33.8 Tesla with a $YBa_2Cu_3O_{7-X}$ Superconducting Test Coil

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A small coil, wound of YBCO composite superconducting tape, was tested in the DC field facility of the NHMFL. In a background field of 31 Tesla, the coil produced an incremental field of 2.8 T to reach a world record field of 33.8 Tesla for the operation of a superconducting coil.

The superconductor YBCO is a type of High Temperature Superconductor, and is also a very high field superconductor when operated at the low temperature of liquid helium. YBCO conductors are being developed rapidly, motivated by potential application in the electric power industry. As a result of their low temperature properties, YBCO conductors are also expected to allow superconducting coils that operate at magnetic fields significantly higher than existing coils that use superconductors based on Nb technology. As an initial step in the development of a YBCO superconducting magnet technology, a small coil was made of a standard SuperPower tape conductor, 4.2 mm wide and having a Hastelloy substrate of 50 um thick and a copper stabilizer thickness of 40 um. The plan was to demonstrate coil performance at the highest practical field, which was provided by a 31 Tesla resistive magnet with an available bore of 40 mm inside the insert cryostat.

The coil is pancake wound, being constructed of five double pancakes with inner winding diameter 25 mm, outer winding diameter 36 mm, and assembled winding length of 46 mm. The pancakes are wound with 38 turns each with a total conductor length of approximately 36 m for the coil. With the background magnet at 31 Tesla, the test coil was operated to increasing fields in 100 A increments. Voltages across the double pancakes were rather linear as a function of ramp current, indicating a lack of magnetic hysteresis and lack of shorting between turns or pancakes. It was observed that the temperature in the bore of the coil increased significantly during the ramps. This heating was attributed to a combination of the ohmic heating in the probe holding the test coil, and the fact that helium gas produced at this field level tends to accumulate in the bore due to the diamagnetic nature of helium and the strong field x field-gradient product present. The coil was operating in helium gas at increasing temperature during the ramps. The final ramp reached 325 A where the coil experienced a quench and was damaged. At this current, the average current density in the coil was 446 A/mm2, with an exceedingly high value of 756 A/mm2 for the current density in the conductor. The helium gas temperature surrounding the coil was estimated as exceeding 12 K, based on available measurements. During the quench, the coil was protected by a fast quench detector and an external discharge in a time on the order of 10 ms. The damage to the coil was attributed to mechanical effects.

It is planned to rebuild the coil with increased reinforcement, and to modify the probe for structural rigidity as the first steps in a continuing program of coil technology development.