PhD Thesis Title:
Design and Fabrication of the HTS synchronous motor using 2G-HTS Stacked Tapes

Abstract:

In this thesis, the theoretical and experimental reports on both the mechanical and electrical designs of HTS synchronous motor that is successfully fabricated at the University of Cambridge is presented. In this motor, the stator is a conventional 4KW, three phase with copper windings and is controlled based on the V/F control strategy, while the rotor consists of a set of 76×46mm stacked-tape superconducting "pseudo-bulks" of nominally 100 layers. Furthermore, the advantage of HTS stacked tapes over HTS bulks are theoretically and experimentally justified. It is proved that the HTS stacked tapes are less vulnerable to get demagnetized due to crossed and rotating magnetic fields.

The required background field to magnetise the HTS stacked tapes are provided with a copper based field coil, which is implemented around the rotor, and two sets of racetrack coils, which are placed around the HTS stacked tapes. At the temperature of 77K, the copper coil is able to provide nearly 1T. Besides, the HTS racetrack coils not only reduce the stray of magnetic field, but also increase the background field required to fully magnetise the HTS stacked tapes. The cooling system is based on conduction-cooling, where two separated internal liquid nitrogen circuits provide cooling to the superconductors and the bulk rotor independently.

Furthermore, the high-temperature superconducting (HTS) stacked tapes with the capability of trapping large magnetic field as well as having high mechanical and thermal stabilities have gained considerable attention as a viable alternative for HTS bulks in potential applications such as electric machinery. Of particular importance is their high tolerance over experiencing crossed field effect, in which an initially magnetized HTS material is subjected to AC magnetic field H_{ab} in a direction perpendicular to the original magnetization $H_{max\|c}$. On the other hand, the prevailing experimental evidence indicates that the decay of magnetization due to the crossed field effect after the application of 100 cycles of transverse AC field with amplitude 2.5 times larger than the maximum value of the initial trapped magnetic field, ($H_{ab}^{peak}/H_{\|c} = 2.5$), is below 5%. Whereas in the case of HTS bulks, more than 50% reduction in initial magnetization was observed upon applying only one cycle of the crossed magnetic field with $H_{ab}^{peak}/H_{\|c} \simeq 1.5$. Similarly, the demagnetization would also occur when a sample is placed in a rotating magnetic field. It has been analysed numerically that application of a rotating magnetic field on a superconductor will redistribute its initial induced current that results

in suppression of initial magnetization.

The main motivation for this work is to develop a model with the aim of characterizing behavior of the HTS stacked tapes that are implemented permanent-magnet like applications. In addition, the interaction between HTS stacked tapes and ferromagnetic materials under various working conditions, such as initial magnetization as well as on the application of crossed and rotating magnetic fields, are throughly discussed.

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