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European superconducting power link project

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RESUME

Le projet européen SUPERPOLI examine l'application des supraconducteurs au transport d'énergie sous moyenne tension et fort courant, sur de faibles distances. Ceci s'applique aux sorties de centrales, et en des points particuliers des réseaux de distribution. L'utilisation des supraconducteurs est ici valorisée par la limitation des courants de défaut, accompagnée d'une forte réduction des pertes et des coûts de génie civil. Un prototype triphasé de 1 GVA est à l'étude; sa conception s'appuiera sur les essais d'un démonstrateur monophasé 20 kV/ 2 kA. Deux types de supraconducteurs sont examinés: des tubes rigides de BiSrCaCuO (2212) connectés par des conducteurs souples, constituent une solution rapide et robuste; les dépôts laser d'YBaCuO sur support inox peuvent offrir à terme les meilleures performances.

ABSTRACT

The European project SUPERPOLI investigates the use of superconductors in medium voltage/ high current power transmission, on short distances. It can be applied to generator out-lines, and to particular points of the distribution grids. Superconductors are valuable here, by the function of fault current limitation, as well as a strong reduction of the Joule losses, and the costs for civil engineering. A 3-phase 1 GVA prototype is under consideration; its design will be aided by realization and test of a 1-phase 20 kV/ 2 kA demonstrator. Two families of superconductors will be investigated: melt cast processed tubes of BiSrCaCuO (2212), linked by flexible conductors, are a rapid and robust solution; ion beam deposited YBCO on a stainless steel substrate promise to eventually offer the best level of performance.

1. INTRODUCTION

At the end of this century, deregulation is changing the structure of power generation, power transmission and distribution. As a consequence of the increasing competition, the whole power system has to operate closer to its upper limit, which makes it more sensitive to perturbations and short circuits. Effective fault-current-limiting devices[1,2,3] are therefore becoming necessary in such power systems. Transmission of high-power current is also needed e.g. to supply area with increasing demand for energy (like major cities) or as generators out-lines.
The main benefit of the SUPERPOLI concept is related to the fault current limitation : when the current rises, the superconducting link becomes resistive and the over currents are reduced to a predetermined value.
Reducing the supply impedance of the transmission or distribution networks improve under normal conditions, the quality of the power delivered to the consumers. However, in this case, the fault currents are increased and the system components must, therefore, be designed for severe fault conditions (over currents, heating, breaking capacities, electro-magnetic forces even, in some cases, internal arcing faults). Current limitation will significantly reduce maximum rating requirements thereby allowing substantial saving without reducing power quality.
Classical links between generator and transformer require high currents and comparatively low voltages. They are typically 20 to 250 m in length. For each phase of a 1 GVA link, a metallic conductor of large cross section cooled by a fluid (liquid or gas) in a metallic tube of about 1.5 m in diameter is required. The dimension of a three phases link composed of three conduits increases to several meters in diameter. The main technical limitation in this classical configuration is the fault protection. Using a superconducting-current limiting link for this application means : reduction of the size of the link (the three phases will require no more place than one phase in the classical solution), limiting the fault currents and thus improving the protection of the system.
This device assures the protection of the generator in case of a fault on the grid side and also the protection of the line side in case of a generator fault and this can furthermore reduce the stresses in the generator (specially for small generators connected to a strong power grid).

2. SUPERCONDUCTING LINK DESIGN

Full-scale prototype:

In the final 1 GVA-class foreseen application, the superconducting power link is 100 to 200 meter long, 3-phased, with a phase current of 28 kA_{rms}, and a phase-to-phase voltage of 20 kV_{rms}; the fault current should not exceed a given level, between 60 and 100 kA_{rms}.
The prototype design is governed by several criteria:

- minimizing the size and the heat input;