I. Introduction

Laboratory of Advanced Technology of Electrical Engineering & Energy (LATEEE) is part of the Shenzhen Branch of National Key Laboratory for Power System, and it is also supported by the High Voltage Outdoor Insulation Laboratory, Electrical Engineering department, Tsinghua University. The Laboratory is located in Building L, Graduate School at Shenzhen, Tsinghua University. With an area of 320 square meters of laboratory, 150 square meters of offices and a total investment in equipment of 2 million RMB, the Laboratory of Advanced Technology of Electrical Engineering & Energy ranks at the top level among universities worldwide, ensuring an academic and educational prestige in China.

II. Research Directions

2.1 Traditional high voltage technology

(1) Investigation on outdoor insulation at high altitudes

Investigation on the flashover characteristics of porcelain insulator, glass insulators, suspension composite insulator and composite post insulator was carried out in natural high altitude areas (1970 m) by LATEEE. The DC generator provided ±250 kV with fluctuating output voltage changes of less than 1%. The fog chamber was 10 m * 10 m * 10 m. The test used the solid layer method with the 50% flashover voltages (U50%) determined by the Up-and-Down Method. The arcing behavior on natural polluted insulator surfaces was studied using a PCI-2000 S high-speed camera at a speed of 250 fps. Test results can be used as a reference for ±800 kV UHVDC transmission project at high altitudes.

(2) Technology of corona cage, corona characteristics and electrical-magnetic environment of overhead transmission line.

Corona cage is used to study the corona characteristics and electrical-magnetic environment of the VHV or UHV overhead transmission line, such as radio interference, audible noise and corona loss. The corona cage consists of a single test conductor or conductor bundle placed concentrically inside a metallic cylinder with a much larger radius. Figure 2 presents the structure of the small corona cage used in our laboratory, and figure 3 is its general view. The total length of this cage is 4m and the cross section varies from 1.6*1.6m to 2*2m.
(3) **Research on dynamic characteristics of the conductors and mechanical characteristics of composite insulators in overhead transmission line**

The advanced 4DOF (degree of freedom) uniform model for overhead transmission line, with the analysis capabilities of multi-span, split-phase conductor and insulator strings, is built for the dynamic problem of the lines, such as wind vibration, ice shedding, galloping and so on, which is crucial in determining the alignment of the conductors, the type of towers and the configurations of spans. The laboratory leads the way in the fields of the structural optimization of V-type and the configuration optimization of interphase spacers, based on the large deflection theory of composite insulators. Our research is widely applied in 220kV, 500kV, 750kV and 1000kV power transmission lines.

(4) **Research on discharge along contaminated surface and Technique of Room Temperature Vulcanized (RTV) silicone rubber**

Room Temperature Vulcanized (RTV) silicone rubber is a good insulation material and is widely used to improve contamination performance. The laboratory has been researching RTV silicone rubber since 1986, and its production technique has been adopted by several companies. Discharge along contaminated hydrophobic and hydrophilic surface has been experimented. The laboratory is currently working on semi-conducting RTV silicone rubber to solve the problems caused by ice build-up on insulators and power lines.

(5) **Diagnosis and evaluation of outdoor insulation status of power transmission system**

This research investigates the method to evaluate the external insulation state of power system, and then predict the possible pollution flashover accidents. The evaluation is based on the online monitored leakage current and the environmental condition in the field. In addition, the group also is developing the online leakage current monitoring system and the external insulation evaluation system.

(6) **Corona Discharge Remote Monitoring Technology on Outdoor Insulation**

Monitoring Technology bases on a device consists of a well designed optical receiver and locator, a PMT (Photo Multiplier), a preamplifier and additional signal conditioning circuit, which locates, captures and amplifies tiny invisible light signals of corona discharge on the surface of objects from a certain distance. An oscilloscope or a computer mounted with a data acquisition card can be connected to the output.
of the device to view or record waveforms, which will be applied with additional analysis to extract useful information for further research.

2.2 High voltage novel technology

(1) Research on atmospheric pressure glow discharge technique

Owing to their suitability for industrial process, especially the possibility of usage for on-line treatment, One Atmosphere Pressure Glow Discharge Plasma (OAUGDP) treatments are widely used for industrial purposes such as modifying the wettability or the adhesion of polymers.

![Fig.7 OAUGDP in a 1mm air gap at 11.93kHz 1762.5V](image)

The method of OAUGDP has been researched: OAUGDP is obtained when the dielectric barrier-controlled discharge is turned on following a slow increase in the densities of ions and electrons in all of the gas due to the occurrence of a lot of small avalanches under a low field. Fig8 shows an OAUGDP in a 1mm air gap at 11.93 kHz 1762.5V

(2) Research on non-biodegradable waste water treatment by discharge plasma

Water treatment by the direct electrical discharge in aqueous solutions is an innovative advanced oxidation technology. Non-thermal plasma is produced during the discharge processes where a large amount of high energy electrons and active species (such as active radicals and molecules etc) are generated. These active species directly react with organic molecules dissolved in water and either oxidize them or even get them completely mineralized. UV-visible spectrophotometer is used to analyze the treated water. This technology has advantages such as high removal efficiency, non-selective, no secondary pollution, etc., and exhibits promising application potential.

(3) Pulsed electric field (PEF) processing of liquid food

Pulsed electric field (PEF) processing is a non-thermal method of food preservation that uses short bursts of electricity for microbial inactivation and causes minimal or no detrimental effect on food quality attributes. PEF can be used for processing liquid and semi-liquid food products. This technology offers high quality fresh-like liquid foods with excellent flavor, nutritional value, and shelf-life. PEF is considered to be the most potential non-thermal processing technique to replace conventional thermal-processing. Fig 8 shows the S. Cerevisiae before treated (left) and treated (right).

![Fig.8 The S. Cerevisiae before treated (left) and treated (right)](image)

(4) Research on electro-spinning technology

Electro-spinning is a simple and straightforward process by which continuous polymer fibers, with diameter ranging from a few nanometers to microns, can be produced. In the present contribution, ultrafine fibers were spun from polyethylene oxide (PEO)/water solution using a homemade electro-spinning set-up. The effects of the spinning voltage in DC, the collection distance and the electro conductivity on the formation of the as-spun PEO fibers have been investigated. Poly vinylidene fluoride (PVDF)/Dimethyl Formamide (DMF) and PVDF/PEO/DMF solution to produce a hydrophobic surface were also used. The electro-spun products obtained a better hydrophobicity than ordinary casting films.

![Fig.9 Experiment circuit of electro-spinning](image)

(5) Treatment of Vehicle exhaust gas with high-voltage pulse discharge

High-voltage pulse discharge is considered to be an efficient approach to dispose exhaust gas both at home and abroad. The instrument will be utilized to study the treatment of vehicle exhaust gas. Results are available to control and reduce air pollution in big cities.
(6) Research of effects of pulsed magnetic fields on osteoporosis

In this research, a therapy system has been developed for osteoporosis, which is a systemic skeletal disease characterized by low bone mass and micro-architectural deterioration of bone tissue, with a subsequent increase in bone fragility and a susceptibility to fracture. Fig 11 shows the interface of this system.

III Papers and achievements

With advanced instruments, facilities, test-bed, power resource and the support of more than 10 million yuan research funds, LATEEE has completed more than 50 enterprise-funded horizontal subjects and government-funded longitudinal subjects. Focusing on the international frontier technology and its application, and the key problems in national economy, the laboratory has taken several projects from National Natural Science Foundation and projects at provincial or ministerial level, such as outdoor insulation performance and insulator selection for 750KV transmission line in high altitude areas, research on key technology of 110KV transmission line in high altitude areas along Qinghai-Tibet railway, design and feasibility research of southern power grid ultra high voltage test base, ±800kV outdoor insulation of contaminated insulators of high altitude areas in Yunnan and Gui zhou province.

In the last four years, 5 invention patents have been claimed, and more than 100 papers have been published, including 11 papers in SCI, 7 in ISTP, and more than 30 in EI. The laboratory aims to become the South China centre and base of high voltage research, academic communion, and novel technology application. With the support of Shenzhen government and Tsinghua University, it will continue its contribution to electrical power development in China.

To contact us

Laboratory of Advanced Technology of Electrical Engineering & Energy, Shenzhen Graduate School, Tsinghua University Shenzhen 518055, China
Tel & fax: +8626036055
Website: eea.sz.tsinghua.edu.cn
Activities of High Voltage Research Laboratory at Democritus University of Thrace – Xanthi, Greece

Michael G. Danikas
Democritus University of Thrace, Department of Electrical and Computer Engineering, Power Systems Laboratory, 67100 Xanthi, Greece
email: mdanikas@ee.duth.gr

The High Voltage Laboratory of Democritus University of Thrace, Xanthi, Greece, is part of the Power Systems Laboratory. Its activities started in 1993. Since then it has grown to the current state of research activities.

The following facilities are available in the High Voltage Laboratory:

(i) Test Cell for Air/Gas Breakdown

The laboratory is equipped with a test cell for discharges research with air and gases both at low and high pressures. The test cell containing the electrodes is more than 2 cm thick so that the test cell can withstand extremes of pressures (either very high or very low). Special windows have been constructed in the test cell, so that the activity, taking place in the electrode gap, can be observed with special optical means.

(ii) Test Arrangement for the Study of the Behaviour of Water Droplets Under Electric Fields

A uniform electrode arrangement together with the appropriate power supply is available for the study of water droplets on polymeric surfaces under the influence of electric fields. The whole arrangement was constructed so that it contains the uniform electrodes, the polymeric material and the water droplets on it. Various conductivities of water, surface roughness of the polymeric surfaces, droplet volume as well as the positioning of droplets w.r.t. the electrodes and their effect on the flashover voltage was investigated in numerous experiments. Both horizontal and inclined electrode arrangements were used. The angle used for the inclined arrangement is similar to those of real insulators.
The most remarkable conclusion from all the experiments, apart from the strong influence of the aforementioned parameters on the flashover voltage, was that the positioning of the water droplets w.r.t. the electrodes plays sometimes a more dominant role than the droplet volume. The effect of the positioning of water droplets on the flashover voltage is evident for both horizontal and inclined electrode arrangements.

(iii) Electrode Arrangement for the Study of Discharges in Air
A point-plane electrode arrangement is used to study discharge behaviour in air at or even below the so-called inception voltage. The whole approach is based on the work performed by Bruning and co-workers (of Lectromechanical Design Co.), who indicated that the damage caused in a solid dielectric material above inception voltage is qualitatively similar to the damage caused at voltages below inception. In our laboratory, this idea is followed by having a constant voltage applied to the point-plane gap, finding the inception value, and then increasing the gap up to the point of only intermittent discharges. What we find is that there are sporadic discharges even below the so-called inception voltage, something which implies that there are similar phenomena appearing in solid dielectrics and in air. The whole approach of the very small discharges, an idea elaborated for a number of years by Prof. Toshikatsu Tanaka of Waseda University and other researchers, and their role in insulation deterioration, is a subject worth of further research. It goes without say that the industrial importance of such studies is not to be neglected, since the influence of very small partial discharges might be taken into account also in formulating ageing insulation models.

(iv) Dielectric Strength of Transformer Oil Samples (Project in Cooperation with the Public Electricity Corporation (PPC))
Since 1994 there is a cooperation with the Public Electricity Corporation (PPC) of Greece regarding the study of samples taken from distribution transformers of 15-20 kV. The purpose of this work is to measure the dielectric strength of the samples with a Foster Test Cell and then try to correlate it with the previous history of the transformers (lightning overvoltages, switching overvoltages, etc.). Transformer oil samples were taken from distribution transformers from a large area of Northern Greece.

(v) Test Cell and Filtration System of Transformer Oil
A plexiglass test cell was constructed with its filter system in order to study the influence of the filter particles and filtering cycles on the transformer oil dielectric strength. The filter system does not allow particles larger than 5 µm to go through it. The purpose of this project is to study the influence of filters of various sizes on the dielectric strength of transformer oil. The increasing number of filtering cycles was found to have a positive influence on the dielectric strength of transformer oil.
(vi) Simulation of Electrical Treeing Propagation in Solid Dielectrics

Electrical tree simulation is studied with the aid of MATLAB and TOOLBOX programmes. Particular importance was paid in the simulations on the local variation – even slight – of the dielectric constant. This idea was refined and was introduced as dielectric inhomogeneity factor in subsequent work. This was a contribution of our research group in comparison to other previous simulations performed by other researchers. Various aspects of tree simulation were studied, e.g., the simple case of point-plane electrode arrangement, and the case where enclosed cavities and/or particles (insulating and/or conducting) exist in the insulating material. Moreover, tests carried out with plexiglass samples of various thicknesses showed that the observed trees were similar in shape with those obtained from simulation. The idea of the aforementioned inhomogeneity factor is used now in order to study electrical tree simulations in composite insulating systems, such as machine insulation.

(vii) Devices of the High Voltage Laboratory

Our laboratory has a Tettex PD detector, oscilloscopes to register waveforms of various frequencies (up to 100 MHz), a sphere gap, power supplies for d.c. voltages, microscope facilities to observe damaged areas of insulating materials and small house models for student demonstrations of the protection against lightning.

(viii) International Cooperation

Our laboratory has a cooperation with Helsinki University of Technology (HUT), Helsinki, Finland, on neural networks and partial discharges. This cooperation came about after my intellectually stimulating staying at HUT during the summer of 2002 as invited professor. Since 2000 there was an interesting exchange of ideas with Prof. R. Sarathi of the Indian Institute of Technology (IIT) Madras, India, on the subject of electrical tree simulation. This cooperation materialized in publishing common research papers on other subjects as well. A further cooperation takes place with the National Technical University of Athens (NTUA), Athens, Greece, with Associate Professor F. Topalis on subjects such as barrier effect and neural networks in GIS. Needless to say that the cooperation with Dr. A. M. Bruning and his co-workers (of Lectro-mechanical Design Co., Virginia, USA) on the very small partial discharges and their effects on polymeric materials continues.

Conclusions

As a head of the High Voltage Laboratory of Democritus University of Thrace, I am pleased to say that we made certain advancements in various fields of high voltage research. Research also means interaction with other scientists from other institutions and, possibly, from other countries. That is why I invite professors from all over the world to visit our facilities and to enhance scientific cooperation with us. In today’s antagonistic world, it is only through cooperation and dialogue that science and engineering can flourish for the benefit of all of us.

Acknowledgments

I, as the author of this short report wish to sincerely thank Dr. Yoshiyuki Inoue, of Functional Materials Technology R & D Department, Toshiba Co., Yokohama, Japan, for giving me the opportunity to write about the high voltage research in our laboratory. I also thank Mr. E. Sarkavos for his technical help.
China Corner

Lecture series for graduate students
-------- Insulating materials and their applications

Lecture series for graduate students “Insulating materials and their applications” was held in Xi’an Jiaotong University from August 11 to 19, 2007. The lecture was sponsored by Degree Committee and Education Offices of Shaanxi Province, and Xi’an Jiaotong University, organized by School of Electrical Engineering and State Key Laboratory of Electrical Insulation and Power Equipment, Xi’an Jiaotong University. 15 famous professors and experts (13 persons from outside China) were invited to give their lectures. The topics and lecturers are given in Table 1. About 300 participants from universities and colleges, institutes and companies attended the lecture.

Table 1 the topics and lecturers of lecture series “Insulating materials and their applications”

<table>
<thead>
<tr>
<th>Topics</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part I: Theory of dielectric materials under high electric field</td>
<td></td>
</tr>
</tbody>
</table>
| Electrical conduction under high filed in dielectric materials | Prof. Teruyoshi Mizutani  
Aichi Inst. Tech. & Nagoya University, Japan |
| Electrical aging and breakdown in insulating materials | Prof. L. A. Dissado  
University of Leicester, UK |
| Space charge and electroluminescence in insulating polymers | Prof. Christian Laurent  
National Center for Scientific Research and Toulouse University |
| Computer simulation in the theory studies on electrical aging and breakdown | Prof. Kai Wu  
Xi’an Jiaotong University, China |
| Part II: Insulation aging and fault diagnosis in power equipment | |
| The aging and tests of composite insulators | Prof. Xidong Li  
Qinghua University, China |
| Insulation breakdown and diagnosis in power transformers | Dr. Tsuneharu Teranishi  
Toshiba Corporation, Japan |
| Breakdown and degradation of ZnO varistor blocks | Prof. Shengtao Li  
Xi’an Jiaotong University, China |
| Rotating machine insulation: Failure processes and diagnosis | Prof. Greg Stone  
Iris power, Canada |
| Partial discharge diagnosis of high voltage insulation systems | Prof. Gian Carlo Montanari  
University of Bologna, Italy |
| Condition based monitoring and asset management of electrical infrastructures | Prof. Johan J. Smit  
Delft University of Technology, The Netherlands |
| Space charge phenomena, aging and diagnosis in cables | Prof. G. Chen  
University of Southampton, UK |
| Applications of nonlinear analysis in power engineering | Prof. Steven Boggs  
University of Connecticut, USA |
| Part III: New techniques of insulation | |
| Environmental-friendly materials and systems for electric and electronic application | Prof. Yasuo Suzuoki  
Nagoya University, Japan |
| Interfacial phenomena and nanocomposites | Prof. J. K. Nelson  
Rensselaer Polytechnic Institute, USA |
| Superconducting power applications and their cryogenic electrical insulation techniques | Prof. Hitoshi Okubo  
Nagoya University, Japan |

by Prof. Shengtao Li
Xi’an Jiaotong University, China
Workshop on Dielectric Materials and Electrical Insulation for Power Equipment

This workshop was sponsored by State Key Laboratory of Electrical Insulation and Power Equipment, Xi’an Jiaotong University, and Engineering Dielectrics Committee of China Electro-technical Society. The workshop was held in Xi’an Jiaotong University in August 12 and 17, 2007, respectively. Prof. S. A. Boggs, Prof. T. Mizutani, Prof. L. A. Dissado, Prof. G. Chen, Prof. J. K. Nelson, Prof. C. Laurent, Prof. Y. Suzuoki were invited to attend the workshop. The topics and speakers are given in Table 2. About 50 participants from universities and colleges, institutes and companies attended the workshop.

Table 2 the topics and speakers of the workshop

<table>
<thead>
<tr>
<th>Topics</th>
<th>Speakers</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Session 1</strong></td>
<td></td>
</tr>
</tbody>
</table>
| Reliability problems in UHV power equipment | Prof. Kai Wu  
Xi’an Jiaotong University, China |
| Specific issues related to surface and interface phenomena of insulating materials under high electric field | Prof. G. J. Zhang  
Xi’an Jiaotong University, China |
| High voltage research in Tianjin University | Dr. Y. Gao  
Tianjin University, China |
| Discussion on high voltage vacuum circuit breakers | Dr. Z. Y. Liu  
Xi’an Jiaotong University, China |
| **Session 2** | |
| Some research work on functional dielectrics | Dr. J. Y. Li  
Xi’an Jiaotong University, China |
| Polymer dielectric nanocomposite - development and the problems | Dr. Y. Yin  
Shanghai Jiaotong University, China |
| Preparation and properties of PLS nano-composites | Prof. X. H. Zhang  
Harbin Technology University, China |
| What we do about UHV DC/AC project in China | Dr. P. Liu  
Xi’an Jiaotong University, China |

Fig. 1 the picture of lecture series  
Fig. 2 the picture of the workshop