Stability and Quench Behavior of YBa$_2$Cu$_3$O$_{7-x}$ Coated Conductor at 4.2 K, Self-field

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Introduction
There is growing interest in using YBa$_2$Cu$_3$O$_{7-x}$ (YBCO) coated conductors (CCs) at 4.2 K to generate very high magnetic fields. The transition from high field conductor to high field superconducting magnet, however, requires that some challenging issues be addressed. One of the most important challenges remaining is to better understand the stability and quench behavior at 4.2 K so that an effective quench protection system can be developed.

Experimental
YBCO CC is obtained from American Superconductor Corporation and mounted on a probe designed for studying quench behavior. The YBCO sample is instrumented with a series of voltage taps and temperature sensors, along with a nichrome heater which is used to induce a quench. After cooling to 4.2 K in liquid helium and establishing a steady-state transport current, the heater is pulsed and the voltages and temperatures are monitored as a function of time. This data is interpreted for minimum quench energy (MQE) and normal zone propagation velocity (NZPV). [1]

Fig. 1 (a) voltage $V(t_2)$ for a series of increasing heat pulse amplitudes with $I = 350$ A. (b) NZPV versus voltage criterion for different transport currents. (c) MQE and MQE density versus I and $I/I_c$ for the YBCO CC and Bi$_2$Sr$_2$CaCu$_2$O$_{8+x}$ (Bi2212) and MgB$_2$ round wires. (d) NZPV for a voltage criterion of 5 mV versus I and $I/I_c$ at 4.2 K for the YBCO CC studied here. Also shown is the NZPV versus I and $I/I_c$ at 4.2 K for the YBCO CC and Bi$_2$Sr$_2$CaCu$_2$O$_{8+x}$ (Bi2212) and MgB$_2$ round wires.

Results & Discussion
As seen in Figure 1, YBCO conductor is very stable and has very slow NZPV. Due to longitudinal and transverse temperature gradients, the onset of a measurably non-zero voltage occurs before the surface temperature reaches the current sharing temperature. This may have implications for the development of quench protection in YBCO magnets. The MQE of YBCO CC at 4.2 K is approximately three orders of magnitude greater than that of Nb-based conductors and, for the parameter ranges studied, significantly more stable than MgB$_2$. Compared to Bi2212, the fundamental behavior is similar and the stability and quench behavior is thus driven by the specifics of the conductor geometry, and in particular the conductor $I_c$.

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