Superconducting Power Apparatus

Background

Zero electrical resistance in superconducting wires appears under the critical temperature (Tc). When applied to electrical equipment, it is expected to realize higher efficiency, smaller size and weight. However, in the case of the use of superconducting wires in an AC system, AC losses of superconducting wires cause the decrease in efficiency of equipment and the increase of refrigerator power.

The technologies such as the precise AC loss measurement, the reduction of AC losses, and the improvement of superconducting properties have been developed to use the superconducting wires in an AC system in CRIEPI so far.

Principal results

The highly precise AC loss measurement method of coils wound by metal superconducting wires has been established. Metal superconducting wire with lower AC loss than conventional copper wire has been developed. It was applied to a field winding of a superconducting generator, and verified to have no reduction of performance in practical conditions including the daily start and stop operation for 30 years.

In high-Tc superconductors, fundamental technologies for practical use have been established by a field test of a 500m long the high-Tc superconducting (HTS) cable. The R&D of a reactor type current limiter and a high-performance cylinder using a thick superconducting film have been carried out. A low-cost and high-speed fabrication technique of YBCO superconducting films has been developed. In the introduction of various superconducting equipment to the power system, the introduction effects such as the efficiency improvement and the transmission stability have been verified by analyses.

CRIEPI participated in national projects such as the SMES project and the super-ACE project, and contributed to development promotion such as the SMES, the superconducting cable and the superconducting current limiter.

Future Developments

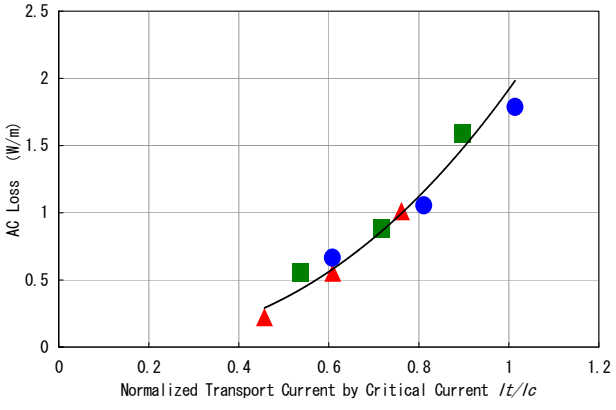
CRIEPI will promote the investigation of the introduction effects for superconducting current limiters, the investigation of the applicability of the YBCO film fabrication technique to manufacturing process, and R&D for realization of superconducting electrical equipment.

In addition, CRIEPI will participate in national projects and cooperate in the development of various superconducting electrical equipment. CRIEPI will also investigate the possibility of industrial applications of superconductors and new technologies to resolve environment problems by the use of superconductors.

Evaluation of AC loss of HTS cable

To realize superconducting power equipment, it is important to evaluate the AC loss of superconductor. So we have measured the AC loss of superconductor cable.

HTS power cable will be used under variable conditions, for example various temperatures and load current, so it was difficult to evaluate the AC loss of HTS cable exactly. We have measured AC loss under various temperatures and current using a 3m long HTS cable, and assumed that AC loss would be estimated from the temperature dependence of the critical current.



Red: 70.7K, Green: 73.2K, Blue: 73.5K
(Temperature at upper side)

Field test of 500m long HTS cable

The world's first 500m-long HTS cable (upper photo) is a race track shape, which includes a 10m high rising and falling section simulating a bridge section over a river and an offset section for absorbing the thermal contraction and expansion. The field test of this cable was carried out during approximately one year. Fundamental technologies for a practical use have been established by stationary running test, a load changing test, and a critical limiting test in a power failure or a refrigerator failure.

Development of reactor type fault current limiter

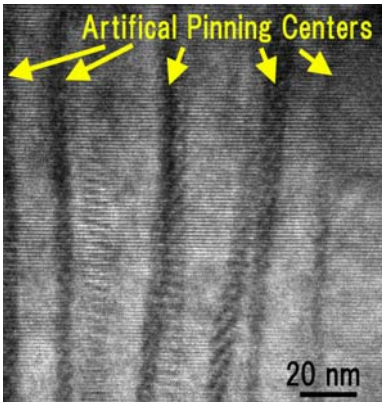
A magnetic shielding type superconducting fault current limiter (SFCL) has a simple structure, which put a coil outside a superconducting cylinder. A large-scale superconducting cylinder made by a Bi-2223 thick film with a diameter of 450mm has been developed to apply to this type SFCL. The development of the 60kV-class SFCL is carried out by using this superconducting cylinder.

Photo: The Bi-2223 thick film on MgO cylinder

Fabrication technique of the YBCO films

Deposition and crystallization for the YBCO film fabrication are successfully separated into each ways by the use of fluoride as a part of starting materials. The deposition without crystallization can be high-speed. The heat treatment in a low pressure can be more easily reacted than the conventional heat treatment. As a result, the fabrication speed will be faster than the target value of 5m/hr as an industrial fabrication speed.

Photo: A high-speed and dry fabrication system of the Y-based superconducting films



Improvement of critical current densities of YBCO thin films

The introduction of artificial pinning centers (APCs) into YBCO films to improve the critical current density under a magnetic field have been studied. The APCs have a function to fix fluxoide in a superconducting film. The optimum structure of APCs can be clarified by investigation of microstructures of superconducting films introduced APCs.

Photo: A microstructure of the superconducting films introduced nanorods as APCs.