on the Nb_3Sn filaments upon unloading.

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However, the effect of transverse stress on J_c was nearly identical for the two conductors, indicating that the transverse stress effect is probably not dependent on grain morphology. The data also indicate that the effect is not highly sensitive to the conductor fabrication procedure, and hence these data are probably applicable to a wide variety of Nb_3Sn conductors for magnet engineering.

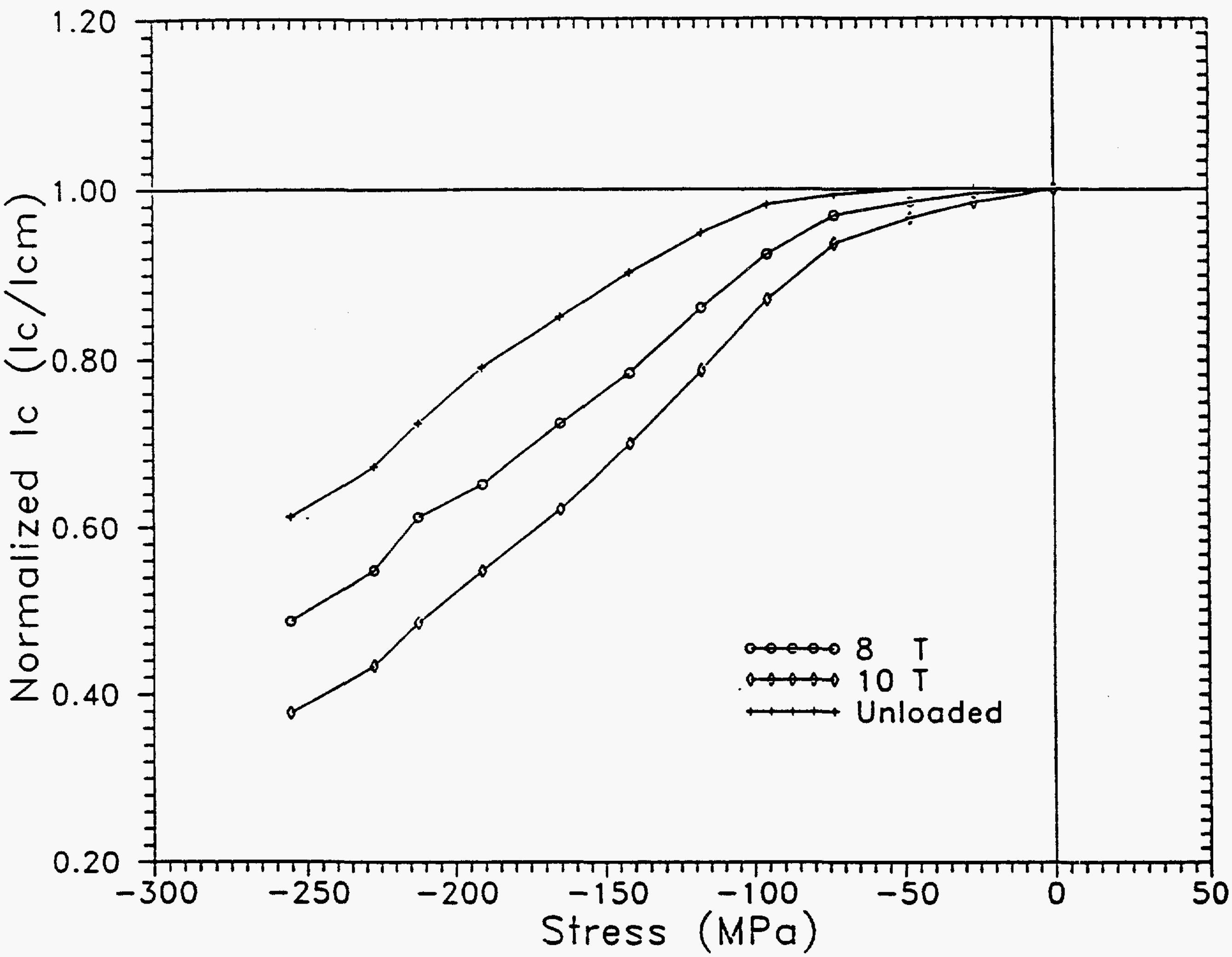

Fig. 1. Bronze process Nb_3Sn I_c-vs-stress curves at 8 and 10 T. The critical current has been normalized by its maximum value, Icm. The "Unloaded" data points indicate the measured I_c at 10 T after unloading the sample from the indicated stress level.

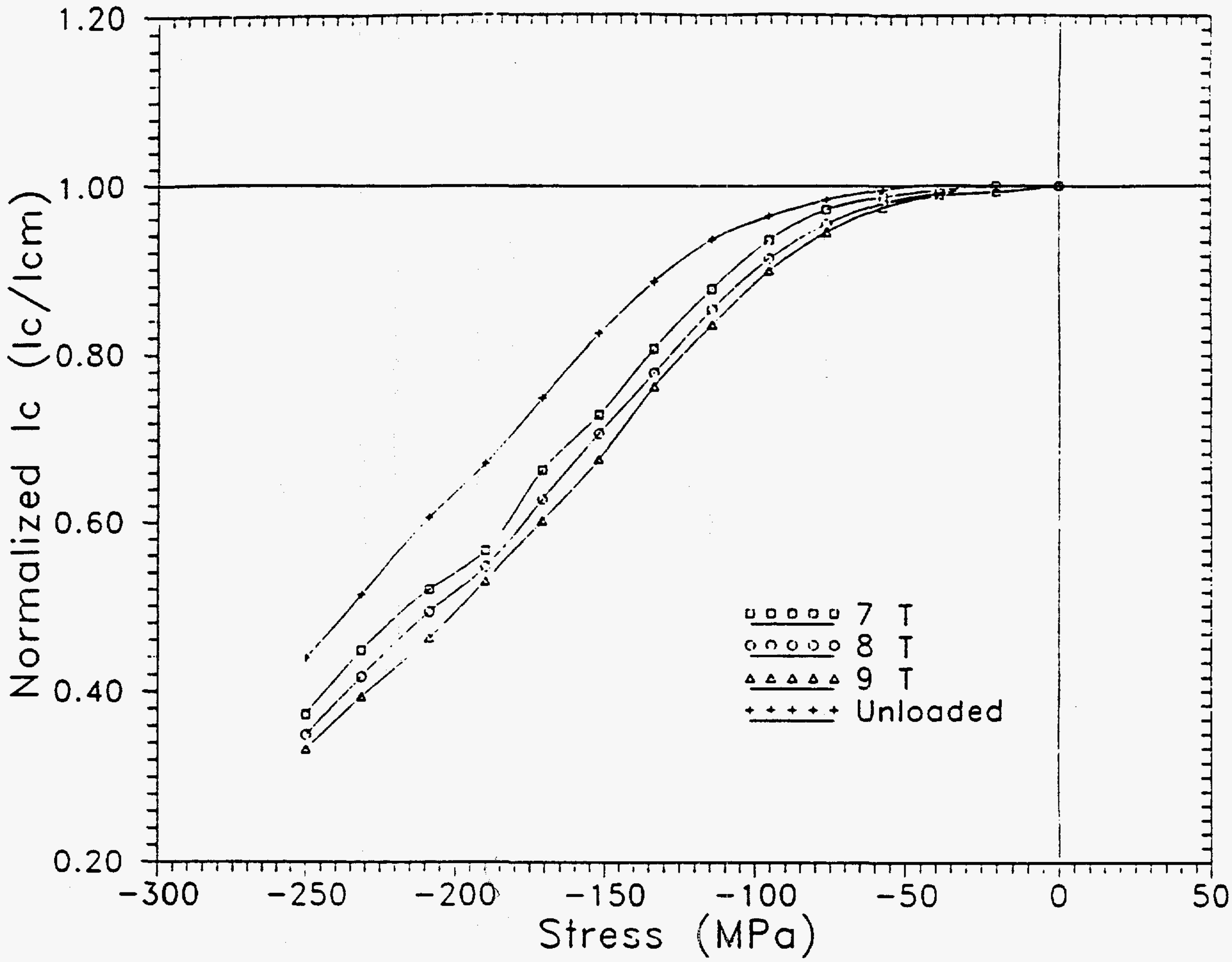

Fig. 2. Internal tin process Nb_3Sn I_c-vs-stress curves at 7, 8, and 9 T. The critical current has been normalized by its maximum value, Icm. The "Unloaded" data points indicate the measured I_c at 9 T after unloading the sample from the indicated stress level.

References:

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