The 20th Anniversary Special Issue

Electrical Insulation News in Asia

No.20 *November 2013*

IEEJ

In-Grid Demonstration of High Tc Superconducting Cable in Yokohama, Japan

(Provided by NEDO, TEPCO, SEI and Mayekawa.)

High-power Testing Facility with State-of-the-art Equipment

Outside of high-power testing facility.

Capacitor bank of adjusting the transient recovery voltage.

(Provided by Hitachi, Ltd. Power Systems Company)

500kV Gas Insulated Bushings with Downsized Porcelain Hollow Core Insulators (Shin-Haruna Substation of TEPCO)

(Photo: Courtesy of Toshiba Corporation, Provided by NGK Insulators, LTD.)

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PREFACE

Prof. Toshikatsu Tanaka

Congratulation on the 20th Anniversary of EI Magazine and the New Rise of Asia!

EINA Magazine is just for you. Surprisingly, almost twenty years have passed since its first issue appeared in 1994. The years we spent with you certainly corresponds to a starting period of Asia's rise between the end of the 20th century and the beginning of the 21st century. Importantly, the Magazine has kept offering valuable information on electrical insulation to insulation people in Asia and beyond, who I believe have ever obtained much impetus and vigor for future. Acknowledgment for this accomplishment should go to editors, readers, members of various related IEEJ study committees and people who incessantly contributed their own attractive and vivid articles. I have been working on this task from the beginning, and then personally I'd like to congratulate on such a memorable anniversary occasion and share with you the pleasure of having a long-term mutual acquaintance via this valuable media.

You may find many enormous changes during the twenty years in all disciplines like health, energy, sustainability, education, economic opportunity, national security and human exploration of your keen interest. These social changes are certainly based on scientific and technological achievements that we human beings have accomplished. You might pick up some examples immediately. For example, internet technologies including popular smart phones have already substantially changed our communication world and will keep changing it to a direction beyond our imagination. The discovery of i-PS cells has ever been giving a revolutionary change in human health care and even opening a completely new world in which Androides and Cyborgs might be symbiotic with human beings. Voyager 1 of 36 years of age has left the solar system in 2013 for the space between the stars to send our message to extraterrestrial being as human exploration. It is minor worldwide but major to Japan that the 2020 Olympic Games have been decided to be held in Tokyo. Global geopolitical change seems to be taking place. It is certainly due to the Asian rise.

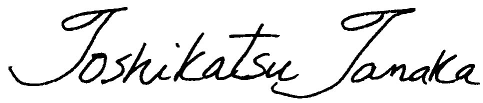
A big change appears also in electrical insulation. Electric power delivery systems are an indispensable lifeline. They are supported by many technologies. Electrical insulation is most requisite among them. The late Professor Masayuki Ieda focused in the first issue of EI Magazine in 1994 on his thought that we Japanese had obtained our scientific and technological achievements in electrical insulation from North America and Europe for their favor and then should act to forward Japanese new achievements to the Asian countries that would need them. He had looked "east" ("west" from Japan). Then this magazine started after a certain incubation period of two or three years during which an IEEJ Committee named "Asian Interlink in Dielectrics (AID)" had been activated as pre-EINA activities. I strongly believe that EINA Magazine has contributed much to form a communication tool and construct a friendship especially among Asian countries in electrical insulation as he wanted.

The rise of Asia is a symptom for a big change. You might feel it everywhere in daily life. This appears in electrical insulation, too. Lots of insulation-related international conferences are held in Asia, for example, Asia based ICPADM, CMD, ISEIM and ICEE, and even the North America-based CEIDP and Europe-based ISH. The Magazine is full of Asian news that attracts much attention. Specifically you see the column named “the country corner” contributed from China, Korea, India and Indonesia that are very much informative. Other countries are requested to join this corner.

Electrical insulation is not new from the standpoint of engineering, but is always needed to support electricity lifeline. Lifetime span is postulated to be usually in the range of thirty years. Therefore, there is only a narrow chance if you want to introduce new technologies in developed countries since no new installation is taken into consideration until lifetime comes. On the other hands, in Asian countries, there are many opportunities available for you to introduce new technologies since lots of new installations are projected thanks to their favorable economic growth. A variety of new materials with improved performances are available if you want to use them. Polymer nanocomposites are one of the examples. Computer technology is very much beneficial to optimize the design of power apparatus and even to create new functional materials via simulation study. So a lot of chances are waiting for you. Challenge yourself to a newly born wide opportunity in electrical insulation.

Doors are widely open. Your proactive and aggressive participation in this field will certainly create a new interesting world of insulation.

Professor Toshikatsu Tanaka
Waseda University, Japan
Xi’an Jiaotong University, China



OUTLINE OF TECHNICAL COMMITTEES IN IEEJ

Dielectrics and Electrical Insulation (DEI)

Chairperson:	Yasuhiro Tanaka	(Tokyo City University)
Secretaries:	Masaaki Ikeda	(JNES*)
	Yoitsu Sekiguchi	(Sumitomo Electric Co. Ltd.)
Assistant Secretaries:	Norikazu Fuse	(CRIEPI**)
	Takahiro Imai	(Toshiba Corporation)

*JNES: Japan Nuclear Energy Safety Organization **CRIEPI: Central Research Institute of Electric Power Industry

The Technical Committee on Dielectrics and Electrical Insulation (**TC-DEI**) has a long history from 1970, in which the former committee named as the Permanent Committee on Electrical Insulating Materials was established in IEEJ (the Institute of Electrical Engineers in Japan). The activity of the Committee has been covering mainly solid and composite dielectric materials and their technologies. From June 2013, the TC-DEI has started a new season with a new chairperson of Prof. Y. Tanaka.

Organized events by TC-DEI

The important activity of TC-DEI is the annual domestic Symposium on Electrical and Electronic Insulating Materials and Application in Systems (**SEEIMAS**), formerly called Symposium on Electrical Insulating Materials. **The 44th SEEIMAS** is to be held in Toyohashi city on November 25-27, 2013, with technically cosponsored by IEEE DEIS Japan chapter, CIGRE Japanese national Committee and locally arranged by colleagues of Toyohashi University of Technology. New materials and the improvement of their properties, functional materials, nano-composite materials, insulation systems under inverter surges, partial discharge and space charge assessment, outdoor insulations, thin dielectric films and other topics will be discussed. Especially in this year's symposium, the special session featuring the diagnosis of electrical insulation degradation with demonstration using actual equipment is supposed to be carried out, and it must attract participants.

Following the 44th SEEMAS, **the 30th young researchers' seminar** will be also held in Mikawa area, near Toyohashi City, on November 27-28, 2013. While the seminar was used be mostly held with two years interval by 2001, it was not held for long time mainly because of the financial crisis in Japan. However, to activate the youth in this research field, the TC-DEI decided to bring back the seminar in 2009. The 30th memorial seminar will be held following the last seminar in 2009.

In every 3 years, we hold SEEIMAS as an international one technically cosponsored by IEEE DEIS, namely the International Symposium on Electrical Insulating Materials (**ISEIM**). Next year we will hold the 7th international symposium (**2014 ISEIM**) with Honorary Chair of Prof. M. Nagao and the General Chair of Prof. Y. Tanaka, in June 1-5, 2013 at Toki Messe, Niigata, technically cosponsored by IEEE DEIS, co-sponsored by Niigata University and Waseda University, in cooperation with IEEE DEIS Japan chapter. The TC-DEI is now planning a new type special session concerning "Measurement of Space Charge Distribution using PEA system" to attract many participants. Information about the 2014 ISEIM will be updated on the following URL. Please visit there. We are expecting your participation.
http://www2.iee.or.jp/~adei/ISEIM2014/index.html

Investigation Committees run by TC-DEI

Adding to organize some events, the TC-DEI runs Investigation Committees (IC's) that organize several technical meetings a year. The investigation committees are categorized into three research areas:

New materials including nano-materials related

> Nano-Materials and Structure Control for Organic Devises with New Function and High Performance (04/2011 - 03/2014, Chairperson: K. Kato (Niigata University)).

> Forefront of the Study of Organic Dielectrics, Conductive Electrical and Electronic Materials in the District of Asia (11/2010 - 10/2013, Chairperson: M. Iwamoto (Tokyo Institute of Technology)). Next committee is now under consideration.

> Applied Technology of Advanced Dielectric Polymer Nanocomposites (04/2010 - 03/2013, Chairperson: T. Tanaka (Waseda University)). Next committee is now under consideration.

Ageing and diagnosis of electric and electronic equipment related

> Investigation of Degradation Diagnosis Technology of Electric Power Apparatus for its Transfer (04/2013 - 03/2016, Chairperson: Y. Ehara (Tokyo City University)).

> Testing methods of winding insulation systems for Invertor-fed motors (05/2013 - 04/2016, Chairperson: M. Nagata (University of Hyogo)).

> Current state and future view of innovative diagnostic techniques of power apparatus (10/2012-09/2015, Chairperson: M. Ikeda (JNES)).

Basic dielectric and breakdown phenomena related

> Evaluation of Properties and Improvement of

Polymeric Insulating Materials for Outdoor Use (04/2010 - 03/2013, Chairperson: H. Homma (CRIEPI)). Next committee is now under consideration.

> Standardization of Calibration and Development of Application on Space Charge Measurement using PEA Method (03/2009 - 02/2012, Chairperson: Y. Tanaka (Tokyo City University)). Next committee is now under consideration.

Electrical Discharges (ED)

Chairperson:	F. Tochikubo (Tokyo Metropolitan University)
Secretaries:	A. Kumada (The University of Tokyo)
	H. Kojima (Nagoya University)
Assistant Secretaries:	Y. Yamano (Saitama University)
	N. Shimura (Toshiba Corporation)

The Technical Committee on Electrical Discharge (TC-ED) belongs to the Fundamentals and Materials Society (A-Society) of the IEE Japan. The mission of the TC-ED is the wide promotion of the research activities concerning a variety of electrical discharges in vacuum, gas, liquid and on surfaces of materials and their applications to advanced technologies in various fields.

Several investigation committees are established every year to survey the up-to-date research subjects under the control of the TC-ED. The activities of these committees usually continue for three years. Three investigation committees in Table 1 are in operation.

The TC-ED organizes about six domestic technical meetings on electrical discharges every year. In these meetings, approximately 180 papers are presented in total from both academic and industrial sides by researchers, engineers, professors and students. The technical meetings play an important role for young researchers as a good training ground. The domestic technical meetings are sometimes co-organized with other Technical Committees such as Pulse Electromagnetic Energy, Plasma Science and Technology, Dielectric/Elect- rical Insulating Materials, High Voltage Engineering, and Switching and Protecting Engineering.

In order to promote the international activities in electrical discharges, the TC-ED has jointly organized “Japan-Korea Joint Symposium on Electrical Discharge and High Voltage Engineering” with KIEE Electrophysics and Applications Society every second year. The last J-K symposium was held jointly with the eighth International Workshop on High Voltage Engineering on November 16-17 2012 in Kanazawa. Next J-K symposium will be held in Korea in 2015.

The TC-ED also contributes to the organization of a young researcher seminar every year in cooperation with the Institute of Engineers on Electrical Discharges in Japan to encourage the young researchers in the field of electrical discharges. About 40 young researchers and engineers participate in the seminar and discuss vigorously the topics related to electrical discharges for two days. The seminar in this year will be held on November 29 and 30, 2013.

Table 1 Investigation Committees in TE-ED

Chairperson	Research subjects and established time
K. Satoh (Muroran Institute of Technology)	Atomic and molecular collision cross section and fundamental parameters of discharges (established in April 2011)
T. Oda (The University of Tokyo)	Electrostatic discharges as electromagnetic interference source (established in April 2011)
K. Miyagi (Kanazawa Institute of Technology)	Electrical/chemical behavior and application technology in dielectric liquids (established in October 2012)

Plasma Science and Technology (PST)

Chairperson:	Hiroshi Akatsuka (Tokyo Institute of Technology)
Secretaries:	Jaeho Kim (National Institute of Advanced Industrial Science and Technology)
	Masanori Shinohara (Nagasaki University)
Assistant Secretaries:	Naoki Shirai (Tokyo Metropolitan University)
	Ryuta Ichiki (Oita University)

The Technical Committee on Plasma Science and Technology (TC-PST) was founded in April 1999. This committee has the basis on the plasma researcher's society that had organized Technical meeting on plasma science and technology in IEE Japan several times every year since about 30 years ago. The field of activity of this committee includes researches and investigations of various plasmas over wide ranges of their density, temperature, ionization degree, and applications such as nuclear fusion, plasma processing, and plasma chemistry.

The major activity of this committee is to succeed to organize several technical meetings on plasma science and technology every year. In 2013, two technical meetings were held; in May at Nagaoka University of Technology in Nagaoka and in September at Nagasaki University in Nagasaki. In 2012, also four technical meetings were held. At each symposium, about 20–60 presentations are made. Presentations by young researchers in bachelor course and master course are strongly encouraged and appreciated. Some of the technical meetings are jointly organized with TC-PPT.

TC-PST currently runs four investigation committees as shown in Table 1. Here we introduce their activities. In the committee of atmospheric pressure plasma source for analysis of trace-order element, physics and chemistry of atmospheric pressure plasmas as well as their appropriate diagnostic methods and applications are being investigated. In addition, innovative technologies required for the various industrial applications are widely surveyed. In the committee of generation and application of metal vapor plasmas with high density and high ionization degree, upon the research outputs of the advancement of metal sputtering plasma committee held in 2006–2008, investigations are made over their characteristics, overview and perspectives to activate related research activities in domestic institutes. In the committee of the standardization of experiment and simulation modeling in liquid interface plasma, upon the research outputs of the advancement of the plasma–water applications and their reacting processes committee held in 2008–2010, investigations are made over the characteristics on plasma–water interface, overview and perspectives to activate related research activities in domestic institutes. Finally, in the committee of the propulsion performance of electrical propulsive rocket engine and its internal plasma physic phenomena, the progress of the propulsion performance and the understanding of physical phenomena in plasma are investigated by researchers of electrical engineering or plasma engineering.

Table 1. Investigation Committees in TC-PST.

Atmospheric Pressure Plasma Source for Analysis of Trace-Order Element	3 years from 2010, Chairperson: A. Okino (Tokyo Institute of Technology)
Generation and Application of Metal Vapor Plasmas with High Density and with High Ionization Degree	3 years from 2010, Chairperson: T. Ikehata (Ibaraki University)
Standardization of Experiment and Simulation Modeling in Liquid Interface Plasma	3 years from 2011, Chairperson: K. Yasuoka (Tokyo Institute of Technology)
Propulsion Performance of Electrical Propulsive Rocket Engine and Its Internal Plasma Physic Phenomena	3 years from 2011, Chairperson: K. Tahara (Osaka Institute of Technology)

Pulsed Electromagnetic Energy (PEE)

Chairperson: Eiki Hotta (Tokyo Institute of Technology)
Vice-Chairperson: Sunao Katsuki (Kumamoto University)
Secretary: Takashi Kikuchi (Nagaoka University of Technology)
Assistant Secretary: Jun Hasegawa (Tokyo Institute of Technology)

The Technical Committee on Pulsed Electromagnetic Energy (TC-PEE) was founded under the Fundamentals and Materials Society of the IEE Japan in June 1999. The activity of TC-PEE covers the collection and spread of information on pulsed power technology and its applications.

The application of this technology is now covers the following broad fields; new material development, thin film synthesis or ion implantation in industrial field; sterilization or medical treatment in biological and medical field; toxic gas decomposition and ozone or radical production in environmental field; nuclear fusion or particle beam accelerator technologies in energy field; and the destruction of rocks or concrete blocks in the civil engineering field and growth promotion of plant in the field of agriculture science. Thus the pulsed power technology becomes to be widely recognized as the basis of many technologies.

Recent activities of TC-PEE

The major activity of TC-PEE is to organize several technical meetings every year. In 2013, four technical meetings have been held or planned to be held, including the meetings in cooperation with the Technical Committees on Electrical Discharges or Plasma Science and Technology; in January at National Institute for Fusion Science (NIFS) in Toki, in May at Nagaoka University of Technology in Nagaoka, in August at Foundation for Computer Science (FOCUS) in Kobe, and in October at Kumamoto University in Kumamoto. In Kobe we visited the site of super computer KEI (see Fig. 1) after the technical meeting.

Presentations by young researchers are strongly encouraged and selected young researchers who make excellent presentations are awarded. In 2012, 6 students and young researchers recommended from TC-PEE were awarded.

Recent Activities of the Investigation Committee on Agricultural Applications Using Pulsed Power and Plasmas

This investigation committee is aimed to conduct an investigation on the present status of research and development in agricultural applications using pulsed power and plasmas. 22 committee members from various fields are chaired by Prof. Takaki. The activities are to hold regular meetings and symposiums in addition to the publication of the research report. Three of regular meetings have been carried out in the past one year. In each meeting, in addition of the regular presentations, a guest speaker from industry was invited in order to close the perspective gap between academia and industry. The attendee of meeting reached over 20 for each time. Two international meetings were supported by the investigation committee: the 9th International Bioelectrics Symposium (September 5-8, 2012, Kumamoto, Japan) and the 9th International Conference on Flow Dynamics (September 12-21, 2012, Sendi, Japan). 139 presentations were given in the former symposium, and 8 invited talks presented in the session named "Advanced Physical Stimuli and Biological Responses of Cells" in the later one. Other two symposiums will be held by the end of this academic year: "Research Innovation of Plasma-Agriculture Fusion Science" for the 30th Annual Meeting of the Japan Society of Plasma Science and Nuclear Fusion, and "Application of Pulsed Electromagnetic Energy for Agriculture, Fisheries and Foods" for the 2014 Annual Meeting of the Institute of Electrostatics Japan.

Fig. 1: Group photograph taken in front of the super computer KEI.

Fig. 2: The 9th International Bioelectrics Symposium held in Kumamoto.

Investigation Committee on the Status and Outlook of Pulsed Power Technology in Extremely High Power Level

In order to conduct a research on the progress and present status in ultra-high power level of pulsed power technology, a committee chaired by Prof. Horioka was also organized in January of last year until December of 2014. The topics are in its applications to high energy density physics, laboratory astrophysics, high power particle accelerators, energetic radiation sources, material science at extreme state, radiation hydrodynamics, intense plasma shock wave, and nuclear fusion science.

The committee meeting, the executive meeting, and the observation tour in the above research topics are held in the term. The photograph of the observation tour for the intense pulsed power devices in Extreme Energy-Density Research Institute, Nagaoka University of Technology is shown in Fig. 3.

The goals of the committee are to overview the state of the art in the pulsed power technology, and to get an outlook on the future directions of the technology at more than GW power level.

Fig. 3: Observation tour for intense pulsed power devices in Extreme Energy-Density Research Institute, Nagaoka University of Technology.

Reported by
Eiki Hotta (Tokyo Institute of Technology)
Douyan Wang (Kumamoto University)
Koichi Takaki (Iwate University)
Takashi Kikuchi (Nagaoka University of Technology)
Toru Sasaki, (Nagaoka University of Technology)
Kazuhiko Horioka (Tokyo Institute of Technology)

Electro-Magnetic Compatibility (EMC)

Chairperson:	T. Funaki (Osaka University)
Vice Chairperson:	K. Kawamata (Tohoku Gakuin University)
Secretaries:	T. Ushio (Osaka University)
	H. Sekiguchi (NMRI)
Assistant Secretaries:	Y. Hayashi (Tohoku University)

The Technical Committee on Electro- Magnetic Compatibility (EMC) has a vital role of researching following subjects;

1. Comprehensive understanding of electrical power system and EMC issue,
2. Establish the interdisciplinary cooperation among several groups and/or institutes related with EMC problem,
3. Investigations on new and high technology for EMC,
4. Advertisement to the public on EMC issue and key technologies,
5. Introductory advertisement of international EMC standard to the domestic EMC researchers.

For these purposes the committee pays their attention to the causes of electromagnetic interference phenomena, the situation of electromagnetic interferences occurrence, the novel measurement techniques and method for EMC, the protection technology and counter measurement for EMC and international and domestic EMC regulations. The committee has been organizing four dedicated research sub-committees to realize the effective activity.

1. Investigation committee on technical trends in evaluation of biological protection and compatibility with electromagnetic field.
2. Investigation committee on the analysis technology of electromagnetic filed including human body.
3. Investigation committee on the characteristics of noise accompanied with discharge.
4. Investigation committee on smart grid and EMC.

These sub-committees basically work independently, and each sub-committee meeting is held every two or three months regularly to announce their investigations and to share the obtained knowledge among sub-committee members. The practical period for the sub-committee activity is two or three years, and they are expected to publish their investigating results as a technical report of investigation committee or to have special conferences, which are related to their research theme. The investigation committee on EMC technologies for Electro Static Discharge, which finished the research work and dissolved in March 2011 presented their research work as the journal paper in the special issue of IEEJ transaction on fundamentals and materials in (May 2012).

The Special Committee on Human Health Effect of

Electromagnetic Fields, which belongs to the head quarter of IEEJ, was dissolved on March 2012. Then, the function of responsibility and authority for research work of this special committee was transferred to this technical committee on EMC.

Electromagnetic environment is the field, where electromagnetic phenomena exist. They are electromagnetic fields due to naturally-originated sources like lightning and earthquake, and artificial ones generated from electrical and electronic equipment as well as radiated from power lines or communication cables, and so force. EMC is the capability of electrical and electronic systems, equipment and devices to operate in the above-mentioned electromagnetic environment, without suffering or causing unacceptable degradation as a result of electromagnetic interference. In other words, a system is considered as electromagnetically compatible if it satisfies the following three criteria:

1. It does not cause interference with other systems;
2. It is not susceptible to emissions from other systems;
3. It does not cause interference with itself.

The problems related to EMC had been discussed in the "Special Research Committee of EMC Engineering", which was established in 1997 by IEICE and IEEJ joint venture. The high activity of the committee promoted the establishment of the technical committee on EMC in the Fundamentals and Materials Society of IEEJ. The committee was established to substitute the former committee in April 1999. Then Prof. T. Takuma of Kyoto University was elected as the first chair of the committee. After that, Prof. O. Fujiwara and Prof. Z-I. Kawasaki chaired the committee respectively from 2002 to Apr. 2005, and from May 2005 to Apr. 2008. Currently, Prof. T. Funaki succeeds the chair since May 2008. The committee holds some technical conferences. They were June, 22th(50th), November 13th(51th) for 2012, March 12th(52th), June 21th(53th) for 2013.

1. Investigation committee on smart grid and EMC.

This committee, chaired by Emer. Prof. M. Tokuda in Tokyo City University, was established in Apr. 2011. The mission of this committee is to sort out the international and domestic EMC problem related to smart grid, and to clarify the difference in the research and development of smart grid technology stemming from the difference in the regulation of EMC over the world. The committee is working on the following subjects.

1. Overall conditions of research and development of smart grid technology over the world;
2. Trend in the standardization of smart grid;
3. EMC regulations related to smart grid;
4. EMC problems in generation and transformation of electricity;
5. EMC problems in transmission and distribution of electricity;
6. EMC problems in communication network for smart grid;
7. EMC problems in load and energy storage.

This committee envisions clarifying the EMC problems expected to occur in smart grid.

2. Investigation committee on the characteristics of noise accompanied with discharge.

This committee, chaired by Prof. K. Kawamata of Tohoku Gakuin University, was established in Apr. 2011. The mission of this committee is to measure and figure out the characteristics of voltage and current response associated with ESD from the view point of EMC, and to clarify the mechanism in emission of electromagnetic field by ESD with associating the characteristics of electromagnetic field and parameters for discharge. The investigation subjects are summarized as followings.

1. Systemize the interfering object by ESD;
2. Basics and mechanisms of ESD;
3. Dominant factors and parameters of current waveform by ESD;
4. Measurement and prediction of transient waveforms by ESD;
5. Characteristics of electromagnetic field by ESD;
6. Optimization of ESD immunity test;
7. EMC modeling and simulation of ESD.

This committee envisions to clarify the difficulties of noise immunity for electric and electronic appliances, and to offer basic data to deal with.

3. Investigation committee on technical trends in evaluation of human exposure to electromagnetic fields.

This committee, chaired by Dr. K. Yamazaki of Central Research Institute of Electric Power Industry, was established in Jul. 2013. The mission of this committee is to survey the current technical trends in numerical calculation and measurement evaluation of human exposure to electromagnetic fields. Moreover, this committee aims at accumulating the knowledge of this province by inquiring the standards and evaluation methods for electrical safety of human body, and by studying the applicability of numerical analysis of electrical magnetic field. The investigation subjects are summarized as followings.

1. Surveying the research trends for the evaluation of electrical quantities in human body with numerical analysis of electromagnetic field;
2. Surveying the trends in guidelines and standards for protection of human body to the exposure to electromagnetic field;
3. Surveying the standards and evaluation method for the indirect influence of electrical magnetic field on the human body protection and the human body safety with the facilities and instruments;
4. Find issues for future work.

This committee envisions understanding comprehensively the foundation and attitude for the indirect influence of electrical magnetic fields.

4. Investigation committee on the health risk analysis of electromagnetic field.

This committee, chaired by Dr. C. Ohkubo of Japan EMF Information Center, was established in Jul. 2013 as the subsequent of special committee of studying the exposure effects of electric magnetic fields on biological system, which was established on Dec. 1995 as the direct subordinate for the president of IEEJ and dissolved on Mar. 2012. The mission of this committee is to survey the trends in the research of health risk assessment with uncertainty for the exposure of electromagnetic fields and the policy in managing the risk. The committee is working on surveying the current status, trends and future tasks of following subjects.

1. Health effects due to exposure to extremely low frequency (50/60Hz) magnetic fields emitted from electrical power equipment and household electric appliances evaluated by epidemiology, human volunteer study, animal experiment, and cellular experiment;
2. Health effects due to exposure to intermediate frequency electromagnetic fields (300Hz – 10MHz) emitted from induction heating apparatus and wireless power transmission evaluated by epidemiology, human volunteer experiment, animal experiment, and cellular experiment;
3. Health effects due to exposure to radio frequency electrical magnetic fields in human;
4. Risk management and risk communication on electromagnetic fields;
5. Others.

This committee envisions to summarize the trends in the influence of electrical magnetic field on human body and to offer back data for the sound development in utilizing the energy with the form of electrical magnetic fields.

Light Application and Visual Science (LAV)

Chairperson: Yoshiaki Tsunawaki (Osaka Sangyo University)
Secretaries: Mitsuhiro Kusaba (Osaka Sangyo University)

Activities of the technical committee on light application and visual science (TC-LAV) have been covering fields of visual/optical information processing and various kinds of application of optical engineering in the wavelength region from far-infrared (THz-wave) to extreme ultraviolet. In this report, two recent topics are introduced with respect to the formation of grating structure on a metal surface under the irradiation of femtosecond (fs) laser, and energy recycle using a base metal and solar pumped pulse laser.

The first topic is "Periodic grating structures on metal induced by fs laser pulses". The grating structures are self-formed on metal surface with irradiation of linear polarized femtosecond laser pulses and they are oriented perpendicular to the laser polarization. To investigate the mechanism of self-formation, the grating structure interspaces dependence on laser fluence have been measured for Cu(1) and several metals(2). In the ranges of the laser fluence in which the grating structures are self-formed, the interspaces of the grating structures are shorter than the laser wavelength of 800 nm. The interspaces increase up to 680 nm as laser fluence increases. This dependence of the interspaces on laser fluence has been explained by the parametric decay model(3). However the model shows disagreement in the relatively low fluence range. This disagreement may be considered to arise from non-uniformity of ablation. Thus the formation of periodic structures is not yet fully understood(4). In this study, the relation between the ablation threshold and the formation threshold of periodic grating structures for metal is discussed.

In the experiments, short pulsed laser system (λ = 800 nm, τ = 160 fs, 10 Hz) has been used. The laser beam is focused to a spot size of 45 μmϕ on the target surface with a lens (f = 10 cm), at normal incidence in air. To avoid non-uniformity of intensity in the irradiated area on the surface, the laser intensity distribution is adjusted to be spatially uniform. The targets are Ti and Mo metals, which are mechanically polished. The roughness, Ra, is less than 2 nm for metals. The fluence is varied in the range of F = 50–2100 mJ/cm^2. The number of irradiating pulses is 50. Laser-produced surface structures are examined by scanning electron microscopy (JSM-5560, JEOL). The periodic grating interspace is determined by reading the peak value in the frequency domain after taking the Fourier transform for the 20 μm × 15 μm area of the SEM image, which is equivalent to the laser irradiated area on the targets. The resolution of the present measurements of the periodic spacing is better than 34 nm. The dependence of the periodic structure interspaces on laser fluence for Ti and Mo metals is compared with the calculation results according to the parametric decay model (Fig.1), in which ablation threshold is taken into account. The model is in good agreement with the experimental results in the fluence range in which periodic grating structures are formed. These experimental results indicate that the formation

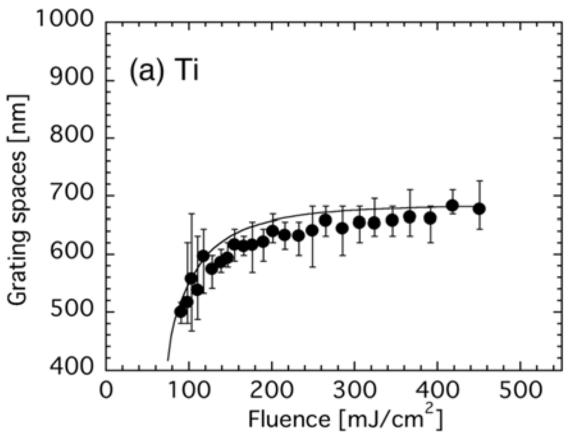


Fig.1 Laser fluence dependence of the periodic structure interspaces produced by femtosecond laser pulses (pulse duration: 160 fs at 800 nm). Solid lines show calculation results based on the parametric decay model[(3)(5)].

threshold of grating structure is closely related to ablation threshold.

The second topic is "Proposal of energy cycle using solar-pumped pulse lasers and base metal". Rescently, power generators using natural power sources, such as solar power, wind, heat, and biomass, have become more widespread due to the depletion of fossil fuels and safety problems concerning atomic power.

Our proposed energy cycle using solar-pumped pulse lasers and base metals is shown in Fig. 2. Solar light can be converted to coherent laser light. We develop solar-pumped lasers with high optical-optical conversion efficiency using Nd/Cr:YAG ceramics[(6)]. Also, we investigate hydrogen production method using base metal nanoparticles[(7)], which are also applicable to metal air cells[(8)]. Metal air cells generate electricity from the reaction of metal with oxygen. Metal oxides are produced after the base metals are used for power generation. The metal oxides in liquids are reduced using the solar-pumped pulse lasers. The apparatus is shown in Fig. 3. With this method, metal nanoparticles are produced in the reduction. Thus, chemical potential energy increases during the reducing process. This means that solar energy is stored in the metals efficiently. Used metals changed to metal oxides, and the metal oxides are reduced by laser pulse irradiation again. Our proposed air cells can be used as recyclable primary cells and can be used for transportation, such as for cars and bikes, small electrical devices, and as an electrical power source for homes. We conducted an experiment for charging Pb batteries of a small electric motorbike using electricity generated from air cells. The output power of the motor of the motorbike was 100 W. The small motorbike could run for around ten miniutes after charging. We now discuss the electrical properties of the new metal air cells and their practical applications.

Air cells using metal plates with different species metal junctions were fabricated[(8)]. Reduced metal nanoparticles from metal oxide powder by pulsed laser irradiation were used for making the metal paste. For an example, a sintered Fe metal paste is shown in Fig. 4. Also, a LED illumination using these air cells is shown in Fig. 5. We succeeded in generating electricity using these metal pastes, and the output voltage of the air cells improved.

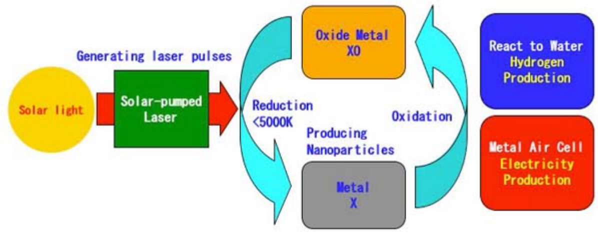


Fig.2 Energy cycle using solar-pumped laser and metals.

Fig.3 Apparatus, which produces metal nanoparticles from metal oxides using solar-pumped pulse laser.

Fig.4 Sintered Fe metal paste.

Fig.5 LED illumination using air cell.

References

(1) M. Hashida *et al*., Proc. SPIE **4830** .452-457 (2002).
(2) K. Okamuro, *et al*., Phys. Rev. **B82** 165417 (2010).
(3) S. Sakabe, *et al*., Phys. Rev. **B79**, 033409 (2009).
(4) M. Hashida *et al*., Phys. Rev. **B81** 115442 (2010).
(5) M. Hashida *et al*., Appl. Phys. Lett.. **102**, 174106 (2013).
(6) D. Graham-Rowe, Nature Photonics **4** 64 (2010).
(7) T. Okada, *et al*., ISRN Renewable Energy **2013** 827681 (2013).
(8) T. Saiki, *et al*., Int. J. of Energy Science **2** 228 (2012).

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Instrumentation and Measurement (IM)

Chairperson:	Kazuo Tanabe (CRIEPI)
Vice-Chairpersons:	Yoshitaka Sakumoto (JEMIC), Akihito Otani (Anritsu)
Secretaries:	Terumitsu Shirai (JEMIC), Kazuaki Kodaira (JEMIC)

Annual activities

The Technical Committee of Instrumentation and Measurement (TC-IM) of IEEJ was set up in Jan. 1980, succeeding the Committee on Electronics Instrumentation and Measurement.

The technical committee of instrumentation and measurement hosts the following activities;

1) The general meeting of the committee is held four times per year for discussing the various activities of the committee. Fifteen members including the chairperson, two secretaries, and two assistant secretaries constitute the committee.
2) Workshops for the presentation and discussion of studies and researches take place almost every month in principle as a main activity of the committee.
3) Visits to various professional facilities are planned once or twice a year.
4) A special volume of the transaction of the society A (Fundamentals and Materials) in IEEJ is planned.
5) The investigating R&D Committee for Metrological Traceability related to Smart Grid (Jan. 2012 - Dec. 2014), which is the affiliate of the TC-IM, is active currently and the chairperson is Mr. Akio Iwasa who works for National Institute of Advanced Industrial Science and Technology.

Topics in workshops

The two contents, which were presented in the workshops in the preparatory stage, are roughly introduced in this article.

1) C_0 Cancellation of Crystal Resonator for QCM [1]

Quartz crystal microbalances (QCMs), which can detect masses of nanograms or less, are used for measuring antigen responses, antibody reactions, and film thickness of evaporated thin films. A high frequency oscillation and expansion of the electrode's area is important for improving detection sensitivity of a QCM. However, since degradation of an impedance of interelectrode capacitance (C_0) reduces excitation current, a quartz crystal cannot comport as an inductance. Therefore, we proposed a new tunable inductor using microstrip line (MSL) with a combination of a varactor diode for cancellation of C_0.

Fig. 1 shows a proposed circuit's design of the MSL. This is designed for 3rd overtone frequency of a 155MHz AT-cut quartz crystal resonator. Fig. 2 shows a measurement result of resonators. In a resonator simple substance, it shows capacitive impedance in all

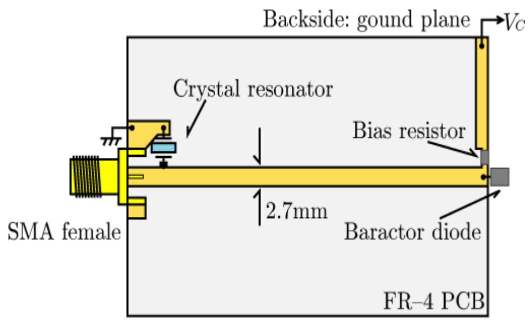

Fig. 1 MSL with varactor diode for C_0 cancellation (Size: 40mm × 60mm).

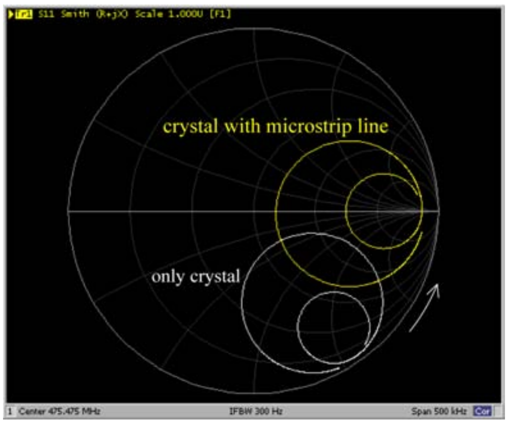

Fig. 2 Impedance characteristics of crystal resonator.

the portions of the range. On the other hand, in the proposal circuit, it shifted to inductivity from capacitive impedance like a usual crystal resonator. Table 1 is equivalent constant of crystal resonators shown in Fig. 2. Our method has improved C_0 to 1 / 40 without degrading Q factor that represents the performance of a crystal resonator. Although it is difficult to obtain high-Q variable coil in ultra high frequency, our method is advantageous in order not to use a coil. Furthermore, this technology is applicable also to a MEMS resonator that has comparatively large capacitance, and the fabrication of a GHz band crystal oscillator.

This work was supported by grant-in-aid from Futaba Denshi Memorial Foundation, Japan.

Table 1. Equivalent constant of crystal resonator.

	R_1 [Ω]	L_1 [mH]	C_1 [fF]	C_0 [pF]	Q
Only crystal	60	0.44	0.25	3.8	22×10^3
Crystal + MSL	64	0.47	0.24	0.08	22×10^3

2) Experimental Manufacturing and Evaluation of a Novel Tunable Millimeter-wave Band Filter [(2)]

Rapid progress in millimeter-wave wireless communication technologies requires accurate spectrum analysis in the frequency domain over 100 GHz. A tunable preselection filter is a key device in building such a spectrum analyzer. Therefore, we proposed a new tunable preselection filter in the frequency range from 110 to 140 GHz.

Fig. 3 shows a cross sectional view of the proposed filter. Two half-mirrors are constructed in a single, TE_{10}, mode rectangular waveguide. These half-mirrors compose a Fabry-Perot resonator. The resonator length L is changed mechanically to choose a specific spectral element. Since only the TE_{10} mode propagates in the waveguide, the propagation distance of the transmitted wave is uniquely defined and the phase of the electric field in the waveguide is adjusted without a special device to input a planar wave to the half-mirrors.

In order to validate the tuning function, we designed and fabricated a prototype. Fig. 4 shows an overview of the prototype. Fig. 5 shows the measurements and the theoretical center frequency f_c. The theoretical curve shifted to the left and matched the experiments, indicating the required filter tunability was achieved.

This work was carried out under the sponsorship of the R&D program for expansion of radio resources promoted by the Ministry of Internal Affairs and Communications, Japan.

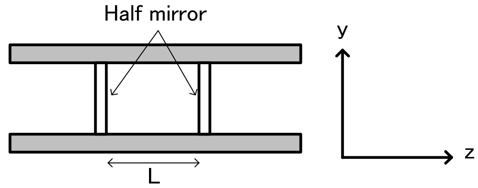

Fig. 3. Cross sectional view of waveguide（E-plane）

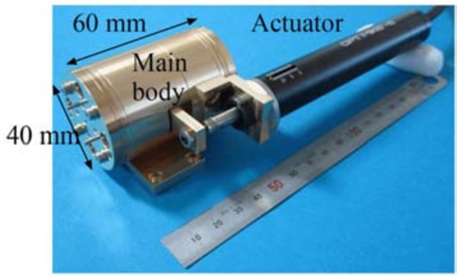

Fig. 4. Overview of prototype

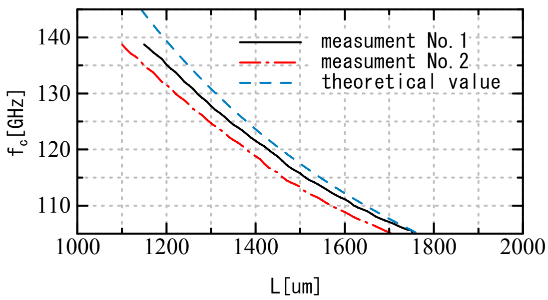

Fig. 5. Measurements of center frequency f_c

References

(1) T. Imaike, Y. Sakuta and Y. Sekine: "C_0 Cancellation of Crystal Resonator for QCM", IEEJ, IM-12-039, pp. 13-16 (2012)

(2) T. Kawamura and A. Otani, "Experimental Manufacturing and Evaluation of a Novel Tunable Millimeter-wave Band Filter", IEEJ, IM-12-028, pp. 33-38 (2012)

WEB site and authors

Activity of our committee is also described in our website (http://www2.iee.or.jp/~aim/).

Written by **Dr. K. Tanabe** (Chairperson, CRIEPI, e-mail: tanabe@criepi.denken.or.jp), **T. Imaike** (Nihon University), **T. Kawamura** (Anritsu).

Metal and Ceramics (MC)

Chairperson: Akio Kimura (Furukawa Electric Co., Ltd.)
Secretaries: Genzo Iwaki (Hitachi, Ltd.)
Ataru Ichinose
(Central Research Institute of Electrical Power Industry)

Welcome to our Technical Committee on Metal and Ceramics (TC-MC) in the Institute of Electrical Engineers of Japan (IEEJ). It is expected the TC-MC to promote the electrical materials and related technologies. Therefore, we have the pleasure to inform activities of the TC-MC and to communicate with each other.

Mission of TC-MC

The metal and ceramic materials are indispensable to electric and electronic fields and in front of advanced technologies all the time. In the twenty-first century, many advanced technologies need promising materials such as new materials or new functional materials for the diversification and renewable society. Therefore, the metal and ceramic materials are significant still more and will play an important role as a pioneer in the future.

As shown in figure 1, the activities of the TC-MC have been covering mainly electric, electronic and optical materials, and their technologies. Namely their functions are extended such as superconductivity, normal conductivity, semi-conductivity, mechanical strength, heat transfer, thermoelectric, photo-electricity, optical transmission, electro-chemical affinity, radio- activity, composites etc.

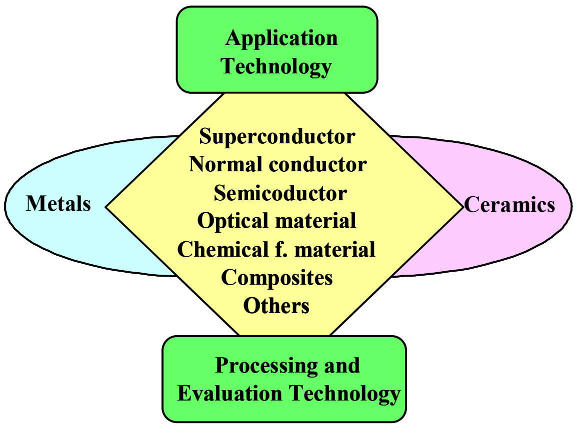

Figure 1 Activity scope of the TC-MC

Furthermore, our activities have been covering data base on their processing technologies and their evaluations in order to fit any applications.

History of TC-MC

The technical committee on the electrical materials in the IEEJ, predecessor of the present the TC-MC has been already set up in 1979. With several reorganizations of the technical committees, the TC-MC under the Fundamental and Materials Society (called A-Society) has been established in 1999 with other eleven technical committees, Research and Education, Electromagnetic Theory, Plasma Science and Technology, Electromagnetic Compatibility, Pulsed Electromagnetic Energy, Electrical Discharges, Light Application and Visual Science, Insulation and Measurement, Dielectrics and Electrical Insulation, Magnetics, and History of Electrical Engineering.

Recent activities of TC-MC

The activity of the TC-MC is based on the Symposium in the National Convention of the IEEJ, the Study Meeting and the Investigation Committee under the TC-MC. The following introduces the resent Symposiums in the National Convention of the IEEJ and Study Meeting under the TC-MC as shown in Table 1 and Table 2, respectively and the third activities will be found in the next section.

Regularly, the TC-MC meetings are held three or four times a year. The main topics to be discussed in the regular meetings involve introduction and understand for advanced metal and ceramics, and development of our TC-MC itself. We previously provided new three technologies and related materials such the attractive carbon nano-tube, the fuel cell and the functional diamond except the superconductors.

Recent year, much attention has been paid on an investigation on advanced superconducting materials. The electrode materials for future batteries and fuel cells to be compatible with clean, green, renewable and sustainable society have been also focused.

Table 1 Symposiums in the National Convention of the IEEJ

Theme	Date	Site
Development and problem of the high-efficiency solar cell	2009.03.19	Hokkaido University
Metal and ceramic materials in energy strange systems	2010.03.19	Meiji University
The 100th anniversary symposium for superconductivity discovery	2011.12.12	IEEJ meeting room
The latest research and development trend about thermo-electric material and its application	2013.3.19	Nagoya University

Table 2 Study Meetings in TC-MC

Theme	Date	Site
Recent research progress in advanced superconducting materials (II)	2011.10.23	University of Tokyo
Recent research progress in advanced superconducting materials (III)	2012.12.16	University of Tokyo
Recent research progress in advanced superconducting materials (IV)	2013.11.17	University of Tokyo

Activities of investigation committee in TC-MC

At present, there is one investigating R&D committee under TC-MC as shown in Table 3, the name of which is “Low temperature electronics based on phase engineering”. The chairperson is Prof. Akira Fujimaki (University of Nagoya) and secretaries are Dr. Masamitsu Tanaka (University of Nagoya) and Dr. Yuki Yamanashi (Yokohama national university). Regularly, there are four meetings a year.

This committee conducts investigation about the low-temperature electronics based on the phase engineering which is an ultramodern field. The possibility and the suitable applicable fields of development of the phase engineering are clarified from the results of an investigation.

This investigating committee performs investigation and examination of the following topics.

1) A new technology based on magnetic superconductive material, superconductor junctions and its possibility of the application to superconducting digital electronics devices are investigated.

2) The recent research trends of magnetic-hybrid devices, including spin injection devices, are investigated.

3) The recent research trends of superconductive circuits based on the precise phase control are investigated.

4) The possible application fields of the phase engineering technology toward such as the detectors and counting systems are investigated.

5) The possible application of the phase engineering technology toward the quantum-information-processing is investigated.

The previous committee has a plan of the study meeting related with the advanced superconducting materials (IV) on November 2013. This meeting will be held to exchange information between young researchers belonging to several communities. Therefore, the new style of the presentation is adopted, which is combination of a short presentation and a poster session.

Table 3 Investigation Committee under the TC-MC

Research Subject	Chairperson (Affiliation)	Period	Remarks
Low temperature electronics based on phase engineering	Prof. Akira Fujimaki (University of Nagoya)	2013.10-2016.09	Open

Technical Committee on Electrical Wire and Cables (EWC)

Chairperson: Yasuo Suzuoki (Nagoya University)
Secretaries: Akitoshi Watanabe (VISCAS Corporation)
Gaku Okamoto (J-Power Systems Corporation)
Kouji Miura (EXSYM Corporation)

Technical Committee on Electrical Wire and Cables (TC-EWC) is a committee organized in the IEEJ Power and Energy Society, and is comprised of members from cable manufacturers, power utilities, railway companies, universities and related research institutes such as Japan Electric Cable Technology Center (JECTEC) and Central Research Institute of Electric Power Industry (CRIEPI). The technical committee organizes technical meetings to promote R&D activities in this field and provides an opportunity to present technical achievements. Two technical meetings were so far held in 2013, one of which was on degradation diagnosis and asset management of wires, cables and power apparatuses and was held as a joint meeting with TC-DEI. The other was on technology for long-distance high-capacity power transmission. The technical committee also held a forum on recent technological trends in overseas power transmission cables. The technical committee plans to organize 3 more technical meetings, a forum and a symposium in FY2013. Two of the planned technical meetings will be jointly held with TC-DEI. The forum will be on the trends and status quo of diagnosis and assessment technologies for distribution wire and cables, and the symposium will be on recycling technology for wire and cables.

In addition to organizing such meetings, forums and symposia, the technical committee supervises investigation committees dealing with subjects related to electrical wire and cables. During the last several years, investigation committees were organized on the following subjects, i.e. technology of wires and associated accessories for overhead transmission lines, accessories for 66kV and higher voltage XLPE power cables, technology of XLPE power cables and associated accessories for underground power distribution, technical trend of environmental tests for insulation materials of distribution wires and cables, and recent technological trends in overseas power transmission cables. The technical report of the last committee was published in December, 2012. The Investigation Committee for Technical Trend of Recycling Technology for Wires and Power Cables is now in action and the Investigation Committee for Technical Trends in Overhead Transmission Cables and Their Accessories will be launched in October, 2013.

Forums on overhead transmission cables and on overseas technical trends in power transmission cables

IEC TC15 Japanese National Committee

Chairperson: Yoshiaki Yamano (Chiba University)
Secretaries: Yoshio Wakashima (Japan Electrical Safety & Environment Technology Lab.)
Associate Secretary: Akihiro Kawaguchi (Japan Electrical Safety & Environment Technology Lab.)

The scope for IEC TC15 is to prepare international standards including specifications for solid electrical insulating materials alone and in simple combinations. This includes coatings which are applied in the liquid state but cure to solids, such as varnishes and coatings. Although TC15 Japanese National Committee has certainly the same scope as that for IEC TC15, its mission is accomplished by consulting with Japanese industrial situations and market in the world.

IEC TC15 establishes definitions, general requirements and specification sheets for individual types of materials. The standards include test methods and guidance where these are required for the specifications. The current activities of TC15 are carried out by 5 working groups (WGs) and 4 maintenance teams (MTs). IEC TC15 has now more than 160 standards published, and 15 work programs for standardization are in progress.

Japanese national committee for TC15 held meetings of three times last year with the attendee of about 15 members. The members are from manufactures, user (customers), laboratories and universities. Over 30 documents for standardization from IEC Central Office have been circulated in specialists of the members, including drafts of CD, CDV and FDIS. They made comments on them to improve the drafts for international industrial situations and market.

To accomplish the tasks of the WGs and MTs in TC15, the experts from Japan participate in MT 3 (plastic films), WG5 (flexible insulating sleeving), and WG 9 (cellulosic materials). They are contributing to accomplish the new work item and revisions of the present standards. Especially in MT3, which deals with plastic films for electrical insulation, IEC 60674-2 (Methods of test) is now going to be revised by the lead of Japanese convener. In WG 9, specifications of an insulating cellulose paper for coil winding are also proposed to include to Part 3 sheet of IEC 60554 from Japan in order to offer the appropriate and useful standards for the market.

IEC TC15 international meeting has been annually held. The meeting of this year was held on May in Kista, Sweden (Fig.1). 5 members from Japan participated in MT 3 and WG 9 meetings and 3 members in the plenary meeting. A draft for the revision of IEC 60674-2 was discussed in MT3, and it was decided that CD will be circulated within this year. In WG 9, an addition of the new type of insulating paper is considered with a plan for consolidation of part 3 sheets of IEC 60554.

Fig.1 Social event after plenary in Kista 2013

RESEARCH ACTIVITIES AND TECHNICAL EXCHANGES IN ASIAN COUNTRIES

Conference Records

International Conference on Electrical Engineering (ICEE 2013)

The 19th International Conference on Electrical Engineering (ICEE 2013) was successfully held at International Seaside Hotel in Xiamen, China from July 14 to 17, 2013.

ICEE 2013 was hosted by the Chinese Society for Electrical Engineering (CSEE) and jointly organized with the Hong Kong Institution of Engineers (HKIE), the Institute of Electrical Engineers of Japan (IEEJ), and the Korean Institute of Electrical Engineers (KIEE). ICEE is a major event that can annually provide an international venue for electrical engineers and experts to highlight key issues and developments essential to the multifaceted field of electrical engineering systems.

ICEE 2013 was attended by 331 delegates from mainland China (204), Korea (57), Japan (53), Hong Kong (13), Chinese Taiwan (2), and some other overseas countries (2) (Table 1). Total 345 technical papers were submitted, 266 of which were accepted and included into the conference proceedings (Table 2). There were 4 Keynote speeches, 13 Oral sessions (75 papers), 6 Poster sessions (145 papers) and 4 Panel discussions.

Table 1 Number of participants from each country (Including accompany persons)

No.	Country /Region	No. of participants
1	China	204
2	Korea	57
3	Japan	53
4	Hong Kong	13
5	Chinese Taiwan	2
6	USA	1
7	Iran	1
	Total	331

Table 2 Number of papers

Sessions	No. of papers
Oral session	75
Poster session	145
Proceedings only (author didn't show up at the conference)	46
Total	266

In the opening ceremony on July 14, 2013, Prof. CHEN Feng of CSEE made his greeting speech and Prof. HIDAKA Kunikiko of IEEJ, Prof. MOON Young-Hyun of KIEE, Ir CHAN Raymond K. S. of HKIE and Mr. ZHANG Lei of Fujian Electric Power Company Ltd. gave their congratulations (Fig.1-4).

After the opening ceremony, 4 keynote speeches were given by Prof. SHEN Bingbing, Ir Prof. CHAN Ching Chuen, Ir Dr. CHAN Fuk Cheung, Dr. SERIZAWA Yoshizumi and Dr. KIM Ho Yong (Table 3 & Fig. 5-6).

Fig.1 Prof. CHEN Feng, conference chair of ICEE 2013, Executive Deputy President of CSEE, gave greeting speech at opening ceremony.

Fig.2 Dr. LI Ruomei, Secretary General of CSEE, chaired the opening ceremony.

Table 3 Presenters and titles of keynote speeches

No.	Name of Speaker	Title of Presentation
1	Prof. SHEN Bingbing	*China's Smart Distribution Grid Technology—Current and Future Development*
2	Prof. CHAN Ching Chuen / Ir Dr. CHAN Fuk Cheung	*Energy and Information-Power Systems Security and Reliability*
3	Dr. SERIZAWA Yoshizumi	*International Standardization and Coordination for Resilient and Smarter Power Systems*
4	Dr. KIM Ho Yong	*Smart Grid Overview in Korea*

Fig.3 Congratulating Address (left to right, up to down): Prof. HIDAKA Kunihiko (IEEJ), Prof. MOON Young-Hyun (KIEE), Ir CHAN Raymond K. S. (HKIE), and Mr. ZHANG Lei (Fujian Electric Power Company).

Fig.4 Photo of the opening ceremony.

Fig.5 Prof. LIANG Xidong, Deputy Director of CSEE Academic Committee and professor of Tsinghua University, chaired the keynote speech session.

Fig.6 Keynote speakers (left to right, up to down): Prof. SHEN Bingbing, Prof. CHAN Ching Chuen, Ir Dr. CHAN Fuk Cheung, Dr. SERIZAWA Yoshizumi, Dr. KIM Ho Yong.

In the oral and poster sessions, technical presentation and discussions were made for some separated topics, such as fundamentals, materials, power systems, transmission & distribution, HVDC and FACTS, information & control Systems and etc. (Table 4). As of the panel discussions, 4 important themes were prepared and active and meaningful discussions were done for over 3 hours each (Table 5).

All participants enjoyed some kinds of local foods and coastal attractions in Xiamen (Fig.7). At the end of the banquet, Prof. MOON Yong-Hyun of KIEE announced the next conference, ICEE 2014 to be held in Jeju Island, Korea.

Fig.7 Photo of the banquet.

Table 4 Main topics of ICEE 2013

No.	Main topics	Sub-topics
1	Fundamentals, Materials	➢ Electrical Materials and Process ➢ Semiconductor Technology ➢ Electronic Materials
2	Power Systems	➢ Power System Planning and Scheduling ➢ Power System Modeling, Simulation and Analysis ➢ Power System Operation, Control and Protection ➢ Power System Stability and Reliability ➢ Power Market and Power System Economics
3	Transmission & Distribution	➢ Transmission & Distribution Systems and Apparatus ➢ Smart Transmission & Distribution ➢ Substation Automation ➢ Disaster Prevention and Control
4	HVDC and FACTS	➢ Modeling, Simulation, and Control for Power Electronics ➢ Operation, Control and Protection of HVDC ➢ VSC based HVDC, technology and application ➢ Design of Power Electronics for Renewable Energy ➢ Power Quality and Control for Wind power, PV, and Fuel Cell
5	HV Engineering	➢ Electromagnetic Fields and Environments ➢ EHV & UHV Engineering and Insulation Technologies ➢ Electrical Discharges
6	Information & Control Systems	➢ Information Technology Applications to Power Systems ➢ Communication Systems ➢ Intelligent Systems and Approach ➢ Control Theory and Application ➢ Knowledge Management
7	Environment, Renewable energy & Energy Efficiency	➢ Thermal Generation System Measurement and Control ➢ Power Plant Heat Rate Performance ➢ Power Plant Pollutant Emission Control and Clean Development Mechanism (CDM) ➢ CO2 Capture and Sequestration（CCS） ➢ Hydrogen Energy and Fuel Cell ➢ Renewable Energy and Distributed Generation ➢ Energy Storage Technology
8	Electrical Machines and Motor Drives	➢ Electric Drives and Application ➢ Electrical Traction Systems and Control ➢ Electromagnetic and Applied Superconductivity ➢ Industrial Process Control and Automation ➢ AC and DC Motors (ADM) ➢ Inverter and Converter Technology ➢ Fault Tolerant Techniques (FT)
9	Sensors & Micro-machines	➢ Micro Machines ➢ Diagnosis and Sensing Systems ➢ MEMS - Micro Sensors and Structures
10	Other Related Areas	

Table 5 Titles of panel discussions

No.	Title of Panel Discussion	Chairperson
1	DC Grid Development and Application	Prof. YU Zhanqing
2	Renewable Energy Integration at the Distribution Level	Prof. WANG Weisheng
3	Nuclear Power in the World: Status and Prospects	Prof. Ir Dr. CHAN Fuk Cheung
4	New Concepts and Tools for Systems Operation and Control	Prof. WEN Jialiang

Finally, Dr. LI Ruomei, Secretary General of CSEE, past the flag of ICEE to the representatives of the host of ICEE 2014, Prof. MOO Yong-Hyun (Fig.8).

Ms. Min LIU
International Dept, CSEE, China

Fig.8 Dr. LI Ruomei passing the flag to Prof. MOON Yong-Hyun of KIEE.

International Symposium on High Voltage Engineering (ISH 2013)

International Symposium on High Voltage Engineering (ISH 2013) was successfully held at Hanyang University in Seoul, Korea from August 25 to 30, 2013.

The ISH is organized by organizing committee of ISH 2013, and co-organized by Korean Institute of Electrical Engineers (KIEE) and Hanyang University (Fig. 1). The ISH 2013 promotes opportunities to be an effective rallying point for a broad range of constituencies, government officials, pioneering engineers, scientists, academics, researchers and many other professionals working in the pertinent fields to discuss the challenges of the day and to provide a platform for all to share cutting-edge technology and up-to-date knowledge and experience. It was the 18th symposium.

With the theme of *"Safe and Reliable High Voltage Engineering for Electric Energy Supply Rising above the Challenges"*, ISH 2013 was well attended by 495 delegates from Korea (127), China (93), Japan (62), Germany (44), Sweden (16), Thailand (14), and 33 other countries (183) (Table 1). Total 471 technical papers were submitted (Table 2). There were 3 Keynote speeches, 33 Oral sessions (194 papers), 8 Poster sessions (274 papers).

In the opening ceremony on August 25, 2012, Prof. Ja-Yoon Koo, chairman of ISH 2013, and Prof. Ernst Gockenbach, chairman International. Steering Committee, made their opening addresses (Fig.2) and Dr. Jae-Hong Kim, Vice Minister for Industry and Technology, Ministry of Trade, Industry and Energy, Mr. Hwan-Eik Cho, President and Chief Executive Officer of Korea Electric Power Corp., and Mr. Duck-Ho Lim, President of Hanyang University, made their congratulatory remarks. After the opening ceremony, 3 keynote speeches were given by Mr. Mark Waldron, Prof. Josef Kindersberger,and Dr. Kyong-yop Park. (Table 3, Fig.3).

Table 1 Number of participants from each country.

No	Country	No. of participants
1	Korea	127
2	China	93
3	Japan	62
4	Germany	44
5	Sweden	16
6	Thailand	14
7	Other 33 countries	183
	Total	495

(Above numbers include accompany persons.)

Fig.1 Group photo of ISH 2013.

Table 2 Number of papers at each session.

Sessions	Number of papers
Oral session	194
Poster session	274
Keynote speech	3
Total	472

Fig.2 A view of opening ceremony.

Table 3 Presenters and titles of keynote speeches.

No	Name of Speaker	Title of Presentation
1	Mark Waldron (National Grid, UK)	User perspective on the application of new developments in High Voltage Technologies
2	Josef Kindersberger (Tech. Univ. of Munich, Germany)	Insulation system under HVDC stress
3	Kyong-yop Park (Korea Electrotech. Res. Inst., Korea)	Simulation Technologies for High Power Apparatus

Fig.3 Prof. Josef Kindersberger at his keynote speech.

In the oral and poster sessions (Fig.4 and 5), technical presentation and discussions were made for some separated topics (Table 4). The topic H, HVDC technologies and applications, is newly established one in ISH 2013.

Table 4 Topics of ISH 2013.

A	Electromagnetic fields
B	Transient voltages
C	High voltage and high current testing techniques
D	High voltage measuring techniques
E	High voltage insulation materials and system
F	Monitoring and diagnostics
G	High voltage systems aspects
H	HVDC technologies and applications

Welcome reception, banquet, technical tours and Farewell dinner were also arranged as the social events of ISH 2013. The banquet was scheduled in the evening of August 26, 2013 at the Plaza Hotel. Prof. Ja-Yoon Koo, chairman of ISH 2013, gave his greeting at the opening of banquet. All participants enjoyed western course meal and historical Korean cultural performances (Fig.6).

Fig.4 A view of oral session.

Fig.5 A view of poster session.

At the end of the symposium, the closing ceremony was held. In this ISH, Young Researcher Award was founded. Winners of 20 young researchers are announced and the prize of $500 is awarded for each winner.

Finally, the chairman of next ISH, to be held in Czech Republic from August 23 to 28, 2015, Prof. Rainer Haller, gave his address of invitation.

Dr. Satoru Miyazaki
Central Research Institute of Electric Power Industry
Japan

Fig.6 A view of banquet.

International Conference to be held in Asia

ISEIM 2014 (International Symposium on Electrical Insulating Materials)

Dates: June 1-5, 2014
Venue: Toki Messe, Niigata City, Japan
Honorary Chair: M. Nagao (Toyohashi Univ. Technol.)
Organizer: Organizing Committee of ISEIM 2014
Sponsored-by: IEEJ Technical Committee on Dielectrics and Electrical Insulation
Technically co-sponsored-by: IEEE DEIS
Co-sponsored-by: Faculty of Engineering, Niigata University, and Waseda University
In cooperation with: IEEE DEIS Japan Chapter
Website: http://www2.iee.or.jp/~adei/ISEIM2014/

International Symposium on Electrical Insulating Materials is positioned as the international version of the domestic symposium held every year by IEEJ Dielectric and Electrical Insulation Committee. Continuing a series of conferences that began in 1995, the 7th conference will take place in Toki Messe in Niigata City, Japan from June 1 to 5, 2014.

Niigata city is in a mid area of Japan, and faces to the Sea of Japan. The conference venue Toki Messe is in the new district of the city. This beautiful water city has various sightseeing spots throughout the suburbs. The city is also proud of wonderful foods, such as seafood, rice and sake. The city also serves as a transportation hub with an airport, bullet train stations, and so on, to be easy to arrive. Many routes to the city are described in detail in the conference web site.

The conference promotes opportunities to be an effective rallying point for polymeric insulators and outdoor insulation, space charge measurements, on-line monitoring and diagnostics of power apparatus, development of polymeric cables and joints for higher electric fields, organic and inorganic thin films, and new and functional materials. In addition, the organizing committee is planning to hold a special session to introduce the advanced space charge distribution measuring technique using pulsed electro-acoustic (PEA) method. Since broad HVDC power network is getting to move forward with full-scale implementation, estimation of dc stress on insulating materials has been paid much attention.

Topics:

1. Space charge, surface and interfacial phenomena
2. Electrical properties of dielectrics and measurement and testing techniques
3. Nanotechnology for dielectrics
4. Inorganic and functional dielectric materials
5. Organic thin films and electronics
6. Dielectric materials for electronics and telecommunication
7. Dielectric properties of biological objects, biodielectronics
8. Inverter Surges
9. Partial discharge
10. Asset management for dielectrics applied apparatus
11. Insulation design, reliability, aging and degradation, their detection and monitoring
12. Polymeric insulators and outdoor insulation
13. Eco-friendly dielectric materials and recycling
14. Electrical insulation phenomena and charging under cosmic and radiological environment
15. Collaborate work with industries and universities

Key dates:

Abstract Submission:	Nov. 29, 2013
Notification of Acceptance:	Middle of Jan., 2014
Full Paper Submission:	Feb. 28, 2014
Conference Dates:	Jun. 1 - 5, 2014

Secretariat:

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ICEE 2014 (International Conference on Electrical Engineering)

Dates: June 15-19, 2014
Venue: Ramada Plaza Jeju Hotel, Jeju, Korea
Organized by:
The Korean Institute of Electrical Engineers (KIEE)
Co-organized by:
The Institute of Electrical Engineers of Japan (IEEJ)
Chinese Society for Electrical Engineering (CSEE)
The Hong Kong Institution of Engineers (HKIE)
Conference Chairperson:
Ho-Yong KIM, President-elect of the KIEE, President of Korea Electrotechnology Research Institute

The conference annually organized by Korea, Japan, China and Hong Kong by taking turns, is held to exchange the results of latest studies in electrical engineering and to attribute to the development of the electrical engineering building and international cooperation which is widely dedicated to sharing knowledge, experience and creative thinking of electrical engineering scholars from many countries around the world. The 20th ICEE has been expanded since its first opening in 1995 by Republic of Korea, Japan, China and Hong Kong. In addition, selected papers from the conference will be considered for publication in JICEE (Journal of International Council on Electrical Engineering) issued by ICEE and JEET (Journal of Electrical Engineering & Technology /

SCIE) issued by KIEE.

Conference Topics:

・Electric Power Engineering
・Electric Machinery and Power Electronics
・Electrophysics & Applications
・Information and Control
・Smart Grid
・Other Related Area

Important Dates:

Abstract Submission:	Dec. 31, 2013
Notification of Abstract Acceptance:	Jan. 15, 2014
Full Paper Submission:	Feb. 28, 2014
Notification of Full Paper Acceptance:	Mar. 15, 2014
Author/Pre-Registration:	Apr. 15, 2014

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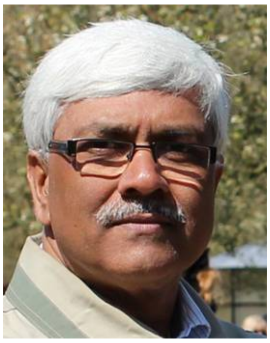
Activities of Laboratories

High Voltage Laboratory
Jadavpur University, Kolkata, India



Prof. S. Chakravorti

1. Introduction

In keeping with the growing demand in India for engineers with adequate knowledge in high voltage engineering, this laboratory was set-up in 1955 and since then it is offering regular undergraduate courses in high voltage engineering. However in mid sixties it had been realized that specialized engineering personnel in the field of high voltage engineering is necessary for the power sector of India. In view of this, the High Voltage Laboratory of Jadavpur University, which is one of the top universities in India, has been empowered to offer regular postgraduate course in high voltage engineering since 1966. This laboratory is also carrying out outstanding research work at the doctoral level for the last thirty-five years, which have resulted in the award of more than 25 PhD degrees from this laboratory. The faculty members associated to this laboratory are having international collaboration with various institutions from Germany, Japan, USA, etc. The investigations carried out on various facets of high voltage engineering by this laboratory have been embodied in about 250 research papers, which have been published in several reputed International and Indian journals or presented in international and national seminars.

2. Courses: UG, PG and PhD

This laboratory caters to the following subjects of Bachelor and Master of Electrical Engineering Courses: Dielectric Materials, Electric Field Theory, High Voltage Generation and Measurement, Over-voltages and Insulation Coordination, Numerical Field Analysis, Dielectric Engineering and Condition Monitoring of High Voltage Equipment. This laboratory offers two elective subjects at the Bachelors level and four specialized course at the Masters level in addition to supervising five masters theses every year. On an average eight research scholars carry out their doctoral research in this laboratory at any given year.

3. Laboratory Infrastructure

Major equipments of this laboratory are as follows: i) 1.4MV, 60kJ, 8-Stage Impulse Generator with matching potential divider, ii) 800kV, 40kJ, 8-Stage Impulse Generator with matching potential divider, iii) 0.5/250 kV, 125 kVA, power frequency testing transformer with capacitive potential divider and peak voltmeter, iv) 200 kV, 20 mA, DC voltage generator, v) 50 kVA, 230/10 V, 5000 A, AC current generator, vi) 1000 A, 4 V, DC current generator, vii) 640kVA, 36kV/22kV/11kV, Duty cycle – 3min ON – 3 min OFF, 20 such cycles, On Load Testing Facility, viii) 7kA, 15V for 5 s, AC Short Time Current Testing Set, ix) 100kV partial discharge laboratory with double layer shielding, x) 135V, 1.2/50 micro-s, 0.1J per pulse, 50 pulses per s, recurrent surge generator.

Major measuring systems are as follows: i) 1.4MV resistive potential divider with DAQ for impulse voltage measurement, ii) 800kV capacitive potential divider with DAQ for impulse voltage measurement, iii) 250kV capacitive potential divider with peak voltmeter for power frequency voltage measurement, iv) Partial Discharge Detector, v) High Voltage Schering Bridge, vi) FRA test set from 10Hz to 20MHz, vii) PDC, RVM and FDS analysers, viii) 50kVrms electrostatic voltmeter, ix) Karl Fischer Moisture Analyser.

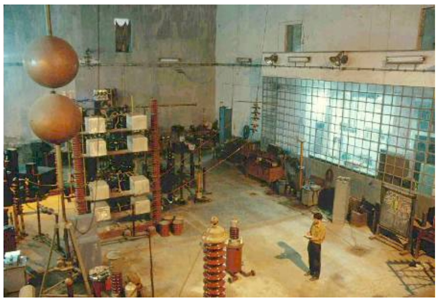


Fig. 3.1 Main Hall of High Voltage Laboratory of Jadavpur University

Fig.3.2 Breaking Test facility for HV Disconnectors

4. Research Activities

4.1. Electric Field Analysis and Optimisation

This high voltage laboratory is involved in numerical electric field analysis from the late nineteen seventies. Over the years several papers have been published in journals like IEEE Trans. on EI & later DEI on field analysis of bushings, insulators, cables etc using Charge Simulation Method as well as Boundary Element Method considering various field parameters like volume resistivity, surface resistivity, dry bands, transient excitations etc (IEEE TEI, Vol.13, No.1, 1978, pp 24-31, IEEE TEI, Vol.28, No.1, 1993, pp 43-53, IEEE TDEI, Vol.5, No.2, 1998, pp 237-244 & IEEE TDEI, Vol.7, No.2, 2000, pp 169-176). Optimisations of electrode as well as insulator contours by artificial neural networks have also been carried out (IEEE TDEI, Vol.1, No.2, 1994, pp 254-264 & IEEE TDEI, Vol.8, No.2, 2001, pp 157-161). Later on asymmetric insulators used in GIS and GIL have been analysed and optimised using Boundary Element Method and soft optimisation techniques like simulated annealing and genetic algorithm (IEEE TDEI, Vol.11, No.6, 2004, pp 964-975 & IEEE PWRS, Vol. 20, No.3, 2005, pp 2144-2152). Recently researchers are developing techniques for efficient field computation in 3-D asymmetric systems with surface pollution and also carrying out studies on the effect of the presence of volume charge within the region of interest for non-uniform field (IEEE TDEI, Vol.19, No.2, 2012, pp 591-599 & IEEE TDEI, Vol.19, No.3, 2012, pp 1068-1075).

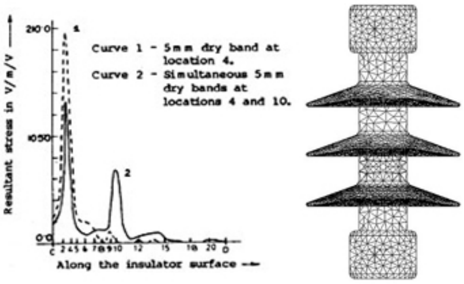


Fig. 4.1.1 Effect of dry band on surface field of HV insulator

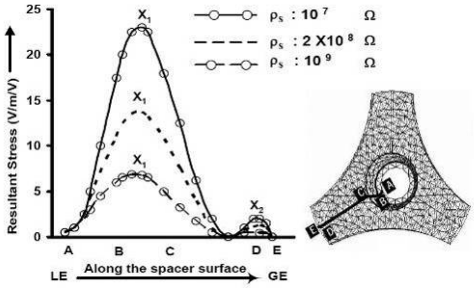


Fig. 4.1.2 Surface field of asymmetric 3D insulator having surface resistance

4.2. Diagnosis of Faults in Transformer Insulation under Impulse Excitation

The major contribution of this high voltage laboratory is in the area of impulse fault diagnosis in transformers through development of tools for accurate identification of minor winding faults, which are difficult to locate in practice, and to provide a non-expert with the necessary information for making unambiguous fault diagnosis efficiently. Refinement of the initial work on expert system (IEEE TDEI, Vol.9, No.3, 2002, pp 433-445) by subsequent use of wavelet analysis (IEEE TDEI, Vol.9, No.4, 2002, pp 555-561), fractal analysis (IEEE TDEI, Vol.10, No.1, 2003, pp 109-116 & IEEE TDEI, Vol.14, No.6, 2007, pp 1538-1547), pattern recognition tools like Support Vector Machine (IEEE TDEI, Vol.21, No.3, 2006, pp 1283-1290) and cross-wavelet transform (IEEE TDEI, Vol.15, No.5, 2008, pp 1297-1304) resulted in accurate fault identification within 10% of winding length. Researchers carried out works on static as well as dynamic (IEEE TDEI, Vol. 18, No.2, 2011, pp 521-532) fault identification. Recently works are being done to identify simultaneously occurring static as well as dynamic faults (IEEE TDEI, Vol.19, No.2, 2012, pp 443-453). The developed fault diagnostic tools were found to be very useful in the analysis of signals resulting from vibration of high voltage equipment (IEEE Journal on Lightwave Technology, Vol.24, No.5, 2006, pp 2122-2131).

Fig. 4.2.1 Impulse fault analysis set-up with analog model of transformer winding

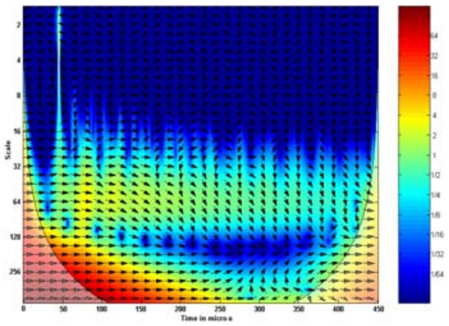


Fig. 4.2.2 Cross-wavelet spectrum of no-fault and series fault current under lightning impulse excitation

4.3. Partial Discharge Analysis

A partial discharge laboratory having dimensions of 7.5m × 4m × 6m has been set-up for data acquisition and analysis in relation to partial discharge occurring in insulation systems as per IEC 60270. The PD laboratory has a double-layer shielding with one layer made up of a good conductor, viz. copper, and the other made up of a magnetic material, viz. Galvanized Iron (GI), which provides 55 dB environmental signal attenuation. Fig.4.3.1 shows the photograph of this double shielded laboratory. A user-friendly integrated partial discharge detector has been developed in this laboratory with the help of financial support from SERC, DST, Govt of India, which can acquire, measure and display the calibrated partial discharge signal directly with minimum human intervention. An Indian patent has been filed in this context. This PD Detector incorporates state-of-the-art software algorithms, which are customized for demonstration that facilitate easy understanding of the operation and methodology (IEEE TDEI Vol.17, No.1, 2010, pp 157-166 and IEEE TEdu, Vol.54, No.3, 2011, pp 410-415). Currently, researchers are active in developing techniques for accurate identification of simultaneously occurring PD sources with optical as well as acoustic techniques (IEEE TDEI, Vol.19, No.1, 2012, pp 18-28).

Fig. 4.3.1 Double Shielded Partial Discharge Laboratory

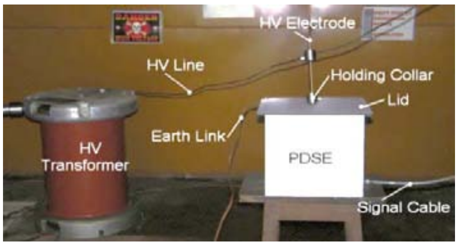


Fig. 4.3.2 Photograph of the experimental set-up for optical data acquisition

4.4. Condition Monitoring of Oil-Paper Insulation

4.4.1. Time-Domain Techniques

A single integrated, portable system has been developed in this high voltage laboratory that is capable of condition monitoring of transformers by acquiring and analysing both PDC and RV waveforms. The developed unit is small in size and weight that is packaged for facilitating on-site testing. This single unit can perform both PDC and RV measurements without any change in external physical connection (IEEE TEdu, Vol.53, No.3, 2010, pp 484-489). This analyser incorporates a simple yet versatile real-time denoising scheme for dielectric response signals in time domain (IEEE TDEI, Vol.14, No.5, 2007, pp 1323-1331). An Indian patent has been filed in this context. National Thermal Power Corporation Ltd collaborated with this high voltage laboratory to develop an expert system for moisture estimation of real


Fig. 4.4.1.1 Developed PDC-RVM Analyzer

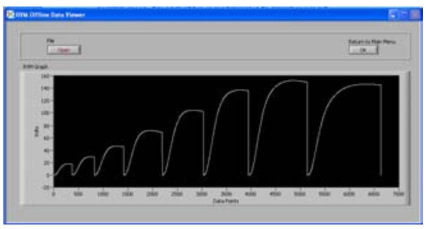


Fig. 4.4.1.2 RVM data as obtained by the developed system for a 420 kV Transformer

life power transformers, which has been copyrighted by JU and NTPC Ltd. Presently researchers of this laboratory are working on accurate modelling and better understanding of the dielectric response of oil-paper insulation of high voltage equipments operating under temperature gradient by modifying the conventional Debye model of insulation (IEEE TDEI, Vol. 20, No 5, pp. 1922-1933, 2013).

4.4.2. Frequency Domain Technique

The voltages used for studying insulation response in Frequency Domain Spectroscopy are usually sinusoidal in nature. But the insulation system in operation on site is stressed by voltage that may deviate significantly from a sinusoid. Thus the researchers of this laboratory are engaged in developing techniques on the use of non-sinusoidal waveform in obtaining the dielectric response for advanced insulation condition assessment. To perform frequency response analysis under non-sinusoidal excitation, a module has been developed in this laboratory to apply excitation voltages of 200Vp having sinusoidal waveform as well as non-sinusoidal waveform over a frequency range of 1mHz to 1kHz. An Indian patent has been filed in this context. Typical non-sinusoidal waveforms currently under study are triangular and square waveforms.


Fig. 4.4.2.1 Experimental set-up for FDS using non-sinusoidal excitation

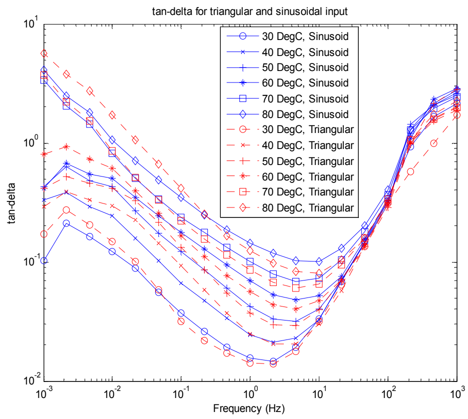


Fig. 4.4.2.2 tan-delta for fundamental components of triangular and sinusoidal input of same frequency

4.5. Remote Monitoring Techniques

Remote monitoring systems may use direct transmission lines, such as standard telephone lines, to transmit signals indicating conditions of a device, equipment, or object to be monitored. But the direct transmission of data using such lines is cost prohibitive in many circumstances as the location of the device may be in remote locations. An alternative means of monitoring devices is manual inspection. As the cost of man-hour increases, monitoring the status of remotely located devices by manual means will also increase. Thus the researchers of this high voltage laboratory have developed a system that includes a transmitter that is coupled to the apparatus to be monitored and that receives the electrical signal from the apparatus and transmits the electrical signal to the receiver via a cellular network. An Indian patent has been granted and a US patent has been filed for this work. Recently, this laboratory personnel are involved in developing schemes of feature selection and classification of power quality disturbances that can be implemented in a general purpose micro-controller for embedded applications for remote PQ monitoring purposes (IEEE Sensor Journal Paper#6826-2012 in print).

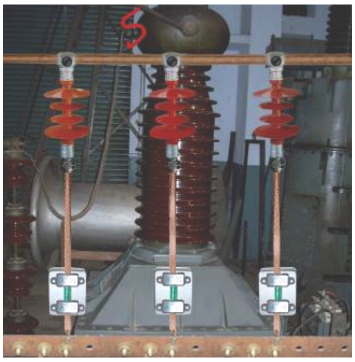


Fig. 4.5.1 Experimental set-up for remote monitoring of HV insulators

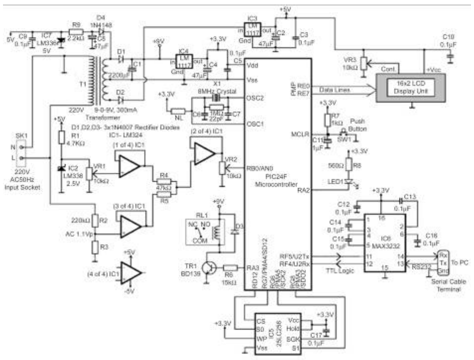


Fig. 4.5.2 Hardware scheme developed for remote PQ monitoring

5. Academic Output and Awards

The academic output of this laboratory is noteworthy in terms of publications, patents as well as software development. The number of papers published in IEEE Transactions from this laboratory is more than 50. In addition there are several papers published in SCI indexed journals. Over the last five years three Indian patents and one US patent have been filed and one has been already granted. One expert system software has been developed in collaboration with National Thermal Power Corporation for condition monitoring of Power Transformer Insulation, for which copyright application has been submitted. One electric field analysis software has been developed by the faculty member of this laboratory in collaboration with Technical University of Munich. Faculty members of this laboratory are recipients of several notable awards such as Fellow of Indian National Academy of Engineering, Fellow of National Academy for Sciences India, Alexander von Humboldt Fellowship, Ministry of Power prize and several other prizes given by national professional bodies in India.

6. Project Works

Over the years, this laboratory has also undertaken several sponsored project works and successfully completed them. These research projects are sponsored by Ministry of Human Resource Development (MHRD) of Govt of India (GOI), All India Council for Technical Education (AICTE), Department of Science & Technology (DST) of GOI, Council for Scientific and Industrial Research (CSIR), University Grants Commission (UGC), Defence Research and Development Organization (DRDO), National Science Foundation (NSF) of USA, National Thermal Power Corporation (NTPC) Ltd of India etc. AICTE have awarded one faculty member of this laboratory with the Technology Day award for best R&D project.

7. Testing and Consultancy

The High Voltage Laboratory has been actively engaged in industrial testing over the last thirty years. It has facilities for testing power engineering equipment such as transformers, isolators, insulators, bushings, cables etc, to name a few. This laboratory earns annual revenue of about INR 600,000 for the university by means of industrial testing. Presently this High Voltage Laboratory, which is an ISO 9001 certified laboratory for the last eight years, is known all over India as a reliable center for official acceptance tests for high voltage equipment. This laboratory also undertakes several consultancy jobs offered by small as well as large establishments.

8. International Collaboration

Faculty members of this laboratory are acting as the Liaison Officer on behalf of Jadavpur University in relation to the following MoUs: i) signed between the University of Applied Sciences in Augsburg, Germany, and Jadavpur University and ii) signed between the Technical University of Crete, Greece, and Jadavpur University for exchanging scholars, students, academic information and materials since 2008.

9. IEEE and Conference Works

The faculty members as well as the research scholars of this laboratory have played significant role in promoting activities in the field of dielectrics and electrical insulation engineering over the years. The first IEEE Dielectrics and Electrical Insulation Society Chapter has been formed in India primarily due to the efforts of the faculty members of this laboratory.

Submitted by:
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China Corner

China Twenty-year Progress in Electrical Insulation

Prof. Shengtao Li
Xi'an Jiaotong Univ.,
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1. Overall

In order to meet the requirement of the fast development of electric power industry in China, the UHV AC and DC power transmissions have been built to transmit the electric energy generated by the large-scale hydroelectric power stations and thermal power plants in West China to East China. The construction of UHV power transmission can promote the mend of structure of power grids, enhance nation-wide interconnection, improve the power transmission technology and the manu-facturing level of power transmission equipments, and elevate the security and stability level of power grid op-eration. This work will introduce the research progress of electrical insulation in China in the past twenty years, including the developments of dielectrics, characterization of trap distribution properties, and developments of insulating technology.

2 Developments of Dielectrics

2.1 Electrical properties of Nanodielectrics

Polymer nanocomposites have attracted wide interest as a method of enhancing polymer properties and extending their applications [1-3]. In polymer nanocomposites, chemically dissimilar components are combined at the nanometer scale, and stronger interactions between the polymer and nanoparticles produce markedly improved materials with better electrical, thermal, and mechanical performances than the conventional filled polymer composites.

The nanoparticles can affect the dielectric properties of nanocompoistes. It was observed that polyimide/TiO_2 composites exhibited lower relative permittivity at low doping concentration compared to a pure polyimide; and exhibited higher relative permittivity at higher doping concentrations [4]. Nevertheless, the surface treatment of the Al nanoparticles could increase the permittivity and reduced the dielectric loss of PE nanocomposites [5]. In addition, the dielectric permittivity of the $BaTiO_2$/Polyimide nanocomposite film was close to or even higher than that of submicrocomposite films, which was attributed to the advanced interfacial structure between the $BaTiO_3$ and PI phases [6].

The nanofillers can influence the conductivity of nanocomposites. It was found that the incorporation of surface treated Al nanoparticles increased the percolation threshold and the conductivity [5]. Moreover, the current density of the SiOx/LDPE nanocomposites at high electric field increased exponentially with increasing the applied voltage [7].

The introduction of nanofillers can increase the trap density of nanocomposites or generate new traps centers. Experiments showed that the trap density increased in the ZnO/LDPE nanocomposite as compared with LDPE. The charge transport was improved, and the space charge was suppressed in the nanocomposites [8]. Furthermore, the SiO_2/LLDPE nanocomposites with surface-treated silica showed improved space charge distribution, which was due to the silica surfaces and deep traps [9].

The incorporation of nanofillers can influence the short-term breakdown and long-term failure in nanocomposites [1]. The multi-region structure model in interface and the schematic diagram of the relationship between short-term breakdown/long-term failure and the nanoparticle loadings were proposed, which will be discussed in next section.

2.2 Multi-region Structure and Potential Barrier Model in Nanodielectrics

It is very urgent to develop new high insulation materials with higher breakdown field and superior ageing-resistant performance to meet the need in super/ultra-high voltage electrical equipment, high energy storage devices and equipment, aerospace and so on. Nanodielectrics as the third generation insulating materials with superior electromechanical performance open a new window for the industry development as well as correspond to the development strategy. Therefore, it is significant to investigate and develop nanodielectrics.

In the recent years, researchers in China have done a lot of works and have made great progress in the field of nanodielectrics. Various methods were used to prepare nanodielectrics and various polymer matrixes such as polyethylene (PE), silicone, epoxy resin (EP), polyamide (PA), polyimide (PI) doping various fillers such as alumina (Al_2O_3), titania (TiO_2), silica (SiO_2), layered silicates.

The current research is concentrated on invesitigating the properties of nanodielectrics, such as, dielectric response behaviores, breakdown properties, space charge effect, partial discharge (PD) resistance, electrical aging resistance and so on.

A multiregion structure formed around spherical nanoparticles for treated and untreated nanocomposites was proposed to interpret the dielectric properties of nano dielectrics, as shown in Figure 1 [1].

It is assumed that two regions are formed around the nanoparticle: one is the bonded region; the other is the transitional region. The bounded region is formed as nanoparticles are connected with the polymer by covalent, ionic and hydrogen bonds and van der Waals bondings. Moreover, in this region, as the nanoparticle is charged due to the difference of Fermi level between the nanoparticle and the polymer. The polymer chains of the transitional region are strongly bound to the bounded region and nanoparticles surface. The transitional region is considered as the crystalline structure region. The thickness of the transitional region is greater than the thickness of the bonded region. The bonded and the transitional region determine the short-term and long-term breakdown. As nanoparticles loading increases and the regions around the nanoparticles start to overlap, the short-term properties and the long-term properties may be stable and the nanoparticles role becomes dominant.

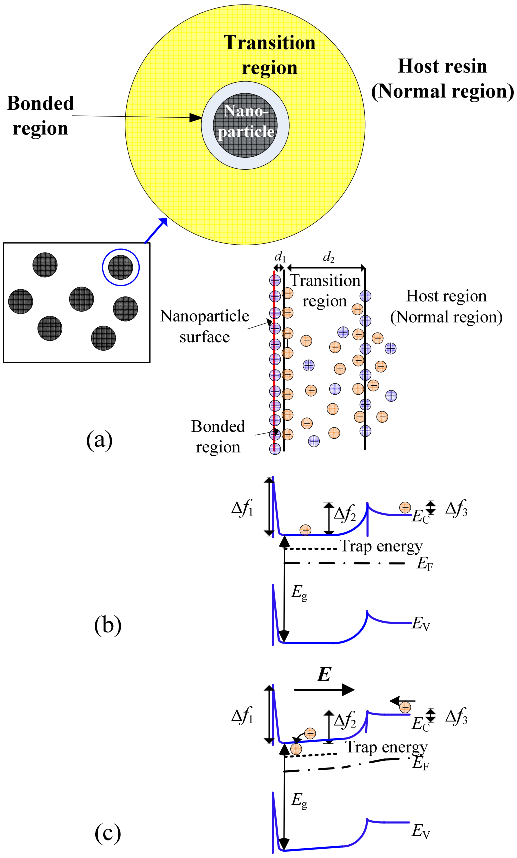

Fig. 1 Multi-region structure and potential barrier model in nanodielectrics [10].

Then a breakdown potential model [10] is built based on the structure model, as demonstrated in Figure 1. According to the potential model, the free path of carriers is shortened due to the existence of nanoparticles, which causes an increase in electrical strength and a reduction in conductivity of nanocomposite. At high nano particle concentration, free path of carriers has a vast extension due to the overlap of interaction zone between two neighbor particles. It can reduce the breakdown field of nanocomposites but improve the conductivity [11].

3 Characterization of Trap Distribution Properties

Disorder in condensed matter is associated with the presence of defects in insulating materials, impurities and distortions coming from the metastability of the structures. Two types of disorder: topological and chemical, exist in the insulating materials. Topological disorder is the lateral disorder in which atoms are located at random positions in space. Defects that cause disorder in polymers are basically due to various forms of chain disorder such as kinks, folds, jogs and twists. Chemical disorder is due to the presence of species, such as dopants and impurities, and to intrinsic defects, such as vacancies, interstitials and their complex associations. Topological and chemical disorder breaks the symmetry of the ordered system at a molecular scale and consequently affects the extended states of the valence and conduction bands, forming localized states which concentrate in band tails. Figure 2 shows that the trap density distributions locate in insulating materials, which can be single discrete trap [12], multiple discrete traps [13-15], exponential distribution of traps [16], and Gaussian distribution of traps [8, 17-19].

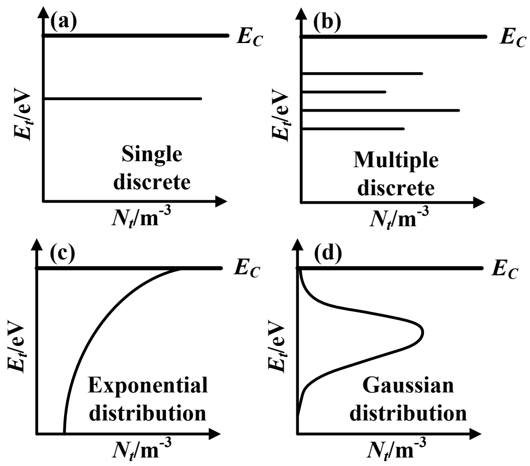

Fig. 2 Schematic of trap density distributions in insulators.

3.1 Characterization of Bulk Trap Distribution Properties

3.1.1 Isothermal Depolarization Current Theory

Consider an insulating material containing an arbitrary distribution of discrete trapping levels throughout its band gap. When the material is in thermal equilibrium, traps below the equilibrium Fermi energy are essentially occupied and those above it are essentially empty. It is assumed that the charge detrapping probability is determined by the attempt to escape frequency υ_{ATE}, trap energy E_T and temperature T [18].

During the current decay process, the decay rate of trapped charges is equal to the product of detrapping probability and trapped charge density. Integrating the decay rate of trapped charges over time, and considering the initial condition, we can obtain the time dependent trapped charges. Integrating the time dependent trapped charges over the thickness of the material L, we can calculate the external current density $j(t)$ during the isothermal decay process. We can approximate the external current density by a Dirac function $\delta(E_T,t)$. Then, we can obtain the trap energy E_T and trap density N_{trap} at time t.

$$E_T = k_B T \ln\left(\upsilon_{ATE} t\right) \tag{1}$$

$$N_{trap}\left(E_T\right) = \frac{2j\left(t\right)t}{q_e f_{FD} L k_B T \delta\left(E_T,t\right)} \tag{2}$$

where, q_e is the elementary charge; k_B is the Boltzmann constant; f_{FD} is the occupied ratio of trap centers. f_{FD} equals to 1 for traps below the equilibrium Fermi energy, and equals to 0 for those above it.

From isothermal depolarization current theory (IDC), we can obtain the trap densities of the materials by measuring the isothermal depolarization current. An electric field of 3×10^7 Vm^{-1} was applied on the LDPE and LDPE/ZnO nanocomposies at 323 K for 40 min. Then, the samples were short-circuited and the discharge current was measured at 323 K. Analyzed by the ICD theory, the trap energy distribution properties of the samples were obtained. The results showed that the trap energies were both in the range 0.8-1.0 eV with a peak density at 0.94 eV [8, 17].

3.1.2 Thermally Stimulated Current

Thermally stimulated current (TSC) acting as a kind of tools has been widely used to study the structures of trap, the store and transport of the space charge, the polymer phase change and molecule motion. From the first order charge trapping/detrapping dynamics, we can derive the thermally stimulated current as a function of temperature.

An auto-separating thermally stimulated current was proposed to allow an easy, accurate, and quick resolution of the overall TSC spectrum [13]. Later, the auto-separating TSC method was improved. Both the general-order kinetic equation of a thermally stimulated process (TSP) and the real peak found by calculating the activation energy varying with the increment of peak temperature were used to replace the first-order kinetic equation and the peak point obtained from the experimental TSC curve, respectively [14]. The trap energies calculated by the auto-separating TSC method were 1.0 eV and 1.34 eV. In addition, through the TSC test system, the relationship between the trap level and the microstructure was built [20, 21]. It was found that the trap levels are gradually deepening with the increase of grain size, e.g. the trap levels change from 0.65 eV to 0.95 eV when the grain sizes change from 3.5 μm to 17 μm.

In order to investigate the trap level distribution in polymer films, a new method was proposed based on modified TSC theory and numerical calculation of the TSC measurement [19]. In this method, a new function was defined to weight the contribution of every trap level to the external current. The demarcation energy was used to study the trap emptying process. The modified TSC theory showed that only the electrons with trap levels very close to the demarcation energy could significantly contribute to the external circuit at any instant temperature. It was found that the trap densities could be expressed as [19],

$$N_{trap}\left(E_T\right)=\frac{2j\left(T\right)}{q_e f_{FD} L \mathrm{A}_{\mathrm{T}}\left(E_T\right)\delta\left(E_T,t\right)} \tag{3}$$

where, $A_T(E_T)$ is the coefficient of the Dirac function of equation. Since $A_T(E_T)$ can not be obtained directly, Tian *et al* developed a numerical method to calculated $A_T(E_T)$ at different temperature.

The modified TSC theory was used to investigate the trap level distributions in the DuPont original polyimide 100HN and nanocomposite polyimide 100CR. The experiment results show that a broad peak appeared at about 440 K on the TSC spectrum of 100CR and a current peak at about 400 K for 100HN, while the trap level distribution exhibits a density peak at about 1.25 eV for 100CR and 1.15 eV for 100HN [19].

3.1.3 Space Charge Accumulation and Decay

When the insulating material is subjected to an electric field, charges can be injected into the material from the electrodes. The injected charges can migrate in the bulk of the material. Since a lot of trap centers are empty before the application of voltage, the empty traps can capture charges. The trapped charges, then, will distort the electric field in the vicinity of the electrodes, which will decrease the injected current density. Accordingly, the external current and the accumulation rate of space charges will decrease with time.

After applying the voltage for some time, we can short-circuit the sample and measure the space charge decay properties of the material. If we have two set of space charge accumulation and decay experimental results, we can calculate the trap distribution properties of the material, such as trap energies, and trap densities, capture-cross sections, and so on. This method has been used to investigate the trap properties of LDPE [15]. It was found that the space charge decaying during the first few hundred seconds corresponding to the fast changing part of the slope was trapped with the shallow trap depth 0.88 eV, with trap density 1.47×10^{20} m^{-3} in the sample volume measured. At the same time, the space charge that decayed at longer time corresponding to the slower part of the slope was trapped with the deep trap depth 1.01 eV, with its trap density 3.54×10^{18} m^{-3}.

3.2 Characterization of Surface Trap Distribution Properties

We consider a system consisting of an insulating material with the thickness of L and a grounded electrode, as shown in figure 3a. The insulating material can be charged by corona discharges or electron beams. When a high voltage is applied on a needle electrode, the electric field near the needle electrode will be distorted. The distorted electric field can ionize the neutral molecules to generate negative or positive ions. The ions will drift towards the insulator, depositing on the surface and transferring charges to the surface trap states of the material. The charges will be accumulated on the surface, and build up a surface potential. After the charging process, the surface charges will be injected into the bulk of the material, and opposite sign charges will also be injected into the bulk from the grounded electrode, as demonstrated in figure 3b. The injected negative and positive charges will migrate in the materials, leading to the SPD process, as indicated in figure 3c.

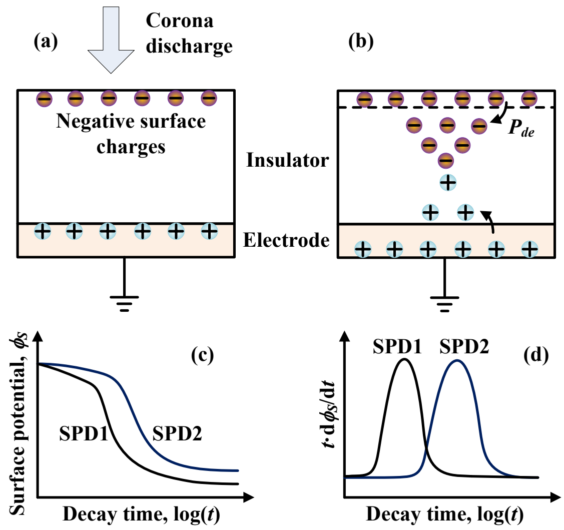

Fig. 3 Schematic of surface potential build up and decay processes, and the typical surface potential decay curves.

If the transit times of charges in the material is very short and the injected charges from the grounded electrode into the bulk is very small, we can assume that the detrapping process of surface trapped charges will dominate the SPD process. The surface deposited charge density is proportional to the surface potential. Considering the charge detrapping dynamics of surface trapped charges, we can obtain the trap energy by equation (1) and trap density by the following equation, as shown in figure 3d.

$$N_{trap}^{surface}\left(E_T\right)=\frac{2\varepsilon\varepsilon t}{q_e f_{FD} L^2 k_B T\delta\left(E_T,t\right)}\frac{\mathrm{d}\phi_S\left(t\right)}{\mathrm{d}t} \quad (4)$$

The samples of LDPE, polypropylene (PP), and polytetrafluoroethylene (PTFE) were charged positively and negatively by corona discharging for about 2 min. After charging, the samples were short-circuited for about 1 min to remove the surface free charges. Then, the surface potentials of the samples were measured by a vibration capacitive probe. Analyzed the experimental results by equation (4), it was found that the trap energy distribution of electron traps of LDPE, PP, and PTFE were in the range 0.85-0.95 eV, 0.80-0.95 eV, and 0.85-0.95 eV respectively [22, 23]. The SPD results of crosslinked polyethylene (XLPE) also showed that trap energy depth covered the range from 0.8 eV to 1.07 eV for electron and from 0.71 eV to 1.06 eV for hole [24].

4 Developments of Insulating Technology

4.1 Extra high voltage bushing

Research platform and experimental manufacturing station were established to investigate the performances of extra high voltage bushing. It was found that the internal stresses were effectively dissipated by extending the impregnation time over 40 h through controlling the nonlinear relationship between the viscosity of epoxy resin and temperature. Secondly, the interface, space charge, and partial discharge effects were suppressed using bond technique without air gap and large scale electrode surface coupled treatment system of voltage bushing. Thirdly, the axial and radial direction non-uniform electric fields initiated by deformation of capacitor core of voltage bushing were successfully solved by adopting dynamically programmable control technology of stretching force of insulating paper, accurate laser position technology of multilayer substrate, and, bushing machine of bushing capacitor core. Fourthly, the key technical matters of impregnation of bushing capacitor core with large length-diameter ratio was tackled by developing technologies of thin film degassing and hybrid gear pump transmission. Fifthly, the insulation breakdown caused by defects and cracks induced by internal stresses was mitigated utilizing high vacuum, large scale automatic testing and process automatic control system. The system can automatic measure the impregnation viscosity of epoxy, temperature, and solidification time, which is capable of controlling the exothermic peak of solidification of epoxy materials and suppressing the internal stresses produced in the solidification processes [25-28].

An extra high voltage bushing manufacturing system was constructed by China XD Group. Cooperating with Xi'an Jiaotong University, China XD Group developed 1100 kV AC bushings and ±800 kV DC bushings, as shown in Figure 4. The bushings were appraised by experts organized by China National Energy Administration in November, 2012 [25, 26].

Fig. 4 The 1100 kV extra high voltage bushing designed and manufactured by China XD Group and Xi'an Jiaotong University [25, 26].

4.2 Voltage-grading Technology

Non-uniform electric field distributions usually occur in extra high voltage electric transmission and transformation system. The enhanced electric field can lead to corona discharging, influencing the insulation behaviors of equipments and the operational safety of the system. The voltage-sharing properties of extra high voltage electric stations and power equipments of transmission lines were investigated through the performance parameter design of materials, the simulation analysis of multi physical fields, structure optimization of inner/outer insulation, coordination of insulation, and anti corona technology, and so on. The connection modes between extra high voltage power transformation equipments and conducting lines and line hardware that have good safety, advanced technology, economic feasibility, experimental friendship were proposed to lay a strong foundation for the electric station hardware design of extra high voltage testing demonstration project [29, 30].

Influenced by frame towers, high voltage conducting lines, and distributed capacitances, the electric fields on the surface of the equipment hardware will be distorted. The electric fields on the terminal balls on the side of switches, tension insulator strings, and equalizing rings of the terminal balls and the tension insulator strings will be much higher than that on the other equipments. The potential and electric field distribution properties of transformers, reactors, arresters, gas insulated switchgear (GIS), post insulator and earthing switch were simulated by finite element method software [30, 31]. Figures 5 and 6 demonstrate the electric field distributions of high voltage system before and after using the voltage-grading technology. The distortions of electric fields are mitigated by utilizing the voltage-grading technology.

4.3 Space Charge Measurement Techniques

The charges which accumulate during the application of an external excitation (electric field or irradiation) modify the materials's internal electric field and can cause an electrical breakdown in certain cases. The charges accumulation has been studied for long time by techniques capable of giving information on the spatial

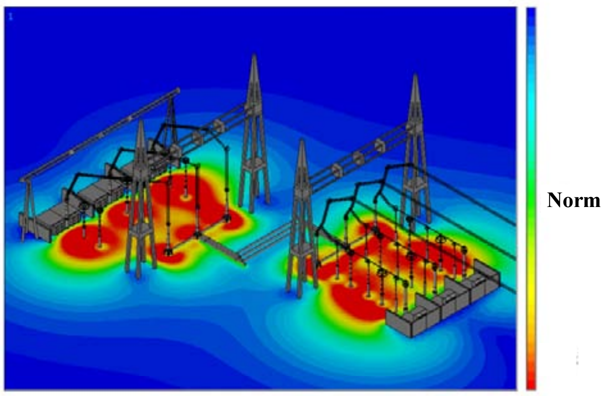

Fig. 5 Electric field distribution of high voltage system before using the voltage-grading technology.

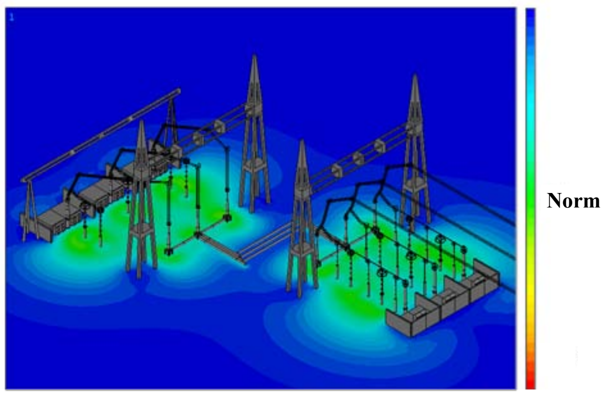

Fig. 6 Electric field distribution of high voltage system after using the voltage-grading technology.

quantity of charges, like the PEA and pressure wave propagation (PWP) methods. Figure 7 demonstrates the schematic of PEA method. In a classic device, the sample is placed between two electrodes. From the electrodes, we can polarize the sample and apply voltage pulses which play the role of the probe to make the measurements.

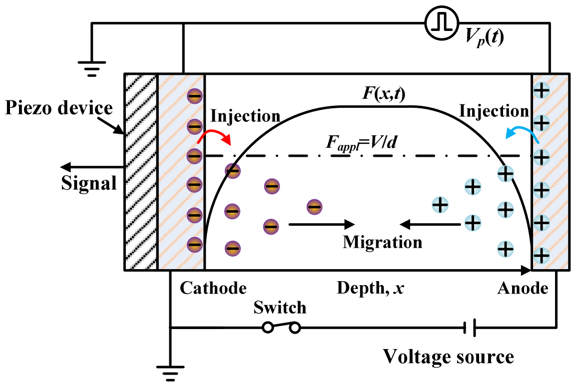

Fig. 7 Schematic of PEA technique.

Since the late 1980s, Tu *et al* in Xi'an Jiaotong University started to develop the PEA technique [32, 33]. During the 1990s, they ustilized the PEA technique to study the charge distribution properties in the thichness of various solid insulating materials [34]. Zhang *et al* in Tongji University began to investigate the space charge properties in solid insulating materials since the late 1990s, and developed laser-induced pressure pulse (LIPP), PWP, and PEA techniques [35]. Zhou *et al* in Tsinghua University also established a PEA space charge testing system with the help of Prof. Takada. It was found that the microstructure of high-density polyethylene (HDPE) could influence the space charge accumulation properties in the material [36].

The numerical methods for measuring distributions of space charge and electric field in solid insulating materials have also been widely studied in the past two decades. Liu *et al* studied the analysis method in frequency domain for measuring space charge distributions in solid dielectrics by PEA method [34]. Wu *et al* corrected the waveform overshoot in PEA measurement [37]. Hu *et al* applied the Tikhonov deconvolution algorithm for the space charge distribution measurement in materials [38-40].

Conclusion

We described the developments of dielectrics, characterization of trap distribution properties, and developments of insulating technology in China in the last two decades. The electrical properties of insulating materials have been improved by adopting nonodielectric technology. A theoretical model of multi-region structure and potential barrier was proposed to interpret the experimental results of nanodielectrics. In addition, several trap characterization techniques have been developed to study the trap energy and density properties of insulating materials. Moreover, the insulating technologies, such as extra high voltage bushing, voltage-grading technology, and space charge measurement techniques, have been briefly discussed.

Reference

[1] S. Li, G. Yin, G. Chen, J. Li, S. Bai, L. Zhong, Y. Zhang and Q. Q. Lei, "Short-Term Breakdown and Long-Term Failure in Nanodielectrics: A Review," IEEE Trans. Dielectr. Electr. Insul., vol.17, No.5, pp. 1523-1535, 2010.

[2] F. Q. Tian, Y. Chun, L. J. He, B. Han, Y. Wang and Q. Q. Lei, "Recent Research Advancement in Dielectric Properties and the Corresponding Mechanism of Polymer/Inorganic Nanocomposite," Transactions of China Electrotechnical Scociety, vol.26, No.3, pp. 1-12, 2011.

[3] Y. Luo, G. N. Wu, J. Peng, Y. Q. Zhang, H. H. Xu and P. Wang, "Research Progress on Interface Properties of Polymer Nanodielectrics," High Voltage Engineering, vol.38, No., pp. 2455-2464, 2012. (in Chinese)

[4] F. Yu, J. H. Yin, M. H. Chen, M. X. Song, B. Su and Q. Q. Lei, "Effect of Nano-TiO_2 on the Polarization Process of Polyimide/TiO_2 Composites," Mater. Lett., vol.96, No.1, pp. 113-116, 2013.

[5] X. Y. Huang, C. Kim, P. K. Jiang, Y. Yin and Z. Li, "Influence of Aluminum Nanoparticle Surface Treatment on the Electrical Properties of Polyethylene Composites," J. Appl. Phys., vol.105, No.1, pp. 014105(10pp), 2009.

[6] Z. M. Dang, Y. Q. Lin, H. P. Xu, C. Y. Shi, S. T. Li and J. B. Bai, "Fabrication and Dielectric Characterization of Advanced $BaTiO_3$/Polyimide Nanocomposite Films with High Thermal Stability," Adv. Funct. Mater., vol.18, No.10, pp. 1509-1517, 2008.

[7] J. Chen, Y. Yin, Z. Li and D. Xiao, "Electrical Prestressing of High-Electric-Field Conduction in Composite of Low-Density Polyethylene/Nano-SiO_x," Jpn. J. Appl. Phys., vol.44, No.2, pp. 940-947, 2005.

[8] F. Q. Tian, Y. Chun, L. J. He, B. Han, Y. Wang and Q. Q. Lei,

"Recent Research Advancement in Dielectric Properties and the Corresponding Mechanism of Polymer/Inorganic Nanocomposite," Transactions of China Electrotechnical Scociety, vol.26, No.3, pp. 1-12, 2011.

[9] X. Y. Huang, P. K. Jiang and Y. Yin, "Nanoparticle Surface Modification Induced Space Charge Suppression in Linear Low Density Polyethylene," Appl. Phys. Lett., vol.95, No.24, pp. 242905(3pp), 2009.

[10] S. Li, G. Yin, S. Bai and J. Li, "A New Potential Barrier Model in Epoxy Resin Nanodielectrics," IEEE Trans. Dielectr. Electr. Insul., vol.18, No.5, pp. 1535-1543, 2011.

[11] G. L. Yin, "Breakdown Characteristics of Polymeric Nanodielectrics Under Power Frequency and Direct Current Voltage," PhD dissertation, Xi'an Jiaotong University, Xi'an, 2012. (in Chinese)

[12] P. Zhang, G. Li, L. Cai and Q. Lei, "High-Field Conduction Current Characteristics of Polyimide Film," Chinese Journal of Material Research, vol.20, No.5, pp. 465-468, 2006. (in Chinese)

[13] Q. Q. Lei, X. Wang and Y. Fan, "A New Method of Autoseparating Thermally Stimulated Current," J. Appl. Phys., vol.72, No.9, pp. 4254-4257, 1992.

[14] Y. Fan, X. Wang, W. Zhang and Q. Q. Lei, "Improvement upon Our Previous Method for Auto-Separating Thermally Stimulated Current Curves," J. Phys. D. Appl. Phys., vol.32, No.21, pp. 2809-2813, 1999.

[15] T. Zhou, G. Chen, R. Liao and Z. Xu, "Charge Trapping and Detrapping in Polymeric Materials: Trapping Parameters," J. Appl. Phys., vol.110, No.4, pp. 043724(6 pp), 2011.

[16] J. D. Wu, "Charge Transport Investigation in Low-Density Polyethylene/Silica Nanocomposite Based on Experiment and Numerical Simulation," PhD dissertation, Shanghai Jiaotong University, Shanghai, 2012. (in Chinese)

[17] F. Q. Tian, Q. Q. Lei, X. Wang and Y. Wang, "Effect of Deep Trapping States on Space Charge Suppression in Polyethylene/ZnO Nanocomposite," Appl. Phys. Lett., vol.99, No.14, pp. 142903(3pp), 2011.

[18] Q. Q. Lei, F. Q. Tian, C. Yang, L. J. He and Y. Wang, "Modified Isothermal Discharge Current Theory and its Application in the Determination of Trap Level Distribution in Polyimide Films," J. Electrostat., vol.68, No.3, pp. 243-248, 2010.

[19] F. Q. Tian, Q. Q. Lei, X. Wang and Y. Wang, "Investigation of Electrical Properties of LDPE/ZnO Nanocomposite Dielectrics," IEEE Trans. Dielectr. Electr. Insul., vol.19, No.3, pp. 763-769, 2012.

[20] S. Li, Q. Huang, J. Sun, T. Zhang and J. Li, "Effect of Traps on Surface Flashover of XLPE in Vacuum," IEEE Trans. Dielectr. Electr. Insul., vol.17, No.3, pp. 964-970, 2010.

[21] Q. F. Huang, "Surface Flashover Characteristics and Mechanism in Vacuum of Polyethylene and its Multilayered Structures," PhD dissertation, Xi'an Jiaotong University, Xi'an, 2011. (in Chinese)

[22] G. Zhang, K. Yang, M. Dong, W. Zhao and Z. Yan, "Surface Electroluminescence Phenomena Correlated with Trapping Parameters of Insulating Polymers," Appl. Surf. Sci., vol.254, No.5, pp. 1450-1455, 2007.

[23] W. Zhao, G. Zhang, Y. Yang and Z. Yan, "Correlation Between Trapping Parameters and Surface Insulation Strength of Solid Dielectric Under Pulse Voltage in Vacuum," IEEE Trans. Dielectr. Electr. Insul., vol.14, No.1, pp. 170-178, 2007.

[24] Y. Gao and B. X. Du, "Characterizing Space Charge Transportation in HV XLPE Cable Insulation Based on Surface Potential Decay Measurement," High Voltage Engineering, vol.38, No.8, pp. 2097-2103, 2012. (in Chinese)

[25] Http://Www.Xdect.Com.Cn/Structure/Kykf/Yjcgnr_23542_1.Htm.

[26] Http://Xjtunews.Xjtu.Edu.Cn/Kxyj/2012-12/1356260353D40262.Shtml.

[27] S. L. Zhang, Z. R. Peng, P. Liu, W. Hu and H. R. Wang, "Electro-Thermal Coupling Model for Computation of Radial Temperature and Electric Field of Resin Impregnated Paper High Voltage Direct Current Bushing," Proceedings of the CSEE, vol.33, No.22, pp. 191-200, 2013.

[28] X. J. Xie, W. Hu, Z. R. Peng, J. F. Hou, Z. M. Xu and Y. J. Yang, "Dielectric Loss Characteristics of 550 kV Resin-Impregnated Paper Oil-SF_6 Bushing During Thermal-Stabilization Testing," High Voltage Engineering, vol.38, No.10, pp. 2749-2754, 2012. (in Chinese)

[29] P. Liu, "Calculation of Electric-Field Distribution and Research on the Voltage-Sharing Performance of 500kV Composite Insulator on Power Lines," PhD dissertation, Xi'an Jiaotong University, Xi'an, 2004. (in Chinese)

[30] T. X. Xie, "Research on Voltage Equalizing Characters of Insulators on 1000Kv Uhv AC Transmission Lines," PhD dissertation, Xi'an Jiaotong University, Xi'an, 2012. (in Chinese)

[31] J. Li, "Voltage-Sharing Characteristics of 1000 Kv Ultra-High Voltage AC Substations," PhD dissertation, Xi'an Jiaotong University, Xi'an, 2012. (in Chinese)

[32] Y. W. Zhang, D. M. Tu and Y. N. Liu, "Space Charge Distribution Measurement in Solid Dielectrics," physics, vol.16, No.3, pp. 165-169, 1987. (in Chinese)

[33] R. S. Liu, D. M. Tu and Z. Y. Liu, "Principle of Measurement of Space Charges in Solid Dielectrics Using Electro-Acoustic Pulse Method," Transactions of China electrotechnical society, vol.5, No.1, pp. 13-19, 1990. (in Chinese)

[34] Y. Liu, Y. C. Zhu and D. M. Tu, "The Pulsed Electro-Acoustic Method by Frequency Domain Analysis for Measuring Space Charge Distributions in Solid Dielectrics," Transactions of china electrotechnical society, vol.9, No.1, pp. 44-49, 1994. (in Chinese)

[35] C. S. Wu, F. H. Zheng, Y. W. Zhang, J. X. Li and Z. F. Xia, "Piezo-PWP and PEA Methods for Measuring Space Charge in Solid Dielectric," Acta Phys. Sin.-Ch Ed, vol.52, No.5, pp. 1137-1142, 2003. (in Chinese)

[36] N. H. Wang, B. Gao, Y. X. Zhou, H. B. Liu, X. D. Liang, Z. C. Guan and T. Takada, "A Practical Space Charge Testing System Realized by the Pulse Electro-Acoustic Method," Electrical Measurement & Instrumentation, vol.41, No.467, pp. 12-15, 2004. (in Chinese)

[37] C. Y. Wu, L. S. Zhong, X. Wang and D. M. Tu, "Correction of Waveform Overshoot in PEA Space Charge Measurement," Insulating materials, vol.2005, No.6, pp. 44-47, 2005. (in Chinese)

[38] L. Q. Hu, F. H. Zheng and Y. W. Zhang, "The Application of Tikhonov Deconvolution Algorithm for Space Charge Distribution in Dielectrics," Chinese Journal of Computational Physics, vol.21, No.5, pp. 432-438, 2004. (in Chinese)

[39] L. Q. Hu, F. H. Zheng and Y. W. Zhang, "An Iterative Regularization Method for the Space Charge Distribution in Dielectrics," Chinese Journal of computational physics, vol.22, No.1, pp. 88-93, 2005. (in Chinese)

[40] L. Q. Hu, Y. W. Zhang and F. H. Zheng, "Novel Numerical Methods for Measuring Distributions of Space Charge and Electric Field in Solid Dielectrics with Deconvolution Algorithm," IEEE Trans. Dielectr. Electr. Insul., vol.12, No.4, pp. 809-814, 2005.

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Diagnosis and Maintenance Techniques for Large Generator Stator Windings

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1. Introduction

The stator winding of large generators eventually breaks down after gradual insulation deterioration and partial discharge (PD) due to creation of internal voids, delamination, and contamination in the endwinding surface caused by thermal, electrical, mechanical, and environment stresses. In the case of the water-cooled generators, dielectric breakdown occurs due to vibration and corrosion of the stator winding, which are caused by leakage of cooling water and absorption of moisture. An unexpected dielectric breakdown in the stator winding insulation of large generators leads to deterioration in reliability, and quick restoration is difficult; therefore, significant economic losses are incurred.

At present, a number of off-line insulation diagnostic tests are carried out to conduct insulation analysis of the generator stator winding. In Korea, insulation diagnostic tests are conducted regularly to evaluate the condition of the insulation aging of the generator stator winding, and research is being performed to determine the evaluation criteria for insulation degradation. Furthermore, the insulation condition is evaluated by considering the overall insulation condition including the distribution of PD pattern during operation. The extent of defects can be predicted by analyzing the trends and patterns obtained by examining the maximum PD activity. These predictions can be used to understand the aging process of the insulation material.

This study will provide a description for the occurrence of dielectric breakdown for three cases: 1) a water-cooled generator (560 MVA, 22 kV) that has been in operation for more than 16 years, 2) an air-cooling gas turbine generator (119.2 MVA, 13.8 kV) that was built using the global vacuum pressure impregnation (VPI) and has been in operation for more than 14 years, and 3) an air-cooled gas turbine generator (137 MVA, 13.8 kV).

2. Cases of Diagnosis and Maintenance

According to the analysis of the diagnostic test results for the water-cooled generator (560 MVA, 22 kV) stator winding insulation, it turned out to be in sound condition; however, in some cases, the insulation was found to have suffered damage. Analysis showed the damage was due to the absorption of moisture caused by the leakage of cooling water in the endwinding. It can be seen from visual inspection of the dielectric breakdown in the water-cooled generator stator winding shown in Fig. 1 that the damage to the copper was so severe that it had to be replaced with a spare coil. This suggests that the insulation diagnosis program did not consider the absorption of moisture in the endwinding caused by the leakage of cooling water. In the future, the insulation condition of the water-cooled generators will be analyzed within the 15 years by conducting an insulation analysis indicative of moisture absorption due to the leakage of cooling water. Stator rewind will be carried out 20 years after the beginning of operation.

Figure 1 Endwinding stator insulation breakdown in water-cooled generators

A ground fault occurred in the phase-to-phase insulation of the endwinding in an air-cooling gas turbine generator (119.2 MVA, 13.8 kV) manufactured using global VPI when operating at rated output 82MW. After the operation was stopped, the insulation resistance was found to be equal to 2MΩ between phases A and B, whereas it was 3,000 MΩ at phase C. After disassembling the upper bracket of the generator, the location of the dielectric breakdown could be determined, as shown in Fig. 2. The grounding occurred in the phase-to-phase winding at slot number 19 of the top coil of phase A and at slot number 66 of the bottom coil of the phase B.

Figure 2 Location of generator breakdown

The generator shown in Fig. 2 is of the global VPI insulation type where the connections of stator windings are installed close to each other. It can be seen in Fig. 3 that insulation separation is intended to function as a phase separator, and that a Nomex sheet is inserted between the two phases. However, this particular location has the highest potential difference; therefore, if the upper winding insulation of the Fig. 2 contains an internal miniature void or gap that weakens its insulation, white powder is likely to occur due to the PD. If the PD occurs continuously for a long period of time, the separator and the surface of the insulation material is eroded, which will lead to the breakdown of the insulation.

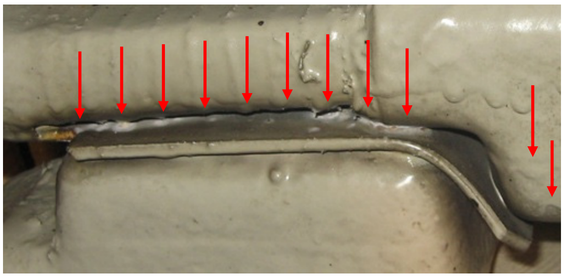

Figure 3 Distribution of white powder at the phase separator due to PD activity

The semiconducting layer of the gas turbine generator was badly eroded, as shown in Fig. 4. The semiconducting layer and insulation material suffered severe damage during operation because of the rubbing between the surface of groundwall insulation and core. This was caused by the thermal and mechanical stresses due to thermal cycling, thermal expansion, and electromagnetic vibration during operation. This wears out the insulation, which becomes thinner, and leads to the degradation in dielectric strength. As a result, both the size of the internal gap of the slot and the movement of the coil will increase. Repetition of this cycle accelerates insulation deterioration. The insulation will eventually fail due to the progress in slot discharge in the semi-conductive layer that was originally spread out on the surface of the coil to prevent PD.

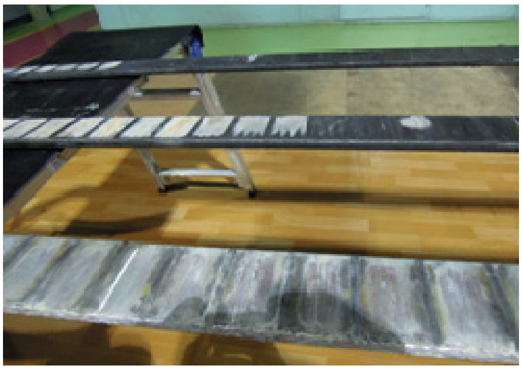

Figure 4 Damaged semi-conductive layer of generator stator winding

The result of the off-line insulation diagnosis of the air-cooling gas turbine generator stator winding (137 MVA, 13.8 kV) showed low alternating current and dissipation factor; however, PD was measured to be as high as 65,000 pC. Six epoxy-mica sensors (80 pF) were installed in 13.8 kV gas turbine generator stator windings in phases A, B, and C, as shown in Fig. 5. The on-line turbine generator analyzer (TGA)-B was used to measure the normalized quantity number (NQN) and maximum PD (Qm) during operation. When the phase voltage of the gas turbine generator stator winding was 8 kV, Qm was measured to be as high as 600 mV, which is the same as the PD measured under off-line condition. On-line PD was measured periodically, and it was concluded that the stator winding required a rewind, since its maximum value increased steadily even after 700 mV. Dielectric breakdown occurred at 17.9 kV during the AC breakdown test that was performed immediately before the gas turbine generator stator winding rewind.

Figure 5 Installed epoxy- mica couplers

3. Conclusion

Insulation diagnostic tests conducted every five years for the water-cooled generator stator winding displayed satisfactory results; however, sudden insulation breakdown has occurred. Analysis revealed that the breakdown was due to moisture absorption resulting from the leakage of cooling water at the stator winding. Therefore, it is suggested that more experiments involving cooling water leakage and moisture absorption be carried out in addition to the insulation diagnostic test of water-cooled generator stator windings.

In the air-cooling gas turbine generator manufactured using global VPI, white powder occurred due to PD between the endwinding insulation and the phase separator. This led to the gradual erosion of the surface, which eventually caused insulation breakdown. Furthermore, the erosion of the semiconducting layer of the stator winding was severe.

Epoxy-mica sensors were installed for the air-cooling gas turbine generator stator winding because the off-line PD measurement was 65,000 pC. The PD measured during operation also turned to be as high as 600 mV, which is the same as the off-line PD measurement. PD was measured regularly during operation, and it was found to have maximum value higher than 700 mV, which implies that stator rewind is required. According to the AC breakdown test conducted before replacing the stator winding, the insulation breakdown took place at 17.9 kV.

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India Corner

Recent Trends in Development of Intense Pulsed Power Technology in BARC

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Abstract Since 1970s, BARC is actively involved in the design and development of various pulsed power systems for fusion, plasma and intense electron beam related research activities. With changing scenario of pulsed power technology [1,2,3] compact and repetitive systems were also developed for industries whereas in our lab for High power microwave, ultrawide band and Flash X-rays applications. Other pulsed power application was in the area of electromagnetic forming and welding where 8-100kJ capacitor banks were developed with synchronised discharge techniques. Major research areas of pulsed power system include various subsystems such as 200-1000kV Marx Generator, 20μs-100ns Magnetic Pulse Compressors, 3kJ/s-40kJ/s fast capacitor charging power supply, remote control operation and pulsed diagnostic system, measurement techniques, computer aided simulation of circuit behaviour, electromagnetic field distribution, high power microwave device, and impulse radiators. In view of vulnerability of sensitive electronics, susceptibility data for different critical electronics circuitry and devices are part of recent studies on Intentional Electromagnetic Interference (IEMI) along with desired hardening topology. EMF system is also developed to carry out special metal joint.

1. Introduction

Significant progress has been achieved in the development of pulsed power technology and its applications in BARC,India. At Accelerator and Pulsed Power Division of Beam Technology Development Group continuous efforts have been carried out on the design and development of MW-GW pulsed power systems and the applications in beam-plasma studies, relativistic electron beam generation, flash X-rays for radiography, ultra wide band electromagnetic impulse and high power microwave generation. Various kinds of pulsed power generators have been developed such as unipolar/bipolar Marx generators, tesla transformers, coaxial/Blumlein pulse forming line, inductive energy storage system, magnetic pulse compressors, inductive voltage adder etc. It also include the development of solid state power modulators for fast capacitor charging (3-40kJ/s) and synchronised capacitor banks (40kJ -100kJ) for electromagnetic forming and welding. In the field of high power microwave generation, extensive studies have been done on the performance of axial, coaxial vircator and reflex triodes. Pulsed relativistic electron beam (REB), is a promising candidate for the electron beam source due to its high current density, high chemical reactivity, and long range, where the range is a mean distance when the electrons will be stopped after interaction with atoms or molecules of the polluted matter. Presently work reported is limited to HPM, UWB and FXR studies.

2. KALI Based Pulsed Power Systems

The series o KALI (Kilo Ampere Linear Injector) started with KALI-75 for fast triggering using PFN module based uni-polar Marx generator and REB combination to give the output of 75J. Thereafter more powerful systems were made viz.KALI-200 (Helical Tesla Transformer, oil based PFL and REB gun), KALI-1000 (Spiral Tesla Transformer, DM water based PFL, vircators),
KALI-5000 (Bipolar Marx generator, Castor oil-Blumlein, prepulse switch followed by Axial/coaxial and reflex triode vircators) and latest one is KALI-30GW system (Bipolar Marx, Transformer oil Blumlein, FXR-gun). Here hardware of KALI-500m has been used with changed Marx design, energy and charging inductor in place. Also castor oil from blumlein of KALI-5000 is removed and transforme roil is filled to match the enrgy between Marx and blumlein PFL thereby REB diode was suitably designed for 1MV capcity after the prepulse switch to prevent plasma formation on the cathode before actual pulse arrives.

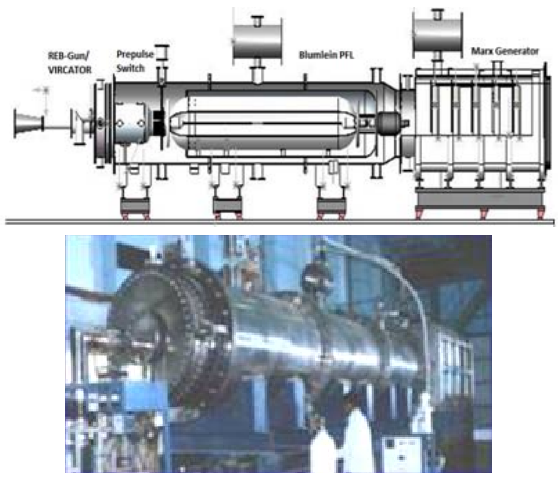
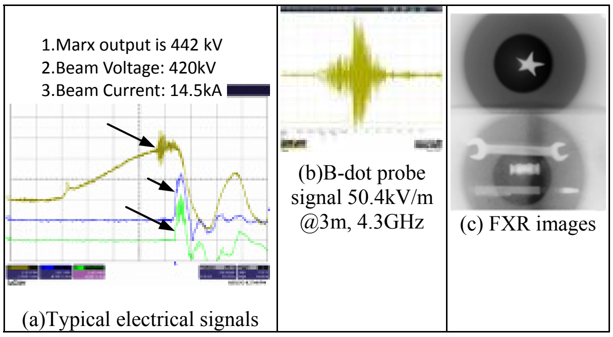


Fig.1 Schematic and Photograph of KALI-30GW system (1Mv,30kA,80ns)

This development has been associated with series of studies on relativitstic electron beam generation, plasma expansion velocity, diode perveance, conversion to High power microwave and flash X-rays. In order to improve the efficiency of these sub-systems involved subsystems have been separately investigated such as low inductance capacitor design with optimised elemental size and configuration within a casing; measurement



(a)Typical electrical signals (b)B-dot probe signal 50.4kV/m @3m, 4.3GHz (c) FXR images

Fig.2 Measured signals, HPM signal and FXR images of KALI-30GW

techniques of low inductance for energy storage capacitors; sparkgap switching characteristics in vacuum, low pressure, high pressure in various gas species; surface flashover phenomena in oil and high pressure medium, recovery characteristics of sparkgaps in low pressure and high pressure gas medium. The research study also included REB diode performance with respect to cathode/anode materials and configurations. The vircators have been studied extensively with respect to V,I,reprate and A-K gap[6].

B-dot probe Signal peak was 4.21 Volts at 4.2 GHz. Sensitivity factor along with 35 m cable length at this frequency was 12 kV/m/V. This corresponds to 50.4 kV/m. A-K Gap was 10 mm. These studies are being continued for optimisation of REB diode in HPM and FXR mode operation.

3 Inductive Energy Storage System

This is also one of the single shot pulsed power source which is based on opening switch using exploding wire array in high pressure gas medium This is more compact than capacitive energy storage system hence it has been optimised [7] to give desired output for a vircator to be used at 300kV,8-10kA using IES-300. The opening switch has been optimised to give voltage gain of 10 i.e. charging at 30kV and out put ~300kV pulse.

The radiated field has been measured as 7kV/m at 3m in 4.3GHz frequency. A few more experiments are planned to see the effectiveness of input current and voltage at fixed energy. Wire, foil, gas medium etc are yet to be explored for relative performance.

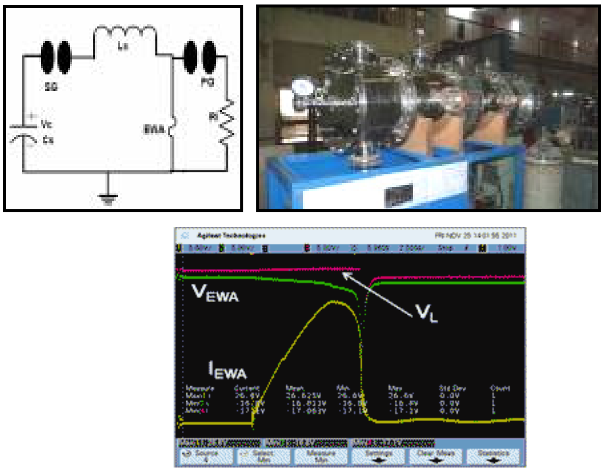


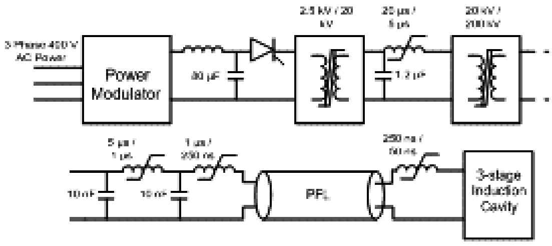
Fig.3 Schematic, Photograph and measured waveforms of IES-300

4 Linear Induction Accelerators: LIA-Systems

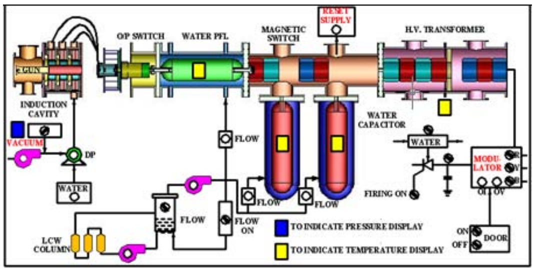
To make system repetitive, sparkgaps are replaced with magnetic switching. Two pulsed power system has been developed using magnetic pulse compressors and all solid state capacitor charging power supply (CCPS) for fast charging to get repetitive operation. It needs fast CCPS with suitable protection schemes and response times.

4.1 LIA-200: 200kV,5kA,100ns,1-100Hz

This is first repetitive pulsed power system developed for technology demonstration in India based on magnetic pulse compressors and tested to its full capacity [5]. The schematic is shown in the following figure consisting of two water capacitors (10nF,200kV), water PFL and 3-stage inductive voltage adder (IVA) cavities at the output having oil/vacuum interface between cavities for isolation. DM water is circulated at 18-20 °C, ~2 MΩ/cm of resistivity in PFL and capacitors. It has continuous reset circuit for amorphous cores at pulse transformers, magnetic switches and induction cavities. This system has been used for cathode material studies for REB generation and HPM conversion.



(a)Typical Electrical Schematic of LIA-200



(b) Layout of LIA-200

Fig.4 Electrical schematic and layout of LIA-200

4.2 LIA-400: 400kV,4kA,100ns,1-300Hz

Linear induction accelerators (LIA) have the unique capability of delivering high average peak power and good beam quality in the repetitive pulse regime. LIA-400 (200 - 400kV, 2 - 4kA, 100ns, maximum pulse repetitive frequency of 300Hz) repetitive pulsed power system comprises of saturable pulse transformer, three magnetic switches, strip forming line, capacitor assemblies and induction cavity. Permalloy is used in magnetic components. The system has been developed, integrated, and tested with a dummy resistive load initially then with electron gun. The LIA-400 assembly chamber is evacuated by rotary vacuum pump and filled with transformer oil and degassed for few days. The vacuum chamber and resistive load were assembled along with indigenously developed $CuSO_4$ voltage divider and Rogowskii coil for measurement of Load voltage and current respectively.

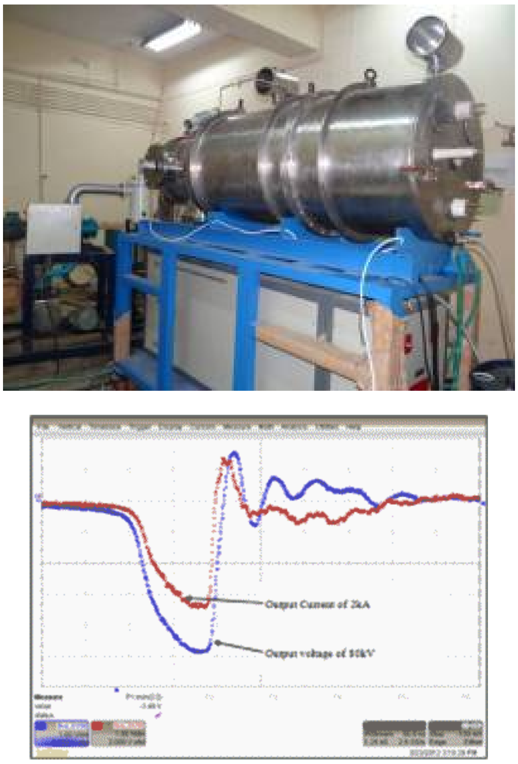
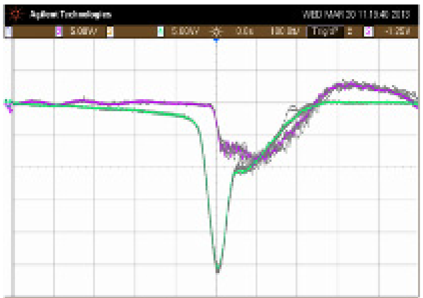


Fig.5 Photograph of assembly with Output voltage and Current waveshapes with aqueous load

This system has been initially tested in single shot mode and characterised with a dummy load as shown in Fig.2. Later, a suitably designed relativistic electron beam (REB) diode has been integrated with vacuum system in place of resistive load. The system is integrated with 70kW capacitor charging power supply, relativistic electron beam (REB) diode as load and vacuum system. The REB diode consists of planar graphite cathode and SS flange anode. An aqueous copper sulphate resistive divider and rogowski coil in the diode chamber measures

(a) Single shot mode operation (315kV,3.5kA)



(b) 100 Hz repetition of LIA-400

Fig.6 Experimental results of LIA-400 with REB generation in single shot and repetitive mode

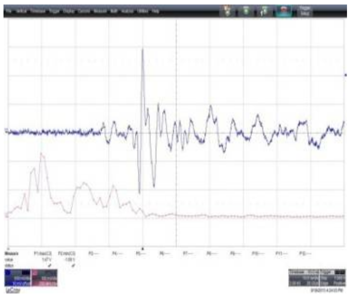
the electron beam diode and voltage. Beam generation experiments in single shot mode and up to 100 Hz repetition rate has been carried out. The operating parameters for single shot mode was 315 kV diode voltage and 3.5 kA diode current at 1 kV charging. In 100 Hz repetition, electron beam with 160 kV voltage and 2.3 kA current was generated at a charging voltage of 500 V. The percentage variation in diode voltage and current in repetitive operation was ± 6 %.

Results have shown good consistency in repetitive pulse mode. Diode characterisation and cathode materials are being studies using this system.

5 UWB Sources

Marx driven Ultra Wideband System are also developed at H-4, BARC. There are two types of sorce one with PFL and other one is without PFL having each capacitor stage as a PFN module. The radiating antenna is designed to match the impedance of the Marx generated in erected condition. Unipolar HVDC 30kV power supply is used for charging of the MARX generator and an electrical trigger circuit to initiate the triggering of the Marx switching.

(a) Marx Driven TEM Horn **(b)Marx + PFL driven balanced Horn**



(c) Typical Radiated signal & FFT

Fig.7 System Photograph and Radiated Waveform E=11.3kV/m @ 7.5m (blue) with FFT (red)

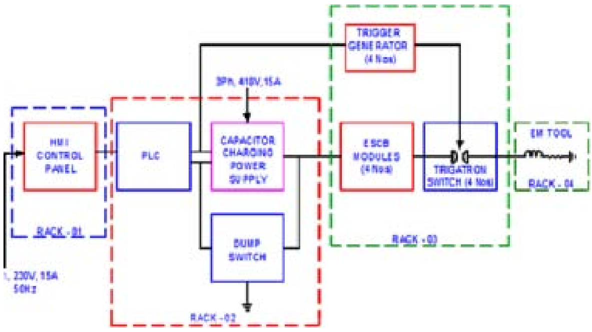
The P FL coupled MARX generates maximum of 250kV voltage pulse to charge the pulse forming line, which discharges into an antenna of matched 60 Ω impedance, a 125kV, 5ns voltage pulse is obtained. Rise time of this voltage pulse is measured to be about 250-450pS depending on the pressure of operation. A wideband TEM horn antenna is used to radiate the pulse generated by the source. Antenna is designed to produce a gain of about 6dB at 200MHz frequency. Radiated field is measured at a distance of 7.5m from antenna mouth. A maximum field of 11.3kV/m is obtained along the principal axis of the antenna. More experiments are in progress to characterise the source and diagnostics [8,9].

6 Capacitor Bank for EMF/W

Electro Magnetic Forming/Welding (EMF/W) is the state of art technology for shaping and joining of metals. In Electromagnetic forming /welding process the forming /welding is carried out by application of an electromagnetic force. In this technique, forming is achieved without physical contact between tool and job piece. Hence it has obvious merits over conventional processes such as brazing, welding, expansion, contraction, contour formation etc., when used for some special applications. Since the bond is achieved by impact/pressure, this method is ideally suited for joining/welding of dissimilar metals with large difference in their melting points. This added advantage is generally not available in the conventional processes. This technique has applications in automobile, electric, defence, aeronautical and other industries. Moreover the system has tremendous potential for use in the manufacture of appliances and consumer products.

The main components of the system are the high voltage power supply, energy storage capacitor bank, charging resistors, trigatron sparkgap, trigger pulse generator, load coil and a remote control console. The capacitive energy is transferred to the load coil through a high current trigatron type sparkgap. The schematic diagram of the EMF equipment is shown in the Fig 8 with photograph of system,tool and Cu-M.S. jobs.

Application of these specially useful for nuclear application where no foreign materials are involved for joining end plugs of fuel pins, welding of high yield stress materials like D9 and ODS tubes. It is a very clean, fast and low running cost process over other techniques.



(a) Schematic of Electromagnetic Forming System

(b) Capacitor bank with tool

(c) Electromagnetic Coil Tool

(d) Job:Cu tube to soft iron disc welding & free forming

Fig.8 Schematic, Photograph and jobs of EMF set-up at BARC

7 Conclusions:

A diversified technology of pulsed power systems are developed in the lab capable of producing MW-GW electron beam pulse power. They are being used for IEMI and FXR radiography applications. More applications are being explored to meet critical requirements and R&D activities are focussed to make system compact and reliable.

8 Acknowledgement

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9 References

1. Hidenori Akiyama, Takashi Sakugawa, Takao Namihira et al, "Industrial Applications of Pulsed Power Technology"; IEEE Transactions on Dielectrics and Electrical Insulation Vol. 14, No. 5; October 2007; pp.1051-64.
2. W. Zhang, J. Sandberg ; "Pulsed Power Systems in Large Accelerator Complex", Presented at the 3rd Japan-US Symposium on Pulsed Power and Plasma Applications; Kauai, Hawaii, August 6 - August 8, 2006
3. Go Imada and Hisayuki Suematsu; "Treatment of Polluted Soil by Irradiation of Pulsed, Intense Relativistic Electron Beam" Research Report NIFS-PROC series 2010, pp23.
4. Rakhee Menon, Amitava Roy, S. Mitra, Archana Sharma, J. Mondal, K. C. Mittal, K.V. Nagesh, and D. P. Chakravarthy, "Generation and Dose Distribution Measurement of Flash X-ray in KALI-5000 System," Review of Scientific Instruments, 79, 103301 (2008).
5. Archana Sharma, K. Senthil, D.D. Praveen Kumar, S. Mitra, V. Sharma, A. Patel, D.K. Sharma, R. Rehim, T.S. Kolge, P.C. Saroj, S. Acharya, R. Amitava, M. Rakhee, K.V. Nagesh and D.P. Chakravarthy, "Preliminary results of Linear Induction Accelerator LIA-200", Journal of Instrumentation, 2010 JINST 5 P05001
6. Amitava Roy, Archana Sharma, Sabyasachi Mitra, Rakhee Menon, Vishnu Sharma, K. V. Nagesh, and D. P. Chakravarthy, "Oscillation Frequency of a Reflex Triode Virtual Cathode Oscillator", IEEE Transactions on Electron Devices. Vol. 58, No. 2, pp. 553-561 Feb. 2011.
7. "Compact Inductive Energy Storage Pulse Power System", Senthil K, Sabyasachi Mitra, Amitava Roy, Archana Sharma and D.P Chakravarthy; Accepted for publication in Review

of Scientific Instruments in June 2012.

8. Somesh V Tewari, A.Roy, C.S.Reddy, Archana Sharma and K.C.Mittal; "Particle-in-cell simulations of discharge along angled Insulators in compressed gases"; IEEE-PPPS, USA, June 16-21, 2013.

9. S. V. Tewari, S. Umbarkar, Ritu A., P. C. Saroj, Archana Sharma, K. C. Mittal, and H. A. Mangalvedekar, "Development & Analysis of PFN Based Compact Marx Generator Using Finite Integration Technique for an Antenna Load", IEEE Trans.-PS, Vol. 41, No. 10, pp 2684-90, 2013

10. Satendra Kumar, M.R. Kulkarni, P.C. Saroj, K. C. Mittal & L. M. Gantayet, " Electromagnetic welding of AL to Copper in Tubular Joints,", International Journal of Applied Electromagnetics and Mechanics, Accepted in July, 2013.

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Indonesia Corner

Application of Room Temperature Silicone Coating on Ceramic Outdoor Insulators in Indonesia

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1 Introduction.

Indonesia is the world's largest archipelago country. It located in tropical area which is situated around the equator. It consists of 17,508 islands, about 6,000 of which are inhabited.

Installed capacity is 33 GW. At the end of 2012 total transmission lines is 38.096,29 kms, which consists of 500 kV networks of 5.052,00 kms, 275 kV network of 1.028,30 kms, 150 kV length of 27.780,04 kms and the rest is 70 kV lines. Main equipments are 49 units of 500 kV transformers, 7 units of 275 kV transformers, 1054 units 150 kV transformers and small number of 70 kV transformers[1].

To support the electric power system, a large number of insulators are being used. The insulators put in service are mainly made from ceramics. A small number of insulators are made from glass. Since there are a large amount of coastal area with highly salt polluted, insulator failures at coastal area is high. Therefore, it is important to keep insulators integrity in order to obtain good operational condition and reliability of the power system.

Outdoor insulators are exposed to environmental climate such as high temperature and humidity as well as pollution from coast and industries. As the result, leakage current may flow on the insulator surface and may degrade the insulator surface[2]. Under particular condition, dry band arcing may take place on the insulator surface leading to the failure of the insulators[3].

(a) non coated **(b) coated**

Figure 1: Silicone coated insulator

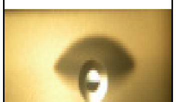
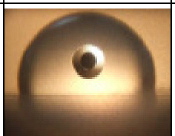
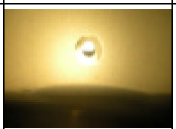
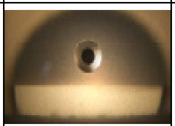
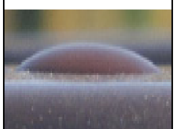
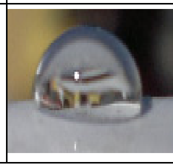
2 Silicone coating.

In effort to mitigate insulator failures, silicone coating application was considered. The trial application of these type silicone coated insulators were conducted at Pangandaran substation which is located at coastal area about 500 m from Indonesian Ocean southern of Java Island. The insulators are 20 kV post-pin type as shown in figure 1.

Hydrophobicity Improvement

Good outdoor insulators have a strong ability to repel water and pollution from their surfaces. This property is called as hydrophobicity. Hydrophobicity is indicated by its contact angle. Table 1 shows water drop profiles and contact angles on insulator surfaces. The table indicates clearly that coating increases drastically the contact angles for both insulators in laboratory as well as in Pangandaran. The hidrophobicity was maintained for many years. In this case the contact angle was maintained in the level of 90-100 degree.

Table 1 : Water drop profile on insulator surfaces and contact angle

	Water drop profile (Non Coated)	Contact angle (deg)	Water drop profile (Coated)	Contact angle (deg)
Clean insulator		55-65		100-110
Kaolin-salt polluted at 3.6 mS		5-8		100-105
13 Months operated at field		25-35		90-100

Leakage Current Wavfrom

Figure 2 shows leakage current waveforms and harmonic contents of coated (a) and uncoated (b) insulators under polluted condition of 10 mS at 11 kV. The figures indicate that silicone coating reduces the leakage current. Similar results are shown in figure 3 for applied voltage of 50 kV. In this figure it is clearly seen that silicone coating reduces the leakage current distortion caused by discharges. The appearance of 3rd harmonics was caused by discharges. As shown in the figure of harmonic contents, the 3rd harmonic of noncoated sample was much higher that the coated sample.

Figure 4 shows typical leakage current waveforms and harmonic contents for coated (a) and non coated (b) insulators. From the figure it is clearly seen that the silicone coating reduced the leakage current.

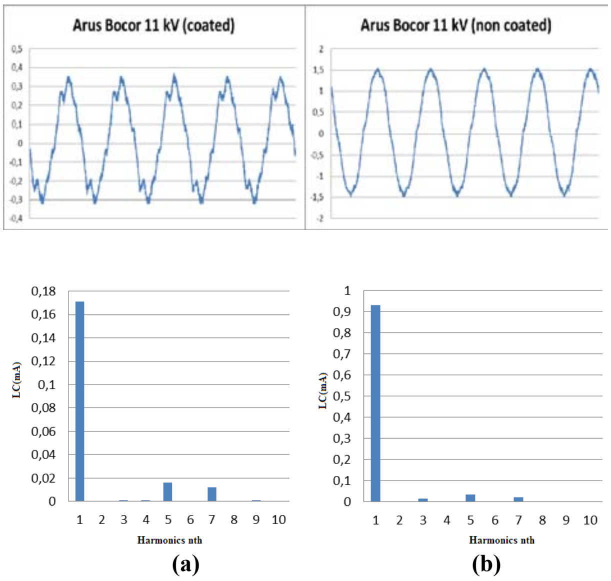


Figure 2 Leakage current waveforms and harmonic contents of coated (a) and uncoated (b) insulators at 11 kV

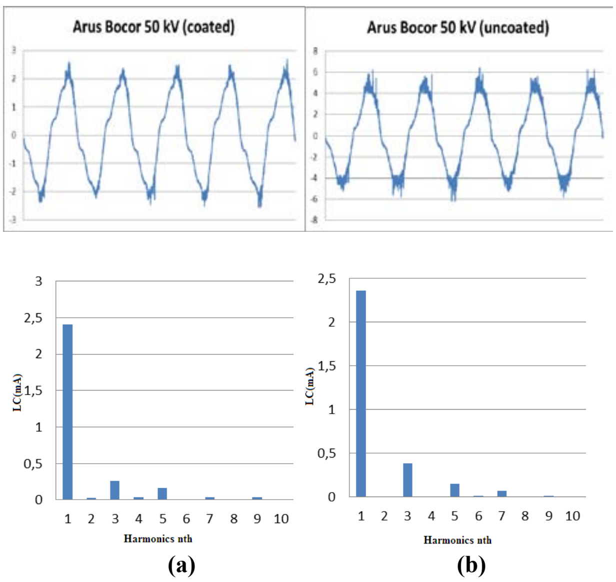


Figure 3 Leakage current waveforms and harmonic contents of coated (a) and uncoated (b) insulators at 50 kV

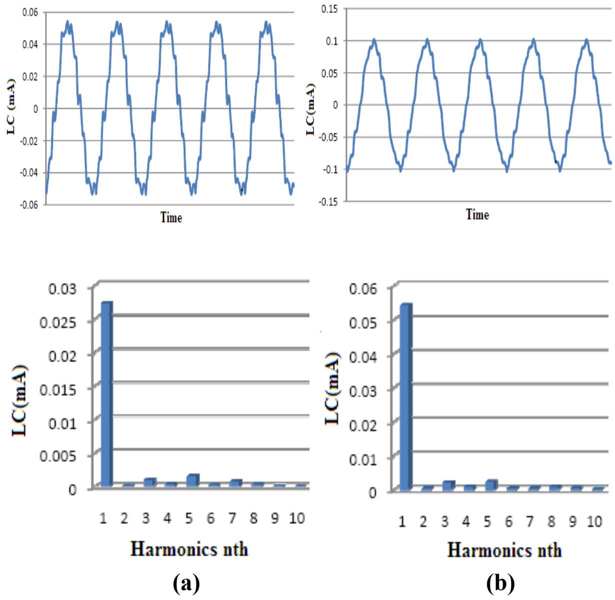


Figure 4 Leakage current waveforms and harmonic contents of coated (a) and uncoated (b) insulators at Pangandaran Sub Station

Non linear behaviour of insulators and simulation of leakage current

The distortion on the leakage current waveforms are caused by non linearity of the insulator surfaces and the appearance of electrical discharges. In order to understand the non linearity of the insulators, a computer simulation was conducted based on the measured leakage current waveforms and an equivalent circuit as shown in figure 5. The equivalent circuit contains capacitances, non linear resistances and electric sparks. The An example measured and simulated of leakage current waveforms are shown in figure 6.

The simulated waveforms were obtained by adjusting the equivalent circuit parameters such as capacitance, the number of arc circuits and the non linearity of the resistances. Typical non linearity of coated and non coated insulators surface are shown in table 2. From the simulation results the non linearity of the coated and uncoated insulators are shown in table 3.

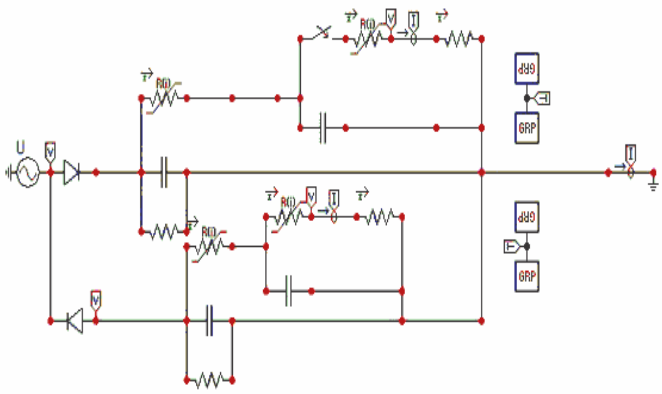
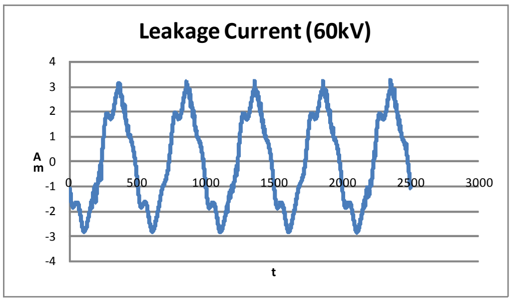
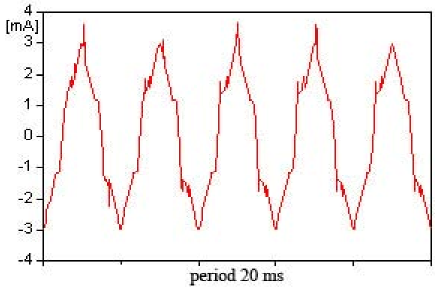


Figure 5 General equivalent circuit model of insulator



(a)



(b)

Figure 6 Measured (a) and simulated (b) waveforms

Table 2 . Typical non linearity of coated and non coated insulators

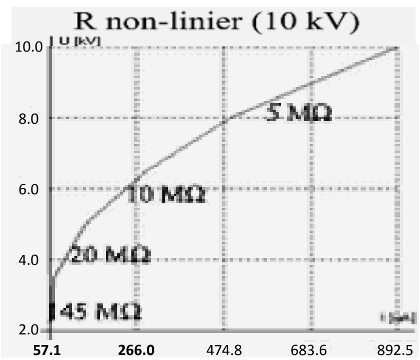
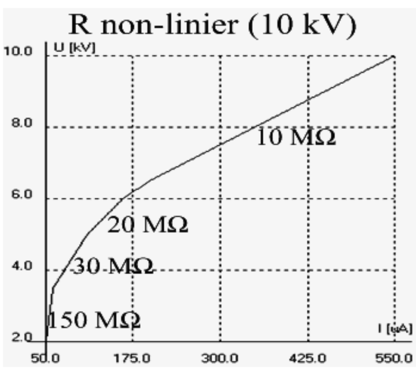
	Clean insulator under clean fog
Non coated	
Coated	

Table 3 Non linearity of the coated and uncoated insulators

R Non-linear	Non coated insulator			RTV Coated insulator		
	Clean	Kaolin-salt 25 ms/cm	Kaolin-salt 40 ms/cm	Clean	Kaolin-salt 25 ms/cm	Kaolin-salt 40 ms/cm
R1 (MΩ)	150	145	20	150	150	150
R2 (MΩ)	30	20	6	30	30	30
R3 (MΩ)	20	10	10	20	20	20
R4 (MΩ)	12,5	7,5	1	12,5	12,5	12,5
R5 (MΩ)	10	5	0,5	10	10	10

REFERENCES

[1] PLN Statistics, 2012

[2] Suwarno, Prasetijo, D., *Researches on high voltage engineering and their future trend in Indonesia*, Electrical Insulating Materials, 2005. (ISEIM 2005). Proceedings of 2005 International Symposium on Volume 1, 5-9 June 2005 Page(s):131 - 134 Vol. 1, 2005

[3] Aydogmus, Zafer and Cebeci, Mehmet. A *New Flashover Dynamic Model of Polluted HV Insulators*, IEEE Trans.s on Dielectrics and Electrical Insulation, Vol. 11, No. 4, Agust, 2004.

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TECHNOLOGIES FOR TOMORROW

Development of Simplified Outdoor Termination for 500kV XLPE Cable

Conventional outdoor termination is designed to use of oil immersion paper insulation which requires long time assembling work by skilled workers on site. Therefore, new outdoor termination with simpler construction is preferred in order to reduce difficulties in site assembling work.

VISCAS has finished development of 500kV class simplified outdoor termination with porcelain insulator. Main insulation part inside porcelain insulator consists of EPDM rubber block and silicone oil. EPDM rubber which has good mechanical performance in both young modulus and stress relaxation is assigned. By selecting proper EPDM compound, interfacial pressure can be ensured by EPDM self elastic force during long life period and compression equipment (spring unit) which has been commonly used is not necessary. Fig.1 shows a comparison of construction among outdoor terminations. Type test and prequalification test in accordance with IEC62067 were completed for 500kV. This type of outdoor terminations have been supplied and installed up to 400kV class in the world.

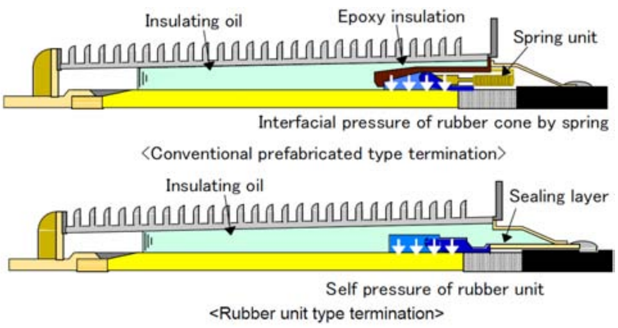

Fig.1 Construction of outdoor terminations.

Further more, Simplified Outdoor Termination with Composite Hollow Insulator has been designed. It has lightweight, good characteristics for polluted condition, and good protection performance to an explosion, in comparison with porcelain insulator. Various composite hollow insulators are lined up, and have already been supplied to 154kV class for Japanese market and 240kV class for world market, respectively.

Currently, development of that for 500kV is ongoing. Initial electrical performance tests and heating cycle voltage test in accordance with IEC62067 500kV class was finished. Fig.2 shows a view of heating cycle voltage test, and Table-1 shows the results.

Fig.2 View of heating cycle voltage test

Table-1 Results of the initial electrical performance tests and heating cycle voltage test

Items	Conditions	Results
AC voltage	580 kV / 60 min	good
AC voltage (pertial discarge)	508kV / 10 sec and 435kV (Sensitivity:5pC)	good
Lightning impulse voltage	±1550 kV / 10 shots	good
Heating cycle voltage test	Loading cycle 20 times * Tc = 95°C Voltage condition 580 kV / 20 days	good

The test results satisfied the requirements, and now prequalification test as per IEC standards 500kV class is under preparation. Simplified Outdoor Termination is expected to be installed for 500kV class application in the near future.

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Large VSDS Full Load Test Facility

For oil & gas applications, full load VSDS (variable-speed drive system) tests at the manufacturer's factory are sometimes required to ensure higher reliability. TMEIC (Toshiba Mitsubishi-Electric Industrial Systems Corporation) installed a high power load test facility at Nagasaki works.

Features of test facility:

(1) Test capacity: Full load back-to-back test up to 25MW

(2) Installation: (Refer to blue parts of fig.1)

1) TR-A: Power transformer
   Output voltage: 3kV, 4kV, 6kV and 11kV classes
2) MV cubicles: DS cubicles to select voltage class and switch gear cubicles
3) TR-B1: 30MVA transformer for VSD
4) TR-B2: 30MVA transformer for TMdrive-XL series[1]
5) VSD: 30MVA variable speed drive with regeneration. (TMdrive-XL85[2] with PWM converter)
6) Cooling unit:

Transformers, MV switchgear cubicles and cooling units are installed outdoors. The VSD is installed indoors, with the test inverter installed on the upper deck of the VSD. (Fig. 2 & 3) Fig.4 shows the example of load test.

(3) Test:

This facility is designed to test the TMdrive-XL series and the TMdrive-MVG[3].
TMdrive-XL drives can be tested in 2 (two) ways shown in Fig. 1.

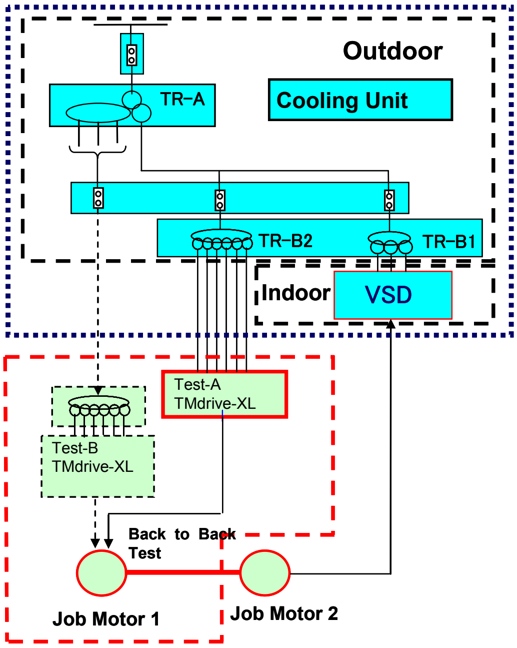

Fig.1 Test Circuit

a) Test-A:

TR-B2 is used for the input transformer. By selecting the input voltage of TR-B2, the output voltage can be configured to accommodate the TMdrive-XL series.

b) Test-B:

This test is performed when a full load test including the input transformer is required. TMdrive-MVG and other types of inverters can also be tested by this method.

Since the maximum output frequency of the VSD is 200Hz, the back-to-back full load test of high speed motors can be performed by this test facility.

Note :

(1) 5 Level inverters with 36 pulse diode source

(2) 30MVA - 5 level inverter with 36 pulse diode source

(3) Multi level inverter

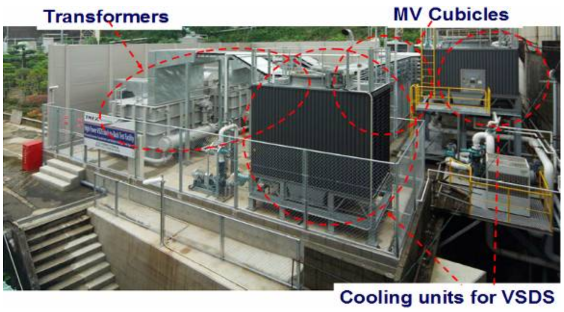

Fig.2 Outdoor Installation

Fig.3 Indoor Installation

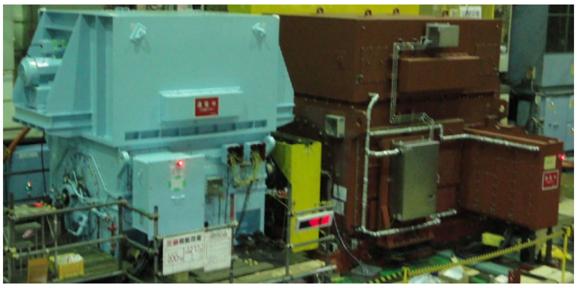

Fig.4 Example of Load Test

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Development of Radiation Retardant Cable

Higher reliability is being required for cables accompanying the greater reliability of nuclear power plants. Hitachi Metals early on introduced equipment for conducting Vertical Tray Flame Testing (VTFT) (IEEE1202-1991), which is more stringent than conventional testing, to evaluate high reliability for flame retardancy (Fig.1). We have also developed radiation resistant cable that can withstand a loss of coolant accident (LOCA) even when exposed to a higher dose of γ-ray irradiation than conventional cable.

A recent trend in Japan is to conduct a long-term evaluation of simultaneous degradation due to heat and irradiation under a low dose rate (100 Gy/h or less) by using an Environmental qualification test to simulate the actual environment. However, simultaneous degradation testing requires a very long evaluation period.

For this reason, in this study, the γ-ray irradiation under room temperature atmospheric pressure up to 2MGy (dose rate 10kGy/h or less) using ^{60}Co radiation source was carried out at first. Then a comparative evaluation as made of the electrical insulation and breaking elongation after degradation of the developed cable and the conventional cable (Table 1). The method used for the degradation order was to perform heat degradation after radiation exposure because this is a severe testing method that gives results close to those of heat and irradiation simultaneous degradation.

The decrease in electrical insulation is thought to be caused by ionization due to degradation of the compounding agents with these ions attracting water into the insulation, so we developed an insulation material that stabilizes the generation of these ions while also improving the breaking elongation after simultaneous heat and radiation degradation.

We fabricated cables using both the conventional and developed materials and conducted a comparative evaluation under the above conditions and also performed the more severe VTFT testing. Flame retardant chloroprene rubber was used as the sheath material for both types of cable.

The results showed that the developed cable had better post-degradation breaking elongation than the conventional cable and also can withstand a LOCA even under exposure to high radiation doses.

Further, both the conventional cable and developed cable also passed the VTFT testing by wide margins.

The results confirmed the high reliability of the developed cable. Further studies will be carried out by performing a long-term evaluation of heat and irradiation simultaneous degradation at low dose late on the developed cable, and the knowledge gained from this study will be used to develop halogen-free radiation resistant materials.

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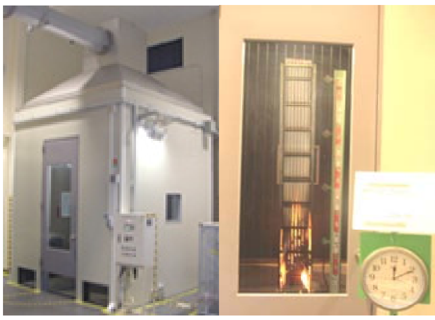


Fig.1 VTFT equipment (IEEE1202-1991)

Table1 Environmental qualification test methods

Method	CONVENTIONAL	COMPARATIVE (This study)	SIMULTANEOUS
Heat aging	121℃×7days	140℃×9days	100℃
γ irradiation (dose rate)	0.88MGy (10kGy/h or less)	2MGy (10kGy/h or less)	arbitrarily (100Gy/h or less)
Degradation order	Heat→ irradiation →LOCA test	Irradiation→Heat →LOCA test	Simultaneous →LOCA test
LOCA test	Steam explosure (max170℃×13days_AC 600V) →Withstand voltage test (3.2kV/mm×5min)		

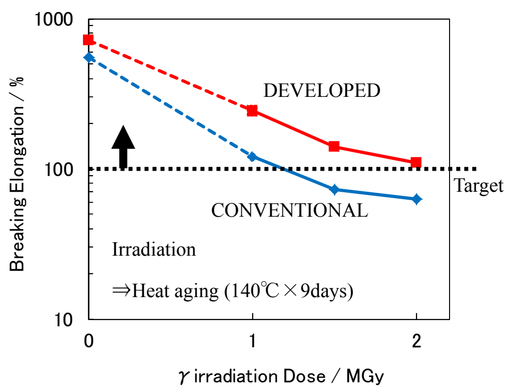


Fig.2 After Degradation Breaking Elongation (0MGy means initial)

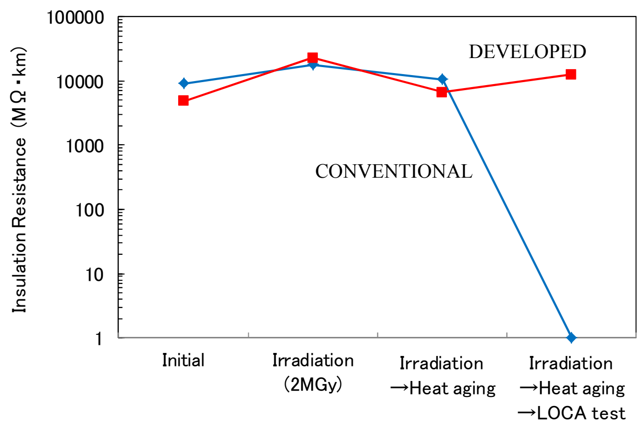


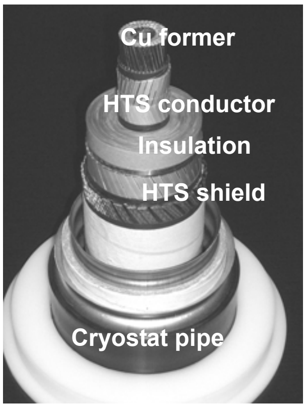
Fig.3 Insulation Resistance after Degradation

TECHNOLOGIES ALERT

Demonstration of World Highest Voltage Superconducting Cable of 275 kV and 3kA

(1) High-Tc Superconducting Cable

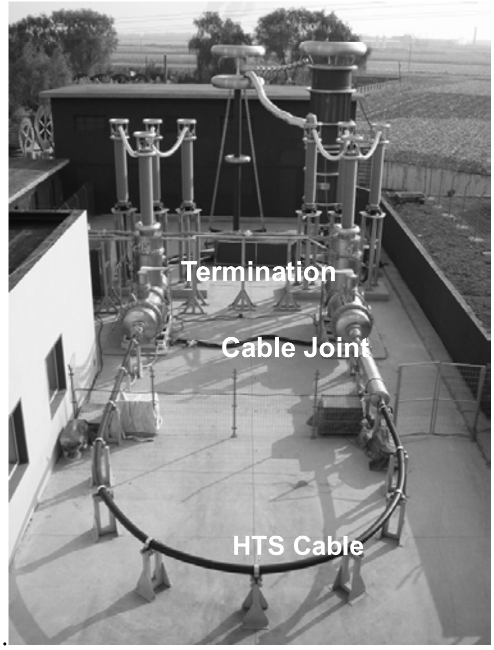
Since a high-Tc superconducting power cable (HTS cable) is capable of carrying massive amounts of electricity with low loss, it is expected to make a contribution to energy savings and the reduction of CO2 emissions. Particularly, the HTS cable made of REBCO wires (2nd generation HTS wire) will be most promising as a large capacity power cable. FEC has developed the highest voltage 275kV HTS cable that enables power transmission of 1.5 GVA,



275kV 3kA HTS cable

(2) Long-term voltage and current loading test

The demonstration test has been conducted at Shenyang Furukawa Cable in China. In the demonstration test, actually, in order to verify a soundness of cable system that consisted of the cable, the termination, and the cable joint in 30 years operation, the HTS cable system has been applied an initial withstand voltage of higher 200kV and 3 kA for one month as an acceleration test. The voltage and current loading test of one month was successfully completed, and any deterioration wasn't detected in the cable system after the long-term test.



Test facility of the long-term test

This works has been achieved in the Technological Development Project for Yttrium Superconducting Electrical Systems, supported by NEDO.

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Supply of DC+/-300kV XLPE Insulation Cable System to Sweden

There are many applications of direct current (DC) power transmission systems in Europe for interconnection of power grids or very long distance power transmission. Alstom Grid (France) are awarded as a contractor of AC/DC converter station at Hurva for the South-West Link project by Svenska Kraftnät in Sweden.

We, VISCAS, supply DC+/-300kV XLPE cable system to Alstom Grid as interconnection cable inside the converter station. The system is bi-pole system. Total four cables are installed to compose two bi-pole systems and outdoor terminations are applied at both ends of the cables. The cables are laid underground. Most part will be "direct buried" but "duct system" will also be applied in road crossing portion.

Main specifications of system are below.

Rated DC voltage	: 300kV
Max. peak voltage	: 315kV
Transmission power	: 360MW
Cable current	: 1200A

Cable is DC+/-300kV XLPE insulated corrugated aluminum sheathed, polyethylene jacketed power cable. The conductor is made of aluminum and 1600mm^2 Milliken conductor. The metallic sheath is annular ring corrugated type and water swellable tapes are applied underneath to make longitudinal water barrier. The jacket is extruded high-density black polyethylene.

The insulation is specially developed XLPE for DC application and it realizes same leveled allowable conductor temperature of 90°C as well as normal XLPE for AC cable. The thickness is 18mm. Fig.1 shows the cross section of the cable.

Prior to this project, we conducted pre-qualification test and type test for DC+/-320kV class in accordance with CIGRE TB496 "Recommendations for Testing DC Extruded Cable Systems for Power Transmission at a Rated Voltage up to 500kV". The design of cable and the accessories were completely proven in the test.

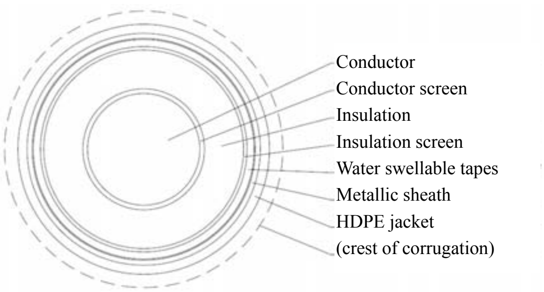

Fig.1 Cable cross section

Cable system with DC+/-300kV is higher record in the field of DC-XLPE application. As Japanese supplier, this is first supply record of DC-XLPE cable system to European market.

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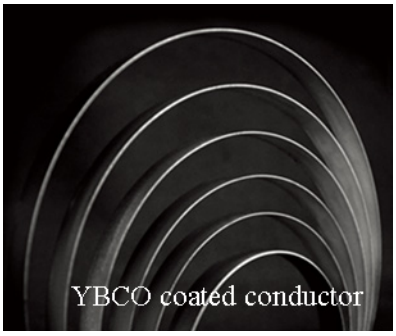
Development of TFA-MOD YBCO Superconducting Coated Conductor

The $YBa_2Cu_3O_y$ (YBCO) high-Tc superconducting coated conductors are well known as one of the candidates of superconducting conductors for practical use. SWCC Showa Cable Systems developed low-cost YBCO coated conductors which are consisted of several layers (see Figure). YBCO coated conductors are fabricated using the metal-organic deposition (MOD) process including trifluoroacetates (TFA) collaborating with SRL-ISTEC since 1999. In 2008, we successfully developed 500 m-class YBCO coated conductors which had the critical current (I_c) values of 310 A/cm-width at 77 K in self field. Moreover, in Materials & Power Applications of Coated Conductors Project, we successfully developed a way for introducing artificial pinning centers (APC) to control the degradation of superconducting properties in magnetic fields. The way was substitutions of Gd for a part of Y elements and introduction of nano-particle $BaZrO_3$, which was a compound of Ba, O and Zr added in the raw material, in the superconducting layer. We successfully fabricated 100m-class YBCO with APC coated conductors which had I_c values of over 50 A/cm-width at 77 K in 3 T. We will improve performance of YBCO coated conductors and develop products of superconducting applications, from now on.

This work was supported by the New Energy and Industrial Technology Development Organization (NEDO).



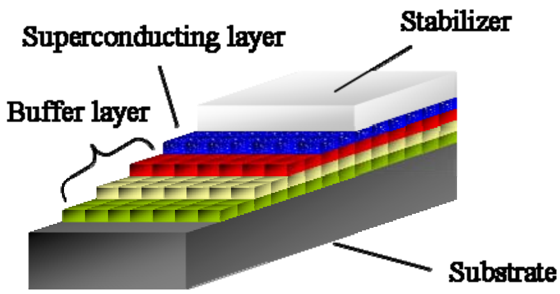


Figure Architecture of the YBCO superconducting coated conductor

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MISCELLANEOUS

Photos on Front Cover, Frontispieces and Rear Cover

Front Cover

+/- 250kV DC-XLPE Cable for Hokkaido-Honshu HVDC Link

Electric Power Development Co. Ltd., and J-Power Systems Corporation cooperatively developed the world's first extruded cross-linked polyethylene (XLPE) insulated cable for use in HVDC transmission power lines where voltage polarity reversal is expected. In the summer of 2012, the two companies added it to the existing Hokkaido-Honshu DC link owned by the Electric Power Development Co. Ltd., to increase the reliability of this important power link. The cable line came into operation in December 2012.

Two of the photos on the front cover show the installation of submarine cable and the upper left photo illustrates +/-250 kV DC-XLPE submarine cable construction for the Hokkaido-Honshu HVDC link. The cable incorporates optical fiber and is armored with double layers of steel wire. Its unit weight is approximately 48 kg/m in air and approximately 33 kg/m in seawater.

When the operation started in December 2012, the operating voltage (+/-250 kV) of the Hokkaido-Honshu HVDC link was the highest in the world for transmission lines using extruded XLPE insulated cables.

The details of the DC-XLPE cable technology will be reported in the IEEJ Transactions on Power and Energy Vol.134 No.1, to be published in January 2014.

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Frontispiece i

In-Grid Demonstration of High Tc Superconducting Cable in Yokohama, Japan

Japan's first High Tc Superconducting (HTS) cable demonstration project supported by New Energy and Industrial Technology Development Organization is in progress. The target of this project is to operate a 66 kV, 200 MVA HTS cable system for 1 year or more in the real grid to prove system reliability and achieve system control and maintenance methods. The Project is conducted by Tokyo Electric Power Company (TEPCO), Sumitomo Electric Industries, Ltd. (SEI) and Mayekawa mgf. Co. Ltd.

The cable has a structure of three cable cores housed in a cryostat. The cable core consists of Superconducting conductors, a dielectric layers, shielding layers and protection layers. The Superconducting conductor and Superconducting shield are used with HTS wires called as BSCCO wires. Electrical insulation is made of PPLP ^{R} (Polypropylene Laminated Paper). In HTS shield, the shielding current is induced to cancel the magnetic field generated in the HTS conductor. Vacuumed multi-layer insulation system between the inner and outer corrugated pipes is adopted for the cryostat to decrease heat invasion from the ambience.

HTS cable system was installed at Asahi Substation in TEPCO's grid, located in Yokohama city. The system has a 240 m HTS cable, a joint, two terminations and a cooling system. One of the terminations is connected to the 66 kV end of a 154 kV/66 kV transformer and the other is connected to a 66 kV bus lines. Liquid Nitrogen is circulated between HTS cable and the cooling system to maintain the cable at around - 200 degree Celsius.

After laying the cable and assembling the joint and terminations, several tests were conducted successfully and then the cable was energized in last October, 2012. It has been transmitting electricity to the customer without any interruption or troubles, so far. On the project schedule, it will be operated up to early next year.

The photographs show the HTS cable in the duct, cable structure model, joint, terminations and cooling system.

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Frontispiece ii

High-power Testing Facility with State-of-the-art Equipment

A major upgrade to the high-power test equipment at Hitachi's high voltage & high power testing laboratory was undertaken in FY 2011, and the facility has been using its new state-of-the-art equipment to perform breaking and other high-power tests since May 2012. In particular, the all-weather voltage source has been upgraded in order to conduct synthetic breaking tests of high-voltage circuit breakers. The equipment includes a main capacitor bank with a rated voltage of 1,200 kV and total capacitance of 8.3 μF, and a capacitor bank for adjusting the transient recovery voltage with a rated voltage of 1,650 kV and total capacitance of 1.64 μF. These are used for testing of circuit breakers and switchgears from medium-voltage to ultra-high-voltage class transmission systems. In addition to utilizing the latest technologies for high reliability in the design and manufacture of each unit to ensure that if suited its intended purpose, Hitachi also took note of the relevant standards such as JEAG5003 and IEEE 693 for seismic capacity to ensure that the equipment would be capable of withstanding a 0.5-G resonant vibration in the event of an earthquake.

The testing laboratory is certified under the ISO/IEC 17025 standard. It is also a member of the Japan Short-Circuit Testing Committee (JSTC), which in turn is a full member of the Short-Circuit Testing Liaison (STL). This means the facility can provide its customers with an independent and objective testing service for certifying compliance with circuit breaker and other related standards set by standards bodies such as the International Electrotechnical Commission (IEC). The facility is also able to issue certificates for type tests.

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Frontispiece iii

500kV Gas Insulated Bushings with Downsized Porcelain Hollow Core Insulators

The picture shows 500kV Gas insulated bushings with downsized porcelain hollow core insulators for heavy contamination area located in Shin-Haruna substation of TEPCO, which installed by Toshiba corporation. These have been started in service since 2005.

Gas insulated bushings with downsized porcelain hollow core insulators established high seismic performance compared with ordinary bushing. That is to say, for the development of this type of bushing, the improvement of electric field analysis engineering, super high leakage type shed developed for 100kV porcelain hollow core insulator, and high strength porcelain material were adopted. As a result, the design of gas bushings with downsized porcelain hollow core insulators achieved the improvement of seismic characteristics by light weight and high strength porcelain body. The development of this bushing had been completed in 2002. Since then, several power utilities in Japan had started to use them.

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Improvement of seismic performance on 500kV Gas insulated bushing with downsized porcelain hollow core insulator

Contamination area	Item	(1) Ordinary hollow core insulator	(2) Downsized porcelain hollow core insulator	Improvement ratio of seismic performance (2)/(1)
L (Low)	Height (m)	5.4	5.2	1.22
	Weight (kg)	2,200	1,580	
	Safety factor in seismic performance	2.89	3.54	
M (Medium)	Height (m)	6.7	5.2	1.71
	Weight (kg)	2,650	1,780	
	Safety factor in seismic performance	1.99	3.40	

H (Heavy)	Height (m)	8	6.2	1.64
	Weight (kg)	3,200	2,180	
	Safety factor in seismic performance	1.43	2.34	

Note: Numbers in table of height and weight show those of hollow core insulator.
Safety factor in seismic performance were performed in accordance with JEAG5003 (Three cycle sine wave with resonant frequency).

Rear Cover

Quantum Chemical Calculation Studies on Space Charge Trapping Sites for Polyimide/Kapton

(a) Chemical structural formula of Kapton.
(b) The energy band of Kapton which is distributed along the formula chain, such as part A and part B.
(c) Orbital electron density at HOMO level and one of LUMO level, respectively, which are drawn on the chemical structural formula.
(d) 3D potential mapping (upper) for the negatively charge which is trapped at the trapping site of LUMO level of part A. 3D potential mapping (lower) for the positively charge which is trapped at the trapping site of HOMO level of part B..

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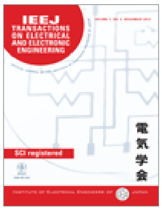
Journals of IEEJ

A Journal which is edited by the headquarters of the Institute and five transactions which are edited by five technical societies* A to E are monthly published.



Another transaction "IEEJ Transactions on Electrical and Electronic Engineering (TEEE)" is edited in English by the five technical societies and published bimonthly by John Wiley & Sons.

An English journal "IEEJ Journal of Industry Applications" was launched in July 2012. It is edited by the society D and published bimonthly. .

Papers in all kinds of journals published by IEEJ can be browsed at **http://www2.iee.or.jp/ver2/honbu/90-eng/14-magazine/index020.html**

You will be able to directly purchase the full text documents by PDF through the Pay-Per-View System.

Two journals "Electrical Engineering in Japan" and "Electronics and Communications in Japan" are translation of the IEEJ Transactions A, B, C, D and E from Japanese into English both edited and published by John Wiley & Sons (not all articles).


Right: Electronics and Communications in Japan
http://www3.interscience.wiley.com/journal/121413813/

Left: Electrical Engineering in Japan
http://www3.interscience.wiley.com/journal/35377/

(*) Five technical societies in IEEJ are as follows:

A: Fundamentals and Materials Society (This magazine is published from EINA Committee under this society.)
B: Power and Energy Society
C: Electronics, Information and Systems Society
D: Industry Applications Society
E: Sensors and Micromachines Society
(please visit **http://www.iee.or.jp/index-eng.html**)

IEEJ Technical Reports

Technical reports listed below were prepared by investigation committees in technical societies A to E in IEEJ and published from the end of September in 2012 to October in 2013. Their extended summaries can be browsed in English on the web site below but the texts of technical reports are described in Japanese.

No.	Title	Issue date
1262	Agent-Based Simulation and Real Data Analysis	2012/10/5
1263	Fuel Cells in Energy Networks	2012/10/5
1264	Recent trends in the GIS standards with other related standards	2012/10/10
1265	Feasibility of MDOF New-Generation Actuators	2012/10/25
1266	Reduction of environmental impact in water and sewage works -trends and future-	2012/10/25
1267	The data acquisition and distribution scheme of power system operation	2012/11/30
1268	Technologies for Automotive Electric Power Management	2012/11/1
1269	Recent technology Trend of Transmission Power Cables in Overseas	2012/12/10
1270	Wind Turbine Grounding Systems for Lightning Protection	2012/12/10
1271	Recent Trend of Material for Transformers and its Application Technologies	2012/12/20
1272	Application technologies of arc and glow discharges	2012/12/25
1273	Fundamentals and Applications of Recent Machine Learning	2013/1/25
1274	Recent Technology of Power Magnetic Devices	2013/1/25
1275	Control Techniques for Applications of Nanoscale Servo	2013/2/20
1276	Present and Future Communication Technology for Protection Relaying	2013/2/5
1277	Technology Trend and Issue of Rust Measure for Steel-materials Distribution Facilities	2013/3/5
1278	Technical trend of vacuum circuit breaker and vacuum switchgear	2013/3/25
1279	Recent progress in motion control for human support	2013/5/20
1280	The development to an engineering field from various technique fields of BACS	2013/5/20
1281	Latest Trends of Technologies and Applications of Permanent Magnet Synchronous Machines	2013/5/20
1282	Electrical insulation of dielectric liquids and applications of EHD, ER.MR	2013/5/30
1283	Application technology of smart grid for electricity customer	2013/5/30
1284	Application of MHD Technology	2013/6/25
1285	Advanced Operation of the Road Facilities	2013/6/25
1286	Report of technology study on improvement of reliability of the water and sewerage facilities	2013/7/10
1287	Optimization Benchmark Problems for Industrial Applications	2013/7/25
1288	State of the practical use of the superconducting technology using a magnetic force control technology and new developments	2013/7/30
1289	Basic and Applications for High Performance Magnetic Sensor	2013/8/20
1290	Superconducting Electric Power Apparatus and Systems toward their High Performance and Multifunctions	2013/9/20
1291	The Interaction of Power Systems and Converters	2013/8/30
1292	Recent Technology of Power Converter system for Utility Power Line Interface	2013/9/30
1293	Microstructures, compositions and physical properties of modern superconducting materials	2013/10/10

Abstracts of the technical reports can be browsed on the web site:

http://www.iee.or.jp/index-eng.html —> “Publications”
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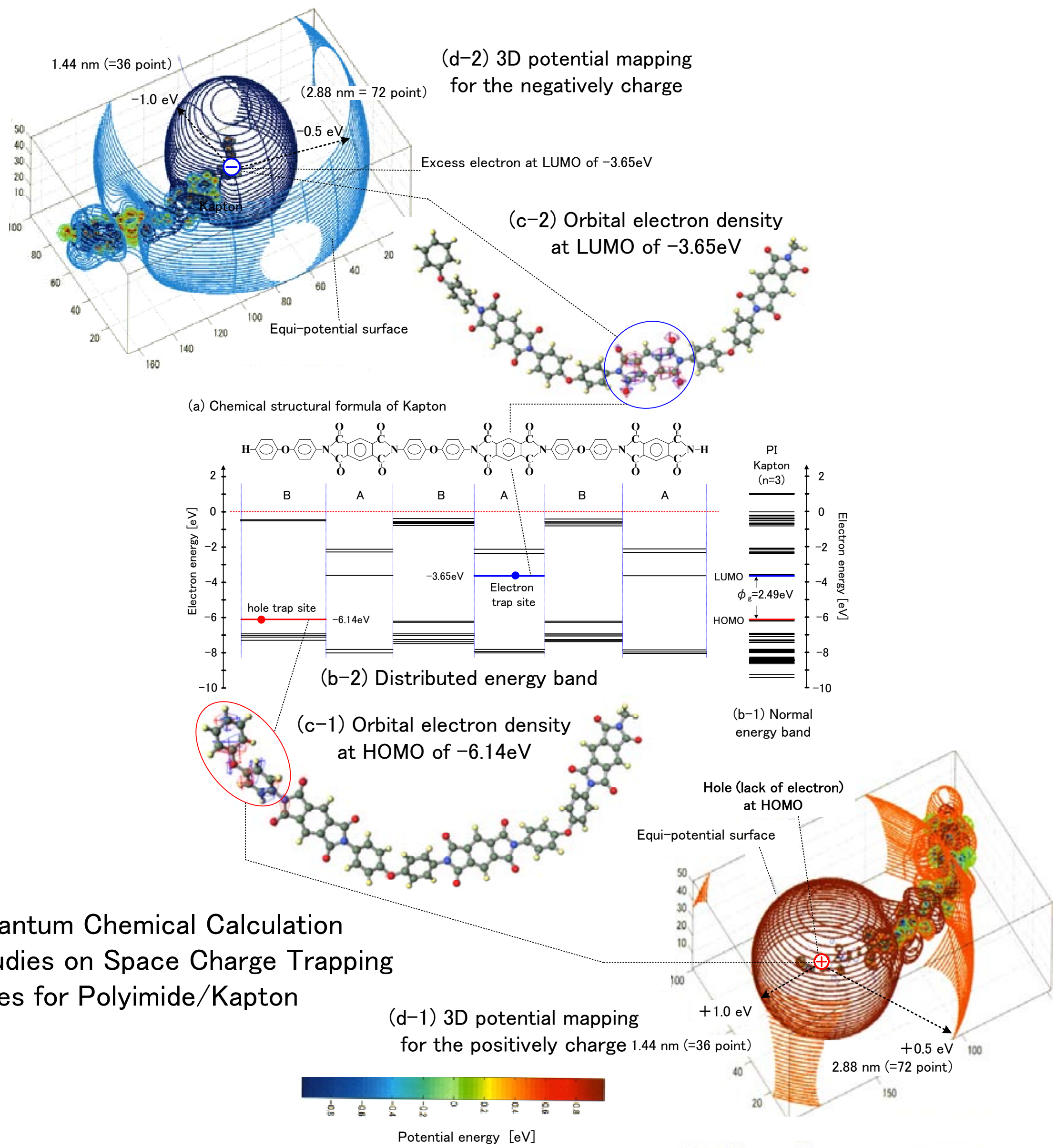

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