

A BREAKTHROUGH IN THE DEVELOPMENT OF LONG-LENGTH HTS CABLES WITH INTEGRATED FCL PROPERTY

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ABSTRACT

The subject of this paper is a breakthrough in the development of long-length high-temperature superconducting (HTS) cables with integrated fault-current limitation (FCL) property, made in the Dutch 6 km FCL Triax HTS® cable project. Made calculations support a possibility of significant improvement of the thermal behaviour of the cryostat. The developed FCL modelling confirms that the stated targets for fault current limiting capability will be achieved in the project. The latest cable tests have demonstrated considerable reduction of AC loss and low flow friction of the cryostat. This is a large step to maturing the HTS cable technology.

KEYWORDS

High Temperature Superconducting cable; Fault current limiting; Long length; Reduction of AC loss; Reducing of the heat leakage.

INTRODUCTION

It is evident that the increase of electricity consumption and the rising penetration of dispersed generation together with the extension of large-scale renewable energy sources lead to numerous technical bottlenecks in electrical grids. Also environmental issues play significant role when high amount of electrical power has to be transported to urban and density areas. Limited space, available for the installation of underground cable connections adds even more complications. The need for new technology solutions, which can manage above listed challenges, has become apparent.

The HTS cable technology demonstrates a great potential in solving of grid congestion issues.

An important characteristic of HTS cables is their high transport capacity. HTS cables can transport up to 10 times more power than conventional cables of comparable radial dimension. This feature is supported by the fact that nowadays a long length commercial HTS tape conductor of the latest generation (see Fig. 1) can carry 300 A/mm² when cooled to 77 Kelvin.



Fig. 1: A sample of HTS tape with FCL properties

In addition to their large power transport capacity and low losses, modern-generation HTS cables also have an integrated fault-current limiting (FCL) property. The HTS cables with an improved non linear voltage-current characteristic behave intelligently, adapting their impedance to the actual need of the network, see Fig. 2.

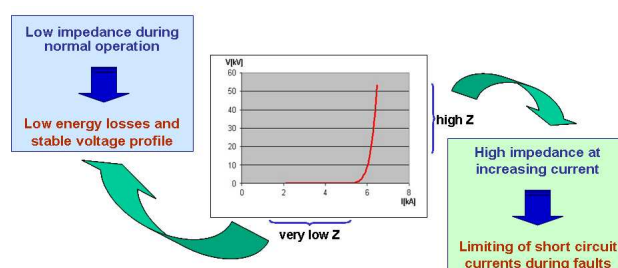


Fig. 2: A schematic of the non-linear voltage vs. current characteristics of HTS cables

In this way, this new generation of HTS cables also contributes to a stable voltage profile in a grid, while reducing short circuit currents. Moreover HTS cables have a very small footprint, which makes them suitable for dense and urban areas with expanded underground infrastructures.

Despite its large potential benefits, the HTS cables technology is not yet widespread. In-field demonstrations have been made with lengths of 100-600 m, meaning this technology is still in its immature state. The currently inefficient cooling technology limits the length of the cables up to 1-2 km. The new functionality of integrated FCL capability adds requirements on the cooling due to additional heat production. Therefore an advanced heat management of HTS cable is needed.

DUTCH 6 KM HTS TRIAX® FCL CABLE PROJECT

To demonstrate high performances of the HTS cables technology in a real network a consortium of the Dutch DSO Alliander, Ultera™ (Southwire/nkt cables Joint Venture) and the Delft University of Technology (TUD) has formulated a Research&Development program with aim to develop and install in Alliander's grid a 6 km FCL Triax HTS® cable.

The consortium works in its project in three directions:

- Considerable improving of thermal insulation of the cryostat. Also cooling channels will be optimized for more efficient flow of the cooling liquid nitrogen;
- Significant reduction of AC loss;
- Optimisation of FCL capability of long HTS cable.

A number of significant breakthroughs in the development of 6 km FCL Triax HTS® cable are presented in this paper.