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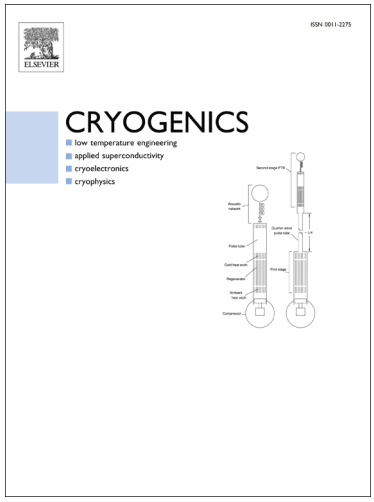

Research paper

Manufacture and Mechanical Characterisation of High Voltage Insulation for Superconducting Busbars - (Part 1) Materials Selection and Development

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Manufacture and Mechanical Characterisation of High Voltage Insulation for Superconducting Busbars - (Part 1) Materials Selection and Development

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Superconducting magnets, Insulation, Mechanical properties, Polyimide, 'Pre-preg'

Abstract

It is planned that the high voltage electrical insulation on the ITER feeder bus bars will consist of interleaved layers of epoxy resin-pre-impregnated glass tapes ('pre-preg') and polyimide. Consideration was given to introducing layers of bonded polyimide in regions where the mechanical stress was relatively low. In addition to its electrical insulation function, the bus-bar insulation must have adequate mechanical properties to sustain the loads imposed on it during ITER magnet operation. This paper reports an investigation into suitable materials to manufacture the high voltage insulation for the ITER superconducting busbars and pipework. An R&D programme was undertaken in order to identify suitable pre-preg and polyimide materials from a range of suppliers. Pre-preg materials were obtained from 3 suppliers and used with Kapton HN, to make mouldings using the desired insulation architecture. Two main processing routes for pre-pregs have been investigated, namely vacuum bag processing (out of autoclave processing) and processing using a material with a high coefficient of thermal expansion (silicone rubber), to apply the compaction pressure on the insulation. Insulation should have adequate mechanical properties to cope with the stresses induced by the operating environment and a low void content necessary in a high voltage application. The quality of the mouldings was assessed by mechanical testing at 77K and by the measurement of the void content.

1. Introduction

The superconducting magnets [1] of the ITER tokamak are supplied with electrical current via superconducting busbars [2] located in so-called 'feeders' [3]. The superconducting busbars are made of cable-in-conduit conductor and have a circular cross section with outer diameter 44.5 mm or 22 mm depending on the magnet to which they are connected; typical lengths of bus bar are in the order of 30 to 40 metres. Figure 1 shows, diagrammatically, one short section of a feeder 'Current Lead' with some of the many changes in section that have to be processed and to have, 'low void content' insulation.

The ITER device will have a number of 'feeders', each with two or more busbars, for each of the superconducting coils that go to make up the tokamak and in total, the length to be insulated is approximately 2100 m.

High voltages (up to 11 kV) are developed on the Central Solenoid and Poloidal Field magnets due to the pulsed operating nature of these magnets. The Toroidal Field Magnets will also develop voltages up to 4kV during fast discharge conditions [4]. Higher voltages (up