Activities of High Voltage Research Laboratory at Indian Institute of Technology - Madras

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The High Voltage Laboratory at IIT Madras was established during 1969-70, under the expert advice of Prof. Dieter Kind, University of Braunschweig, Germany with the assistance provided by Federal Republic of Germany. Since then, it has grown to the current state of art research lab to cater to needs of carrying out cutting edge research work, evaluation/testing, and educational activities.

The following facilities are available in the high voltage laboratory.

(i) High Voltage Testing Transformer

The 800 kV, 400 kVA, 50 Hz cascade transformer has two stages, each rated for 400 kV. The measuring system consists of an 800 kV, 100 pF, SF_6 filled standard capacitor and peak/rms reading instrument.

(a) **(b)**

(a) Power Frequency Test Transformer
(b) Lightning Impulse Voltage Generator

(ii) Lightning Impulse Voltage Generator

The 1.5MV, 37.5 kJ lightning impulse voltage generator, manufactured by Messwandler-Bau (MWB) of Germany, has six stages, with a 0.2 µF,250 kV generating capacitor in each stage. A 1.5 MV capacitance divider and a 2 MV fast response compensated RC divider are available for impulse voltage measurement.

(iii) High Voltage Schering Bridge

The Schering Bridge, manufactured by M/S Schering-Rutloh constructions, Germany rated 200 kV, 50 Hz consists of a 100 pF nitrogen filled standard capacitors and screened bridge arms. The measurement ranges are: loss tangent 10^{-5} to 10 and Capacitance -0.1 to 1 µF.

(iv) Partial Discharge Detector

The WSTS make wide band partial discharge detector facilitates measurement in the range of 5 -1000 pC with a maximum voltage level of 100 kV.

(a) **(b)**

(a) Partial Discharge Detector
(b) Baukasten Unit

(v) Pulse Power Unit

Recently, BARC has donated a 780 kV, 80 J high voltage nano second pulse power unit to the high voltage laboratory. This facility is used for research work in the area of food preservation.

A number of high voltage experimental setup kits consisting of components of standard dimensions are available for setting up of laboratory experiments for under-graduate and graduate students and for conducting research work up to 200 kV AC, 250 kV DC and 250 kV impulse voltage.

High voltage laboratory, IIT madras supports nearby power equipments manufacturers in design and testing of their manufactured components.In addition, the sponsored projects were obtained from the government funding agencies.

1. Ministry of Human Resources and Development
2. Department of Science and Technology

3. Department of Bio-technology
4. Department of Armament Research Board

Current research projects of the High Voltage Laboratory faculty include

(a) Study of Tracking Phenomena in Insulating Materials

Tracking is basically a carbonaceous process, which occurs at the surface of the outdoor insulating material during operation. Researchers worldwide are trying to understand the mechanism of tracking and to mitigate this problem in polymeric insulators. Owing to the practical significance of this problem, the collaborative research work has been initiated in our laboratory with the support of *Prof. Noboru Yoshimura, Akita University, Japan*.

Tracking Experimental Setup with a tracking photograph

An important contribution based on the collaborative work is made to classify the surface condition of insulating material during operation using leakage current measurement followed by adopting predictive capability of wavelets and neural networks. Certain physico-chemical diagnostics studies were carried out to understand the characteristic features of polymeric insulators. At present, the research scholars in HV Lab. are working on the project entitled "Tracking phenomena in nanocomposites insulating materials".

(b) Study of Electrical and Water Treeing in XLPE Cables

"Partial Discharges", a pre-breakdown phenomenon accounts for pre-mature failure of underground cables. These pre-breakdown channels formed around the defect site in the dielectric structure resemble branches of a tree and, hence, the name "treeing" is given to the deleterious process and since such an occurrence is purely due to electrical stress, the mechanism is termed as "Electrical Treeing". Another aspect is that the diffusion of water into the cable insulation form treed structure called water trees. Fundamental studies were carried out to understand the dynamics of electrical trees under different voltage profiles and characteristic changes that occur in cables insulation near the treed zone studied through analytical studies.

(a) (b) (c)

(a) Electrical Tree (b) Water Tree
(c) Fractal Model of Electrical Tree

Generating electrical trees is basically a cumbersome process and visualizing the tree pattern requires sophisticated equipments. Hence modelling studies were carried out to understand the growth patterns of electrical trees homo and heterocharges present in the insulation material. Also studies were carried out to obtain relation between the growth rate and shape of the tree pattern generated through fractal studies. The work is under progress to understand the growth rate of electrical trees incepted from the water-treed zone. Modeling of tree structures in nanocomposites is one of the ongoing research activities in the laboratory.

(c) Study of breakdown characteristics of Insulating material at cryo-temperatures

In India, the study of breakdown characteristics of insulating materials at cryo temperatures is at infancy stage. High voltage laboratory at IIT Madras has taken initiative to work in this emerging area. To start with, treeing phenomena under different voltages using AE technique is being studied. Collaborative research work with *Prof. Hitoshi Okubo, Nagoya University, Japan* has been initiated.

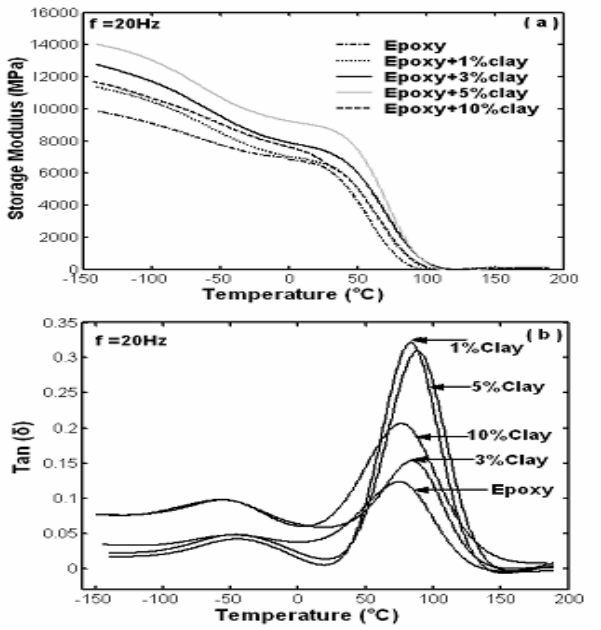
(d) Condition monitoring of GIS using AE technique and UHF Method

Condition Monitoring of Gas insulated systems using AE technique is one of the major areas of research in this laboratory. We have shown that it is possible to mitigate the particle dynamics in GIS by applying composite voltages formed by negative DC and the supply voltage using AE technique. Also, symmetrical dot patterning technique is adopted to classify the incipient discharges from discharges at near point of failure. Identification and classification of partial discharges by adopting UHF sensor technique are being investigated in HV lab.

(e) Nanocomposite material for outdoor insulation

High performance polymer nanocomposites are emerging as a new class of materials for its de-

manding applications as insulating material. Nanocomposites are named when the dispersed phase particle size is less than 100 nm. Reinforcement of polymeric resin with nanoclay platelets as fillers has resulted in light weight materials with increased modules and strength, decreased permeability, less shrinkage, increased heat resistance, decreased flammability and good electrical insulation characteristics. It is planned to understand the characteristic life of nanocomposites material aged under different voltages and to understand the pollution performance of nanocomposites. This work is in progress with the support of *Prof. T. Tanaka, Waseda University, Japan.*



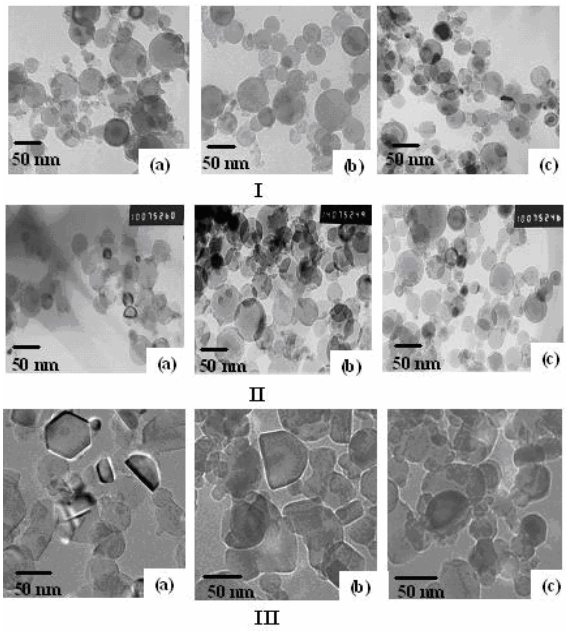
Dynamic Mechanical Analysis of Epoxy Nanocomposite (a) Storage Modulus (b) tan(δ)

(f) Sterilization of Liquid Food using pulse power technique.

Sterilization of liquid foods by pulsed electric field technique is one of the important ongoing research activities in High voltage laboratory, IIT Madras. This work has been initiated with the financial support from Department of Bio-technology, Govt. of India. The aim of the work is to identify the compact cost-effective and reliable pulsed voltage source and to formulate a simple methodology to improve the shelf life of the liquid foods.

(g) Production of Nano Powder by Wire Explosion Process

Generation of nano particle by wire explosion process is one of the major areas of research in this laboratory. The research work is on production of nano aluminium particles for its potential use in rocket propellants.



Typical TEM Structure of the Nano Aluminium Particle Produced in Different Ambience (I) Helium (II) Argon (III) Nitrogen (a) 0.025MPa (b) 0.05MPa (c) 0.1MPa

One of the key findings is that by exploding the wire in binary gas medium, it is possible to produce particle size distribution skewing to the left. The research work is in progress in collaboration with Extreme Energy Density Laboratory, Nagaoka University, Japan initiated by Prof. Kiyoshi Yatsui. Now we are trying to understand the mechanism of nucleation of nano particle at different atmospheres and influence of local temperature variation on nucleation of nano particle.

Research work at other laboratories

Very recently, *Dr. Nilesh J. Vasa* has joined as a faculty member in the Precision Engineering and Instrumentation Laboratory at the Department of Mechanical Engineering. Previously he was at Kyushu University, Fukuoka, Japan where he was working in the areas related to development of tunable solid-state lasers and their applications to gas sensing, nonlinear optical effect combined with electro-optics, diode laser application to electric field, electric current sensing, and Experimental study on lightning attachment manner considering various types of lightning protection measures on wind turbine blades. Currently, at PEIL micro-electro discharge machining of silicon is being studied. He also intends to develop laser based, remote sensing techniques for high voltage industry applications.

Conclusion

As a head of the high voltage laboratory, IIT Madras, I am pleased to share my experience that it is possible to carryout state of the art research work for innovating new ideas and realize its practical applications through collaborative research. It is appropriate to mention here that High voltage Research Laboratory and Precision Engineering and Instrumentation Laboratory at IIT Madras has close association with professors at various universities in Japan. We are earnestly looking forward to enhance the scientific collaboration between IIT Madras and various research laboratories in Japan to work in the emerging research areas of High Voltage Engineering. I personally invite the researchers to pay a visit to our high voltage laboratory, IITM so as to strengthen our scientific collaboration.

Acknowledgement

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