Next Generation Electric Power Equipment for Distribution and Transmission Systems

Background and Objective

Next-generation electric power distribution and transmission systems must be flexible enough to deal with changes such as connection of large amount of photovoltaic power generation to build a low carbon emission society. Moreover, in the near future, replacement of electric power equipment will be a significant problem. Therefore, technology menu for replacement should be prepared.

In this project, super conductive fault current limiters and equipment for transformer substrate are developed to add to a list of technology menu for replacement.

Main results

1. Development of superconducting fault current limiter (SFCL)

Fault current limiters (FCLs) can reduce the limitation on the system configuration caused by a short circuit current. Especially, magnetic shielding type SFCLs are suitable for relatively high voltage system. By optimizing preparation conditions for superconducting thick films, the critical current density (JC) of a small sample has achieved up to 5,400 A/cm^2 required for practical SFCLs (Fig. 1). Furthermore, large-scaled superconducting thick film cylinders with 450 mm in diameter used for practical SCFLs were produced on the base of technology established in CRIEPI. Moreover, examination was conducted on the introduction of SN transition type SFCLs with an excellent compact size into a looped distribution system by computer simulation. As a result, the optimum setting location of these SFCLs for the limitation of a blackout area is shown in (Fig. 2) [R10008].

2. Development of elemental technology for an all solid insulated transformer

The all-solid-insulated transformer is very attractive because of its high safety, compactness and low environmental loading owing to its oil-free insulation. Based on the technique accumulated in this project for the insulation and thermal design of the all-solid-insulated transformer, 60kV-class outer-layer grounded all-solid-insulated transformer model was designed and fabricated (Fig. 3). In this model transformer, all solid compact connector “hyper-connector” being developed in CRIEPI was also adopted. Fundamental data for the design of actual all-solid-insulated transformer for 60kV-class will be obtained using this model.

3. Development of SF6-free gas/solid hybrid insulation system

CRIEPI is developing a new type of electrical insulation method “gas/solid hybrid insulation system”. High-electric-field part of the hybrid insulation system is insulated using a solid insulator. Therefore, the same degree of compactness as the present apparatus can be achieved without using SF6, which has a high global warming potential. However, there are important issues to be resolved before practical applications, such as methods of jointing and supporting a thickly coated conductor. Therefore, we proposed actual model jointing and supporting a thickly coated conductor based on electric field analysis (Fig. 4). Moreover, the insulation performance of the actual model was evaluated. The obtained results verified that these joint and support models are applicable to the gas/solid hybrid insulation system for 300kV-class.

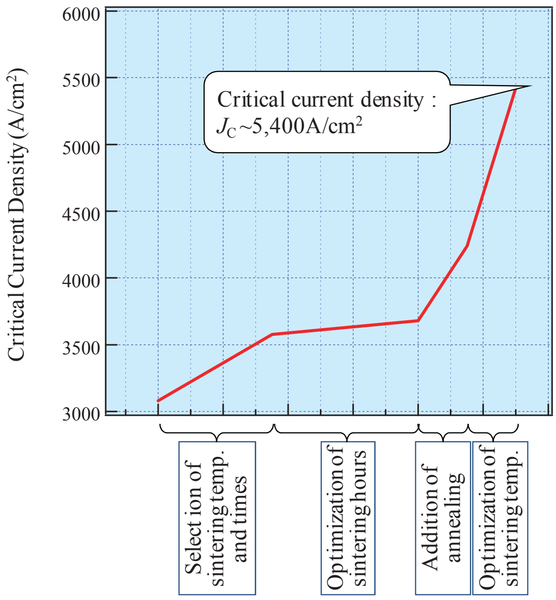

Fig. 1 Improvement on critical current density (*Jc*) of superconducting thick films

As a result of optimization of preparation conditions, *Jc* of 5,400 A/cm² was achieved.

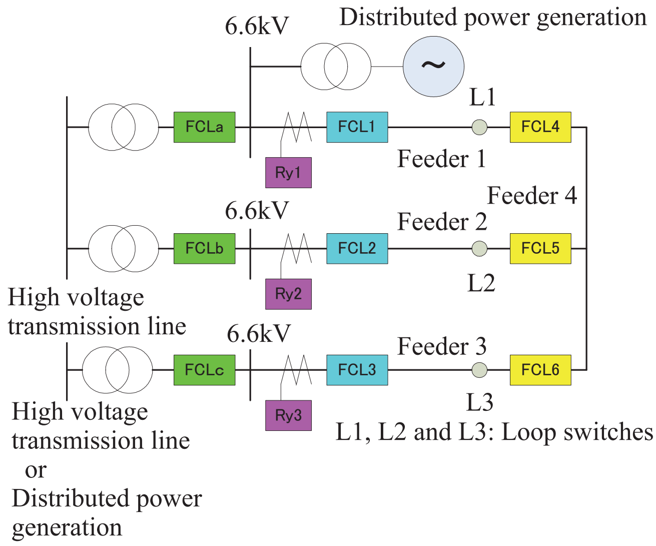

Fig. 2 Optimum setting location of SN type SFCL in a looped distribution system

In case of a looped distribution system, the breakout area can be limited by the setting of SFCL near the loop switches (FCL4~6)

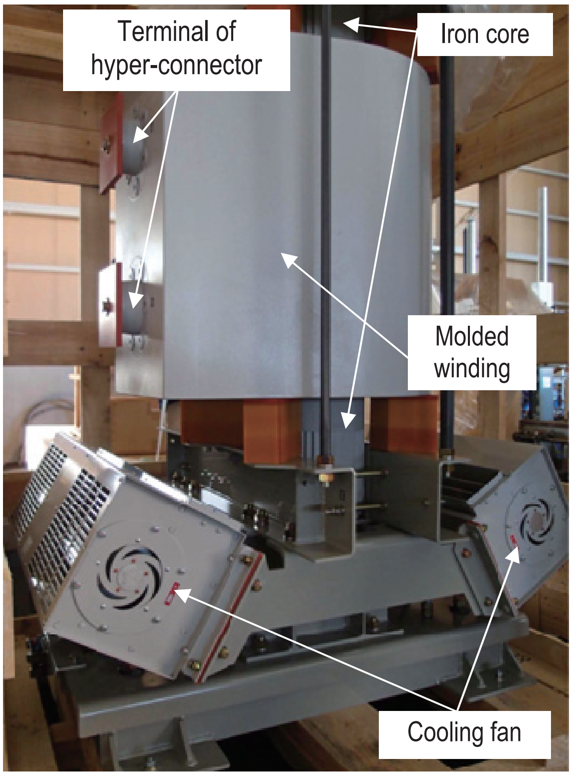

Fig. 3 All-solid-insulated transformer model

This model is an outer-layer grounded molded transformer. All-solid compact connector "hyper-connector" is adopted.

※) Hyper-connector is a compact connection system between high-voltage equipments constituting "All-solid Insulated Substation", and is featured by a bendable bus and compact connectors united with sensors.

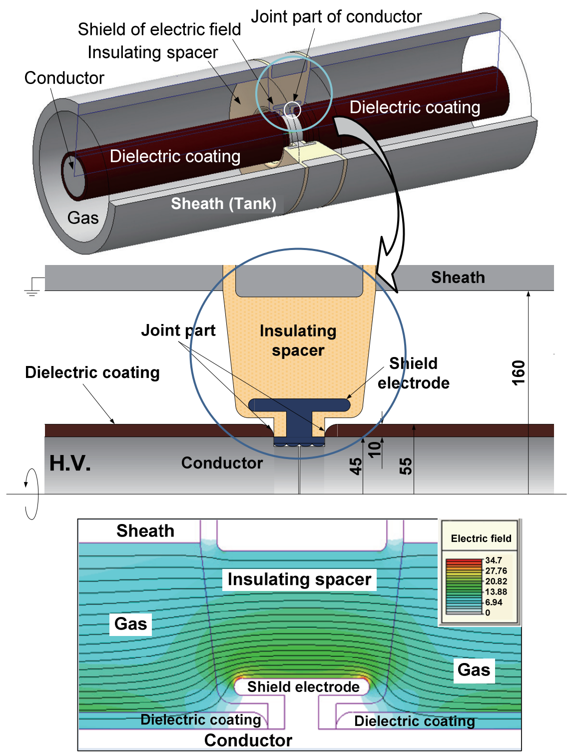

Fig. 4 Basic structure of gas/solid hybrid insulation system (upper), coated conductor joint and support model (middle), and result of electric field analysis (lower)

A long shield electrode in the insulating spacer was installed at the joint part. Therefore, the electric field of the joint part was widely shielded. The maximum electric field strength on the gas side of this model appeared at the surface of the dielectric coating.