Review of Analysis of Fault Current & Power Dissipated in HVDC CB with & Without SFCL

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Abstract— Distributed Generation Resources are increasingly used in distribution systems due to their great advantages. And this is further resulting in increased fault levels in electrical distribution systems, and this rising trend is expected to continue in the future. Using superconducting fault current limiters (SFCLs) is one of the best methods to minimize these problems comparing to the other conventional methods. This paper describes the factors that govern the selection of SFCL and CB combination by comparing different parameters such fault current level, active and reactive power. The total energy dissipated in an SFCL during a fault is particularly important.

Key words: Distributed Generation, Fault Level, Superconducting Fault Current Limiters (SFCLs)

I. Introduction

Superconducting fault-current limiters (SFCLs) have been the subject of research and development for many years and offer an attractive solution to the problem of rising fault levels in electrical distribution systems [1]–[3]. SFCLs can greatly reduce fault currents and the damage at the point of fault and help improve the stability of a power system. In this paper comparison of parameters of transmission line during fault has been analysed such as fault current, energy dissipation and interruption time.

The paper deals with active power and reactive power among four type of HVDC CB namely MCB, P-RCB, A-RCB and Hybrid DC CB. The result with and without SFCL of the above CB is compared. In order to estimate the performance of combined application of SFCL on HVDC CBs, simulation studies using MATLAB were performed on different CB and interruption characteristics were compared to determine the HVDC CBs type most suitable for the applications.

II. Literature Review

J.RAFFERTY described that the most important drawback of VSC-HVDC systems. And they summarized HVDC circuit breakers technologies including recent significant attempts in development of modern HVDC circuit breaker. A brief functional analysis of each technology was presented [4].

UMER AMIR KHAN observed that the passive current limiting by SFCL caused significant reduction in fault current interruption stress for SDCCB. Furthermore, fundamental design requirements for SFCL, including the effect of SFCL quenching impedance on SFCL voltage rating and energy dissipation capacity, were investigated. Finally, advantages and limitations of the SDCCB were highlighted [5].

STEVEN M. BLAIR proposed that the penetration of DG systems in distribution systems can result in the increase of the short circuit current level. The application of the fault current limiter (FCL) would not only decrease the stress on network devices, but also can offer a connection to improve the reliability of the power system [6].

CHRISTIAN M. FRANCK summarized the literature, especially that of the last two decades, on technology areas that are relevant to HVDC breakers. By comparing the mainly 20+ year's old, state-of-the art HVDC CBs to the new HVDC technology, existing discrepancies become evident & he also identified and proposed areas where additional research and development were needed [7].

RAMA RAO described an application of superconducting fault current limiter (SFCL) and proposed its use to limit the fault current that occurs in power system. Due to the difficulty in power network reinforcement and the interconnection of more distributed generations, fault current level has become a serious problem in transmission and distribution system operations [8]

T.SRIPAL REDDY described that Distributed Generation Resources are increasingly used in distribution systems due to their great advantages. The presence of DG, however, can cause various problems such as miss coordination, false tripping, blinding and reduction of reach of protective devices [9].

Ya Xiong Tan, et.al proposed that problem of increasing fault current levels can be solved by Superconducting fault current limiter (SFCL). He further added that by use of YBCO-type resistive SFCL the current flowing time of superconducting coil can be minimized from 50ms to 10ms. Experimental results showed that, with a 250 A current passing by, the resistance of superconducting tape with 10ms-design and 50ms-design are respectively 30 mΩ/m and 80 mΩ/m. Meanwhile, the current withstand ability (according to recovery time within 250ms) are respectively 465 A for 10ms-design and 272 A for 50ms-design. Estimation about the demand of superconducting tapes between two types of resistive type SFCLs with different current flowing time was done. Calculation results showed that the improved resistive type SFCL with 10ms-design only need 1/4th length of superconducting coil used in 50ms-design [10].

Yukinaga Morishita et.al proposed that the fault current be limited by a superconducting fault-current limiter (SFCL) and that this limited current is then interrupted by a dc circuit breaker. In this paper, he had separately investigated the SFCL and dc breaker and their use in combination [11].

W. T. B. de Sousa et.al used simulations of Superconducting Fault Current Limiters (SFCLs) in a real scenario and presented as an alternative solution for overstressing installed components in a substation of the Brazilian Interconnected Power System. And a technical comparison between SCFLs and Air Core Reactors was made and found fast recovery of SFCL was made. [12]

Bin Li et.al stated that in power system, superconducting fault current limiter (SFCL) is one of the best way to solve the large short-circuit current. SFCL presents very small impedance in the normal operation. When a fault occurs, SFCL in the fault transmission line develops high impedance rapidly to suppress the big current, which is helpful for circuit breaker (CB) to remove the fault [13].

Kun Yang, Yi Li,et.al stated that DC resistive type superconducting fault current limiters (SFCL) can be used in multi-terminal DC systems for fault current limiting. They help DC circuit breakers interrupt fault current with lower interruption [14].

H. S. Ruiz in his paper stated the reason for using HTS SFCL and stated that using low temperature superconducting materials (LTS) such as NbTi alloys, very successful projects were carried on before the manufacturing of high temperature superconducting materials (HTS) with reproducible quality. Nonetheless, despite the cost of NbTi alloys into the superconductivity market is very competitive, in general, LTS SFCL seems not be possible to be commercialized due to the high cooling cost and the difficulties to manage a cryogenic system with a nearly zero helium loss. However, a HTS SFCL is intentionally designed to operate at liquid nitrogen temperature, substantially reducing the cryogenic cost of the entire system. Further they stated that SFCL rated on (22.9 kV, 630 A) currently operating at the south-east of Seoul since 2011. In Japan, a consortium formed by different companies and research institutes, has successfully tested a (6.6 kV, 600 A) SFCL, optimizing the thickness of the silver protecting layer of the AMSC tape, and laminating it with a high-resistive stabilizing metal layer. In the same year, AMSC, Nexans, Siemens, and Los Alamos National Laboratory, have reported the successful test of a (138 kV, 1.2 kA) SFCL installed in the Southern California Edison Grid as part of the DOE project called Super conductor limiter. Continuation of this project was granted by the DOE (DE-FC26-07NT43243) in 2009, but the final project report has not been yet released [15].

Jiahui Zhua en.tl in his paper, a simulation model for a resistive type SFCL consisted of YBCO tapes is developed using Matlab software. This model will take into account SFCL's internal electromagnetic behaviour by coupling its internal resistance and the current density characteristics based on the E-J power law. Also the SFCL simulation model is applied in a transmission and a wind farm power grid, respectively. Different fault limiting scenarios are investigated and the results shows that the SFCL is effective in limiting fault currents with a maximum of 50% in transmission lines, particularly for wind farm networks [16].

III. Conclusion

Resistive SFCLs are the simplest and most obvious form of SFCL because the superconductors are electrically in series with the phase conductors. .SFCLs can typically limit the first peak of fault current. An SFCL with suitably rated switchgear to interrupt fault current therefore acts much faster than a circuit breaker alone, without SFCLs, no remedial action occurs until a circuit breaker opens. This offers significantly reduced damage at the point of fault.

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