The SuperConducting Fault Current Limiter (SCFCL) appears as one of the most promising SC applications for the electrical grids. The basic functions of a SCFCL are to guarantee the absence of currents higher than a defined value and to “isolate” the faults. It brings an attractive answer to real today demands: it enhances the security of supply and facilitates the penetration of renewable energies as well as the development of HVDC supergrids. SCFCL is one of the first SC devices to enter market. After many successful experiences, the first orders for permanent operation in grids are indeed taken. After a short state of the art, the design of the resistive SCFCL will be discussed with the objective to reduce the quantity of SC conductor (length and section) to be more cost-competitive. One of the most severe constraint is that the SCFCL should operate safely for any faults, especially those with low prospective short-circuit currents. This constraint leads to specific design of the conductor used for SCFCL. We have to consider that the critical current varies along the length, which leads to a local hot spot for specific faults. The conductor is designed through a suitable shunt to maintain the hot spot temperature below a safe limit when it is isolated. The effects of $I_c$ amplitude and variations are discussed. The operating temperature is analysed in term of cost reduction. Some attractive solutions are under investigation to enhance the propagation velocity and the consequences are analysed. The results are mainly based on numerical simulations with some experimental validations.
Development of a 10 kJ SMES model cooled by liquid hydrogen thermo-siphon flow for ASPCS study

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A new electric power storage and stabilization system named Advanced Superconducting Power Conditioning System (ASPCS), in which a Superconducting Magnetic Energy Storage (SMES) and hydrogen - energy - storage converge on a liquid hydrogen station for fuel cell vehicles, has been proposed [1]. A 10 kJ small BSSCO magnet system cooled by liquid hydrogen has been developed to compose an experimental model of the ASPCS.

Cryogenic scheme of the magnet system has following features.
1) Pure aluminum plates, which are laminated onto every BSSCO pancakes, extend to the liquid hydrogen pipe to conductively cool the pancakes.
2) To prevent large eddy current loss in the pure aluminum plates due to vibrating SMES magnetic field, the plates have many slits every less than 10 mm.
3) Liquid hydrogen flow thorough the cooling pipe is driven by a thermo-siphon mode.

Fabrication and primary test results of the magnet system are to be presented in this conference.


Figure 1. (a) Cryostat of BSSCO magnet cooled by LH2. (b) BSSCO pancake coil with Al plates.
Eddy Current Loss Induced in Aluminum Thermal Conduction Strips for ASPCS Coils Indirectly Cooled by Liquid Hydrogen through Thermo-Siphon System

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To promote renewable energy sources, we proposed a new system called the Advanced Superconducting Power Conditioning System (ASPCS), which consists of Superconducting Magnetic Energy Storage-system (SMES), Electrolyzer, and Fuel Cell, and is also combined with a liquid hydrogen station [1]. The SMES plays a role to compensate the fast fluctuations generated by the renewable energies [2]. In case of the ASPCS with a capacity of 5 MW, we designed the 50 MJ-class SMES composed of 4 solenoid coils. The winding of the solenoid coils is double pancake and a basic coil is 2 m in diameter and 0.5 m in height. Each SMES coil is wound with MgB2 conductor and indirectly cooled at 20 K by liquid hydrogen flowing through a thermo-siphon cooling system. Pure aluminum strips are inserted between the double-pancake coils and the pure aluminum plates gathering the strips lead to liquid hydrogen pipes. This scheme enables the strips and the plates to transfer the heat load in the coils to the cooling pipes and keep the coils at low temperature. On the other hand, we must consider that the strips generate eddy current loss which is strongly affected by a width of the strips [3]. At the same time as the primary study of the SMES coils, we experimented on the thermo-siphon cooling system and investigated the relationship between the heat load and the driving ability of the cooling system. The experiments showed that the cooling system could proficiently function. The estimation of eddy current loss from the particular cooling aluminum strips for the SMES in the ASPCS are reported with the results of the thermo-siphon driving experiment.

Preliminary Design of a 220kV Resistive-type Superconducting Fault Current Limiter

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As short-circuit current in power grid rises up quickly with the fast economic and social development in China, it becomes very important and dispensable to suppress the large short-circuit current that may exceed the current-breaking capacity of existing breaker. Superconducting fault current limiter (SFCL) is considered as one of the effective technologies to cut down the possible large short-circuit current. A 220kV SFCL is proposed to alleviate the possible threat by short-circuit failure in China Southern Gird located in Shenzhen City, a vital metropolis in Guangdong Province. The SFCL adopts a resistive-type principle that takes advantage of physical state transition property of superconductors. By far the preliminary design of the SFCL is completed and some design parameters verified. This paper will discuss in detail the topology of the SFCL, the simulation of the SFCL system, and the basic design of its main parts, including the non-inductive coil and its stack, cryogenic dewar, high-voltage lead, cryogenic refrigeration, and online monitoring and control system.

d-7 Large Scale System Applications
Technical report on design and manufacturing of 4 kW superconducting motor based on HTS stacked tapes

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Abstract

In this paper we report the mechanical and electrical design of superconducting synchronous motor that is successfully fabricated at University of Cambridge. In this motor, the stator is a conventional 4 kW, three phase with copper windings and is controlled by a v/f control method, while the rotor consists of 100 stacks of 76 × 46 mm superconductors. The required magnetizing field is supplied by a relatively large Helmholtz-like coil wound around a brass box containing superconductors. The produced field will be confined and be reinforced by a pair of superconducting coils which are working in persistent mode.

Furthermore, the cooling is provided by two individual internal circuits, one for the outer part and another for superconducting stacked tapes, in order to keep the whole rotor and superconductors as the temperature of 77 K. Provision has been also made to reduce the superconductor temperature further down to 20 K by using liquid helium to the appropriate circuit. Thermal conduction to these cryogenic circuits has been improved, where appropriate, by suitable material choice; e.g. silver impregnated epoxy to bond the field coil.

A set of hall probes and temperature sensors are implemented in order to monitor the trapped fields of superconductors and temperatures for different parts of the motor, respectively. The motor was then tested in different operational conditions and their associated results were thoroughly reported.