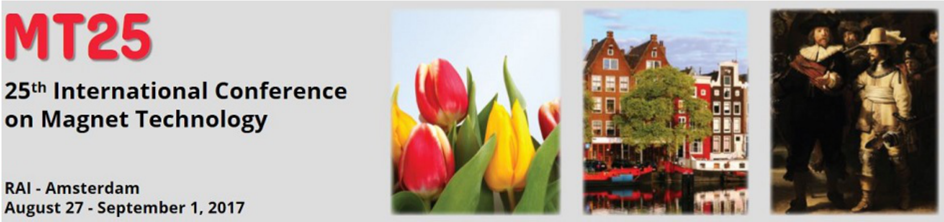

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High Modulus Reinforcement Materials

Thursday 31 August 2017 11:45 (15 minutes)

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Materials used as reinforcement for conductors in high field magnets require both a high capacity for load bearing and a high resistance to deformation under stress; that is a high value for tensile strength and a high modulus of elasticity. In addition, compatibility between the reinforcement materials and the magnet conductor has to be carefully evaluated in terms of their capability for thermal expansion, stability at high temperature, and resistance to oxidization and crack propagation. Austenite stainless steels have been used as reinforcement materials for decades, in particular for cable in conduit superconducting magnets. The Young' s modulus for most stainless steels, however, is below 200 GPa, lower than the value desired for very high field magnets. Increasing the modulus of stainless steels without significantly modifying the chemistry is at present impossible. We studied nickel-based superalloys, whose chemistry is designed for high-temperature applications and therefore has a high Young's modulus. Our samples had been subjected to various procedures that had strengthened the alloys by long range ordering. Our initial work was focused on changes that occur during the deformation in these nickel-based alloys at either cryogenic or room temperature conditions. We observed distinct interfaces between the ordered area and the matrix; we decided that these materials could be described as precipitate-strengthened alloys. At cryogenic temperatures, both the ordered area and the matrix had more resistance to plastic deformation than those same areas at room temperatures. To enhance strength further, we also modified the chemistry of the alloy by doping other elements. This paper outlines the properties of the new alloys and establishes their compatibility to certain conductors commonly used for high field magnets.

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