●Division of Energy

Efficient and Environment-Friendly Electric Energy System

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Outline of Research

Our research activities can be divided into the following 3 categories from the comprehensive viewpoints of materials, apparatus and systems for the efficient and environment-friendly electric energy system:

(1) Superconducting power application

We have been developing superconducting fault current limiting transformer (SFCLT) with the functions of both superconducting transformer in normal operating condition and superconducting fault current limiter in fault condition. As the Step-5 of SFCLT project, we designed and fabricated 2 MVA class SFCLT using YBCO coated conductors with the ratings of 3-phase and 22 kV/6.6 kV. The developed SFCLT is characterized by a hybrid structure of superconducting coils using YBCO, YBCO/Cu and Bi2223 tapes for the design flexibility as both of the superconducting transformer and the superconducting fault current limiter. Fundamental tests of the developed SFCLT verified the excellent performance as both a superconducting transformer and a superconducting fault current limiter.

We have also been investigating electrical insulation technologies of superconducting power transmission cables and superconducting magnetic energy storage (SMES) system for the reliable and rational insulation design under severe and practical operational conditions.

Cryogenic high-voltage laboratory

(2) Condition monitoring and diagnosis

A metallic particle is one of the critical defects in SF_6 gas insulated switchgears (GIS) and their condition monitoring and diagnosis is expected. Using our partial discharge (PD) measurement system developed with a high-speed PD current pulse detection technique, the differences in PD behavior for different defect types have been investigated. Moreover, the correspondence between PD current pulses and UHF electromagnetic waves emitted from PD was studied to clarify how to interpret the measured data by the UHF method.

We have also proposed “Intelligent Grid Management System (IGMS)” as a tool to maintain the balance between cost efficiency and quality of power supply. Through the IGMS concept, we could find the most economically feasible maintenance strategies of power apparatus and suitable power flow routes in a transmission and distribution electric network.

(3) Advanced insulating materials

For the development of environmentally benign vehicles, PD inception and breakdown (BD) lifetime characteristics of magnet wires have been discussed for inverter-fed motors under repetitive surge voltage application. We also clarified that the nanocomposite enameled wires exhibited the longer BD lifetime, which was about 1000 times of conventional enameled wires. The physical mechanisms of PD inception and propagation leading to BD were discussed in terms of charge behavior and theoretical analysis.

A novel technique was developed to fabricate functionally graded material (FGM) and nanocomposite material for the higher electrical insulation performance with the longer lifetime of power apparatus. The developed new materials will contribute to the compactness and simplification of insulating materials under the optimum electric field.

Career

1991 Ph.D., Electrical Engineering, Nagoya University
1996 Associate Professor, Center for Integrated Research in Science and Engineering, Nagoya University
2001-2002 Guest Scientist, Forschungszentrum Karlsruhe, Germany
2004 Professor, EcoTopia Science Institute, Nagoya University

Awarded Prizes
1996 Prize of Outstanding Technical Paper, IEEJ
2003 Prize of Progress, IEEJ
2005 Prize of Outstanding Technical Paper, IEEJ

Membership of Academic Society

IEEE, CIGRE, IEE of Japan, Cryogenic Association of Japan, The Institute of Engineers on Electrical Discharges in Japan

Publications

(1) Development of 2 MVA Class Superconducting Fault Current Limiting Transformer (SFCLT) with YBCO Coated Conductors, Journal of Physics: Conference Series (JPCS) (to be published)
(2) Partial Discharge Activities under AC/Impulse Superimposed Voltage in LN_2/Polypropylene Laminated Paper Insulation System for HTS Cables, Journal of Physics: Conference Series (JPCS), Vol.234, No.032020 (2010)
(3) Permittivity Characteristics of Epoxy/Alumina Nanocomposite with High Particle Dispersibility by Combining Ultrasonic Wave and Centrifugal Force, IEEE Trans. on Dielectrics and Electrical Insulation, Vol.17, No.4, pp. 1268-1275 (2010)
(4) Partial Discharge and Associated Mechanisms for Micro Gap Delamination at Epoxy Spacer in GIS, IEEE Trans. on Dielectrics and Electrical Insulation, Vol.17, No.3, pp.861-867 (2010)
(5) Surface Charge Accumulation and Partial Discharge Activity for Small Gaps of Electrode/Epoxy Interface in SF_6 Gas, IEEE Trans. on Dielectrics and Electrical Insulation, Vol.16, No.4, pp.1150-1157 (2009)
(6) Current Limiting Characteristics of Parallel-Connected YBCO Coated Conductors for High-Tc Superconducting Fault Current Limiting Transformer (HTc-SFCLT), IEEE Trans. on Applied Superconductivity, Vol.19, No.3, pp.1880-1883 (2009)
(7) Dynamic Thermal Characteristics of HTS Coil for Conduction-cooled SMES, IEEE Trans. on Applied Superconductivity, Vol.19, No.3, pp.2036-2039 (2009)
(8) Time Variation of Partial Discharge Activity Leading to Breakdown of Magnet Wire under Repetitive Surge Voltage Application, IEEE Trans. on Dielectrics and Electrical Insulation, Vol.15, No.6, pp.1701-1706 (2008)
(9) Partial Discharge Activity in Electrical Insulation for High Temperature Superconducting (HTS) Cables, IEEE Trans. on Dielectrics and Electrical Insulation, Vol.15, No.3, pp.647-654 (2008)
(10) Quench-induced Partial Discharge Characteristics of HTS Cables, Journal of Physics: Conference Series (JPCS), Vol.97, No.12053 (2008)
(11) Breakdown Characteristics of N_2O Gas Mixtures for Quasiuniform Electric Field under Lightning Impulse Voltage, IEEE Trans. on Dielectrics and Electrical Insulation, Vol.14, No.6, pp.1492-1497 (2007)
(12) High Temperature Superconductivity, Springer-Verlag (2004)