Recent Progress of the Demonstration of Superconducting Power Technology in China

Liye Xiao, Institute of Electrical Engineering, Chinese Academy of Sciences

Abstract **- In last decades, the electric power demand has been rapidly growing in China, leading to the need for large-capacity power transmission at long-distances, stability of the transmission grid and improvement of power quality. Superconducting power technology could be a possible answer satisfying these needs. Therefore, several superconducting grid components have been developed and demonstrated recently. In this report, we will briefly describe the demonstrations of superconducting power technology in a power substation, DC power cable and fault current limiter.**

Submitted April 15, 2013; accepted May 6, 2013. Reference No. RN29; Category 6.

Keywords **- Superconducting power substation, DC superconducting power cable, superconducting fault current limiter.**

I. INTRODUCTION

China is a country where most of the power sources are located in the western and northwestern regions of the country, while most of the load centers are located in the southern and eastern regions. This distribution landscape of power and load leads to a large-scale national power grid, in which all regional grids are interconnected and thus the national power grid covers almost all of the territory of the immense country. In last decades, the power demand has been increasing at a very high speed so that by now the power grid of China became the largest power grid of the world. Its power capacity will be further increased by about 7% annually until the year 2025. For these reasons, it becomes increasingly diffficult to transport large amounts of electricity over long-distances, and to maintain the stability and reliability of the power grid. Superconducting power technology would be a possible solution for these challenges facing the future power grid of China, and thus this technology is being developed widely. In this article, the status and progress of superconducting power substation, DC power cable and fault current limiter demonstrations will be briefly reported.

II. THE 10kV SUPERCONDUCTING POWER SUBSTATION

The superconducting power substation consists of a 3-phase 75m-long 10kV/1.5kA high T_c superconducting (HTS) power cable, a 3-phase 10kV/1.5kA superconducting fault current limiter (SFCL), a 3-phase 10kV/0.4kV HTS transformer with capacity of 630kVA, and a1MJ/500kVA superconducting magnetic energy storage (SMES). That equipment had been demonstrated at substations or in a distribution system during 2004-2008, before they were integrated at Baiyin Industrial Park of Gansu Province. The project was sponsored by the Institute of Electrical Engineering (IEE), Chinese Academy of Sciences, and it took 10 years for IEE to complete this task.

Since the demonstration of the substation at the beginning of February 2011, there has been neither a fault in the distribution system nor any electrical breakdown of the superconducting power equipment. However, a cryogenic fault in the refrigeration system was found, which, however, could be recovered by replacing the cryostat of the power transformer and the LN_2 pump. An overview of this substation is shown in Figure 1. This power substation will be operated to demonstrate its reliability until the year of 2015.

Fig. 1. A view of the superconducting power substation

III. The 360m/10kA SUPERCONDUCTING DC POWER CABLE

Superconducting cable for DC power transmission would be a possible solution for high-rating transmission of power from renewable energy sources. In order to demonstrate the possible application, IEE started to develop a 10 kA HTS DC power cable in 2007. Upon completion and to test the cable, having a current-carrying capacity of 10 kA, IEE decided to demonstrate its viability by installing it at the Zhongfu Group, an aluminum producing company. The power cable has been successfully installed at the Henan Zhongfu Group in September 2012. The power cable, which connects the substation and the bus-bar of an aluminum electrolyzing workshop, is now operated to serve the factory together with the conventional transmission cable. A photo of the installed cable is shown in Figure 2. The ongoing

demonstration of this power cable shows that it can save 65% of transmission losses incurred in its conventional counterpart. This cable will be operated in the aluminum factory for about 1 year.

Fig. 2. The view of the 10kA HTS DC power cable after installation.

IV. THE 220kV/800A SUPERCONDUCTING FAULT CURRENT LIMITER

Recently, a saturated iron-core superconducting fault current limiter (SFCL) has been developed in China by the Innopower Superconducting Power Cable Company. After the factory tests in 2011, the 220 kV/800A SFCL was installed at the Shigezhuang substation of Tianjin, China. Installation of the device was completed in the first quarter of 2012. Figure 3 shows the SFCL after installation. Acceptance tests of this device were carried out by the Tianjing Power Company. Live-grid operation of this SFCL will be demonstrated to test the performance and reliability of the device.

Fig. 3. A view of the 220kV/800A FCL after installation at Shigezhuang substation in Tianjin

V. OUTLOOK

The demonstrations of superconducting power technology highlighted above will verify the feasibility of superconductors for future power grids by testing the performance and reliability of superconducting power equipment systems on the grid or in similar real-life applications. In the next 5 years, the superconducting power technology for high rate power transmission levels, such as a resistive fault current

limiter for the 500kV grid, a DC power cable for interconnections of 110kV busbars, and a SMES for wind power will be demonstrated.

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