Transient Simulation and Analysis for Saturated Core High Temperature Superconducting Fault Current Limiter

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Abstract—In this paper, the transient performance of a magnetic-core fault current limiter (FCL) saturated by high temperature superconducting (HTS) DC bias winding is investigated by using 3-dimensional field-circuit coupled simulation. A high voltage is induced on the DC HTS winding during the fault current state. The induced voltage is computed and some possible methods to reduce it are studied. The numerical computations are verified by the experiment results on an FCL prototype.

I. Summary

For the large-scale power system, the development of FCLs for suppressing the over currents during faults are strongly desired. By applying superconducting technology, superconducting FCLs with diverse principles have been proposed, such as resistive, inductive, magnetic shielding and saturated core FCLs, etc [1-4]. There have been reports on analyzing the superconducting FCL by applying prototype experiment, as well as circuit model with ϕ-I curve of FCL. The finite element analysis (FEA) considering E-J characteristics of superconductor has also been developed in simulation of magnetic shielding type FCL [2].

This paper carries out the numerical simulation for the performance of HTS FCL using 3-Dimensional (3D) transient electromagnet field computation coupled with electric circuit, which is integrated in the commercial FEA package ANSYS. The structure of a prototype saturated core FCL incorporated with DC HTS bias winding is shown in Fig. 1. The computed transient current of FCL in both normal and fault condition are conformed through the measurement of the FCL prototype. Figs.2 and 3 illustrate the measured and simulated currents, respectively. The discussion of the results will be presented in the final paper.

The DC bias winding for FCL is expected to use HT superconductors, which will drive the magnetic core into saturation with a low DC power supply. However, the flux change in the magnetic core will induce an undesirable high voltage in the DC coil, and a large AC current will flow through the coil. In the final paper, the induced voltage in the DC HTS bias winding is computed and analyzed in detail by using transient FEA. Some proper methods, such as magnetic shielding as shown in Fig.1, will be investigated for limiting the induced AC voltage.

II. Conclusion

The saturated magnetic core fault current limiter with HTS DC bias coil has been investigated by using 3-dimensional electromagnetic field computation coupled with circuit. The accuracy of the dynamic characteristics of FCL is proven by the experimental results. The saturated core FCL has a fast response to limit the fault current. The high induced AC voltage in HTS DC bias coil, which may destroy the DC coil, has been simulated by applying FEA. Some possible methods for reducing the voltage have been evaluated and discussed.

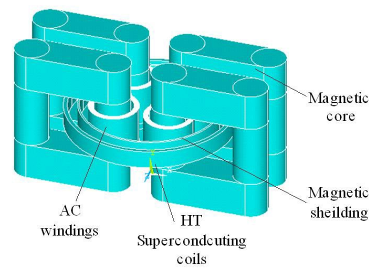

Fig.1. Structure of the saturated magnetic core FCL

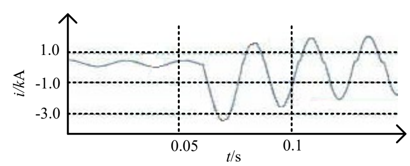

Fig.2. Experimental current flowing through the AC winding

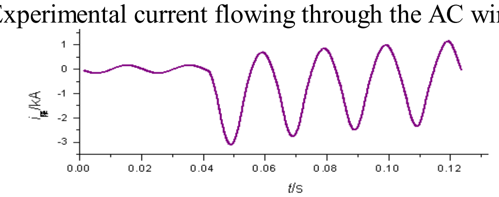

Fig.3. Computed current flowing through the AC winding

III. References

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