Basic Technology Subjects

Electric Power Engineering Research Laboratory

Brief Overview

The Electric Power Engineering Research Laboratory is engaged in the advancement of fundamental technologies, including electrical insulation, high voltage technology, lightning protection, electromagnetic environment and high current technology for power transmission and distribution equipment. It is also developing next-generation power equipment and XTAP (eXpandable Transient Analysis Program), simulation and application of arc, application of power electronics and lasers.

Achievements by Research Theme

High-voltage and Insulation

We aim to clarify the deterioration mechanism of solid electrical insulation materials used in aged electrical equipment, advance external insulating technology for transmission lines, improve the accuracy of high voltage measurements and evaluate new insulation materials for next-generation power transmission and distribution equipment.

- The deterioration of O-rings used for sealing gas insulated equipment influences equipment life. We proposed an estimation method for compression set*1 based on a visco-elastic model in order to construct the deterioration evaluation method for O-rings. Using this method, the compression set is predicted by obtaining the physical characteristics of visco-elastic model and usage environment conditions (Fig. 1)*2 (H13013).
- Measurement uncertainties of Japanese national-standard-class measuring system*3 for switching impulse high voltage have been evaluated and it was found that they are of a minimal level compared with those of leading countries (H13003).

Lightning and Electromagnetic Environment

We aim to develop technologies for the lightning protection design and the insulation coordination that are applicable to the demand and supply system of electricity and energy in an information-communications technology (ICT) society, as well as to establish the technologies for the assessment of electromagnetic compatibility (EMC) and electromagnetic environment in power systems and consumer equipment.

- To improve the prediction precision of outage rate for multiphase faults on 77 to 154 kV transmission lines caused by lightning, the flashover phenomenon in two arcing horns*4 arranged in parallel was experimentally investigated in terms of flashover characteristics - the 50% flashover voltage and the leader developing process. Based on the experimental results, the probability of the simultaneous generation of flashover was clarified to have a proportional relation with the peak value of applied voltage (H13008).

Applied High Energy Physics

We aim to develop numerical analysis methods of pressure rise and propagation characteristics to complement the internal arc testing of electric power equipment, as well as to develop innovative measurement technologies using laser and optical technologies and to work on their application toward the diagnosis of power delivery apparatuses. We also develop plasma melting technology to reduce the volume of radioactive waste for disposal.

- Some openings and wire meshes are installed in electrical equipment such as switchgears to control the pressure rise due to fault arcs in equipment. In order to estimate the pressure rise and propagation in the equipment by numerical analysis, a simple calculation model was developed in which wire meshes were considered a medium of pressure loss and heat sink / conductor. 3D pressure rises in switchgear with wire meshes were calculated using this model. Results showed that calculated pressure developments were in good agreement with experimental results (Fig. 2). This indicates that the calculation method and the model for the effects of the wire meshes are well suited for the understanding of the experimental results (H13011).
- Terahertz waves are effective for measuring the thickness of the topcoat of thermal barrier coating applied to high temperature components in gas turbine thermal power generation, which is usually about 300 micrometers. Measurement accuracy was improved by taking the effects of the surface roughness into account. The measurement method was applied to a real component (gas turbine blade), and the measurement result agreed with the microscopic observation result of the cross section of the blade to within 6%. This confirmed the validity of the method[1].

Electric Power Application

We aim to develop analysis methods for electric power quality and technologies to achieve design and management of rational electric power systems connected to power electric equipment through the development of cooperating technologies with customers for improving electric power quality.

■A technique of processing an internal state update in parallel was developed for the improvement in calculation speed of electromagnetic transient simulations programs (XTAP). Moreover, to speed up computation time, a method to reduce computational demand of a remote power system located far from the source of a simulated transient event was developed (H13005) (H13010).

■In the distribution system, in order to simplify dynamic voltage analysis, the analysis model for XTAP of a distribution substation and a step voltage regulator was developed (H13007).

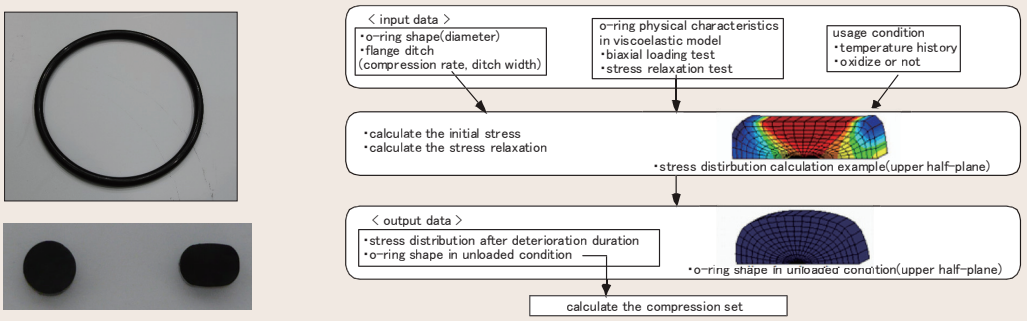
High Current Technology

To estimate the performance of electric equipment upon a short-circuit fault, we aim to improve short-circuit test techniques and establish measuring techniques for power frequency current.

■We developed a simulation code relating to the breaking characteristics of strands of ACSR used in transmission lines by fault current AC arc. The calculation results were in good agreement with the experiment results obtained by AC arc tests (H13001).

[1] T. Fukuchi et al., IEEJ Trans. FM, Vol. 133, No. 7, pp. 395-401 (2013)

*1 An index of remaining permanent deformation when compression force of an o-ring is removed.
*2 Joint study between CRIEPI and Tsukuba University.
*3 The national standard class voltage divider is owned by Chiba Institute of Technology and the national standard class measuring system is operated under Japan High-voltage Impulse testing Laboratory Liaison (JHILL).
*4 Rods attached to the both ends of insulator string, which protect the insulator strings from the arc discharge following the flashover.



(a) New (left) and deteriorated (right) o-ring (b) Calculation flow

Fig. 1: An example of an aged o-ring and the compression set prediction flow

Initial stress and stress relaxation are calculated by constructed method based on physical characteristics and diameter of o-ring and setting condition. The o-ring compression set of can be predicted based on stress distribution and shape of the o-ring in an unloaded state after an optional time.

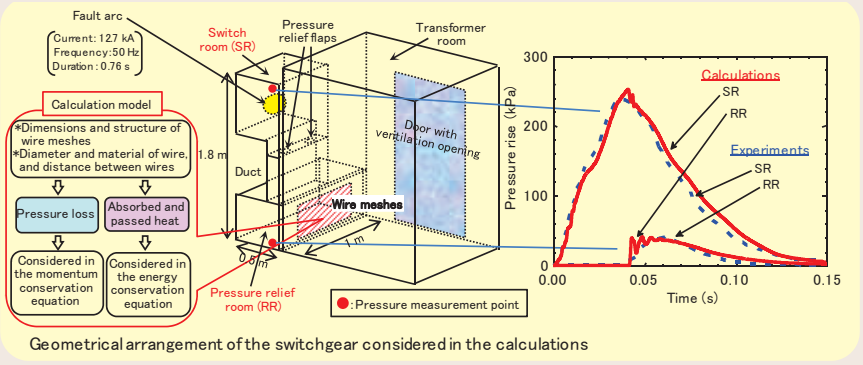


Fig. 2: Comparison between the experiment* and calculation of pressure rise due to fault arc in the switchgear

The calculation results of pressure developments due to fault arc in the switch room were in good agreement with the experimental ones, i.e. the pressure rise in the pressure relief room was suppressed by the opening of pressure relief flaps and the effect of the wire meshes.

*A. B. Wahle. “Untersuchungen zum Einsatz von Energieabsorbern in Ringkabelschaltanlagen im Störlichtbogenfall”, Ph. D. dissertation RWTH Aachen University (2007).