India Corner

High Voltage Engineering Laboratory
College of Engineering, Anna University

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The Division of High Voltage Engineering in the Department of Electrical and Electronics Engineering was established in the year 1960 in the College of Engineering, Guindy(CEG). CEG is one of the oldest engineering and technical institutions in the world ageing more than 200 years, now a constituent college of Anna University, which is one of the India's premier University.

Post Graduate course in High Voltage Engineering is offered since 1964 with an objective to produce high voltage engineers to cater to the needs of the industries in design, manufacturing and testing of power apparatus. The course has been awarded "A" grade by National Board of Accreditation. The curriculum of the M.E. High voltage engineering includes electromagnetic field computation and modeling, transients in power systems, insulation technology, HV generation and measurement, insulation design of HV apparatus, HV testing, EHV transmission, HVDC transmission, HV switchgear in addition to applied mathematics, EMI/EMC, digital signal processing and other interdisciplinary courses as electives. The students are well trained in the High Voltage Laboratory and in the Electromagnetic field computation laboratory to give hands on experience in the field of specialization. Around 25 students are registered for post graduation every year.

The Division is embellished with a library with collection of rare and valuable books, test standards in addition to proceedings and magazines. The Division has been nurtured successfully by the able guidance of highly motivated professors who have an acumen in academics, research and industry collaboration.

INFRASTRUCTURE FACILITIES

High Voltage Laboratory

The High Voltage Laboratory in the Division started with a 1540kV, 19kJ impulse generator (Fig.1) and 450kVA Cascaded transformer and now has been enhanced with the following facilities/equipment.

- A 400kV HVDC/Impulse generator and has been modified to generate impulse voltages from lightning impulse to very fast transients (front time from 0.05μs to 1.5μs and tail time from 6.0μs to 70 μs), oscillatory voltages and non-standard impulses as per CIGRE WG. C4.302 with resistive and capacitive dividers for measurement
- Partial discharge measurement laboratory
- Capacitance and tanδ measurement kit(12kV)
- Energy analyzer Kit
- Sweep frequency response analyzer (0.1Hz – 25MHz)
- Vacuum and high pressure vessel
- Test cells as per International standards to characterize gaseous, liquid and solid dielectrics.
- Digital storage oscilloscopes upto 1GHz, 5S/s.
- High precision impedance analyser (50MHz)

Fig.1 Impulse voltage generator set up

Electromagnetic field computation laboratory

The laboratory has facilities to compute electromagnetic fields using Finite Element Method (Maxwell V-9.0), Electromagnetic Transient Program (EMTP) in addition to circuit simulation packages.

The facilities in the Division are effectively used by both undergraduate (Electrical and Electronics Engineering) and post graduate students as part of their curricula. The Division has an active interaction with other departments in the University and industries. Many of the post graduate students carryout their project works in the industries and R&D centers in India and are mostly absorbed for placement by them. High Voltage Laboratory has been involved in high voltage dielectric tests such as Impulse voltage withstand test, Power frequency voltage withstand test, Partial discharge measurement test etc. as per Indian and International standards and the facilities are effectively utilized by the industries for quality assurance.

RESEARCH ACTIVITIES

The Division is actively involved in research activities in the diversified areas of power engineering and the ongoing research works are:

- High frequency modeling of power apparatus and estimation of transient overvoltage in GIS
- Characterization of insulating materials under non- standard impulses and repeated impulses
- Insulation design of high voltage polymeric insulators
- Fault detection in transformer winding
- Electromagnetic forces in transformers
- High voltage applications in food preservation, agriculture and textile industries.
- Characterization of nano dielectric materials

So far 20 scholars have completed their doctorate degree and 12 research scholars are pursuing their research at present in the Division of High Voltage Engineering.

The High Voltage Laboratory has received funds for research activities from government funding agencies like,

- University Grants Commission (UGC) – Centre for Advanced Studies (CAS)
- Ministry of Human Resource Development All India Council for Technical Education
- Technical Education Quality Improvement Programme (TEQIP)
- Department of Science and Technology – Promotion of University Research and Scientific Excellence (DST-PURSE)

Consultancy works are carried out in the Division for both government and non- government organizations. To name a few, Technology demonstrator for Compact storage devices for armored vehicle for Combat Vehicles Research and Development Establishment (CVRDE), India, Measurement of harmonics on arc furnace in Tamil Nadu grid, Tamilnadu Electricity Board, India, Computation of electric field distribution in polymeric insulators, surge arresters, etc for manufacturing industries.

Characterisation of Impulse strength of transformer insulation

The reliability of a power system depends on the insulation design of the equipment connected in the network. At present the dielectric strength of all equipment are checked by testing only with standard lightning impulse (1.2/50 μs). Even when the transformer is tested with standard waveshape, due to part winding resonance, the winding insulation is stressed with (unidirectional and bidirectional oscillatory) non-standard waves. On the other hand, in practice all the components in a power system are stressed with transient over voltages of wide variety of waveshapes from lightning to very fast transient (VFTO). Hence becomes necessary to estimate the dielectric strength of the insulation under both standard and non-standard impulses using the v-t characteristics.

Impulse strength of transformer insulation under non-standard lightning impulses

While observing the impulse voltage distribution within a transformer winding it can be seen that parts of the windings are excited by unidirectional and bidirectional oscillating voltages. The inter-turn and inter-disc winding failures are attributed to these oscillating voltages.

Attempts are made to study the behavior of air, transformer oil and OIP (Oil-Impregnated Paper) insulation under these voltages. Small gaps in the order of few millimeters, with different electrode geometries are chosen to incorporate the extreme electrical field configurations in practical transformer and experimental v-t characteristics are obtained using statistical procedures. Disruptive Effect method is used to evaluate the insulation strength under unidirectional non-standard impulse voltages. The insulation strength under bidirectional oscillating impulse voltages on these small insulation gaps are estimated using Unconditionally Sequential Approach. The polarity effect on the breakdown due to bidirectional waveshape is duly accounted.

Impulse strength of transformer insulation under impulses of varying front times (from μs to ns)

The behavior of the electrical component under very fast transient over voltages (VFTO) has been a problem of importance with the advent of Gas Insulated Substations. To predict the v-t characteristics of insulation for impulses of varying front times few impulses of different front times from nano seconds to microseconds (40ns to 1.2μs)are generated and their v-t characteristics are obtained for air, oil and OIP under uniform and non-uniform fields (Fig.2). From these v-t characteristics a generalized hyperbolic model is obtained by regression analysis to predict the v-t characteristics for any wavefront and this mathematical model is experimentally validated.

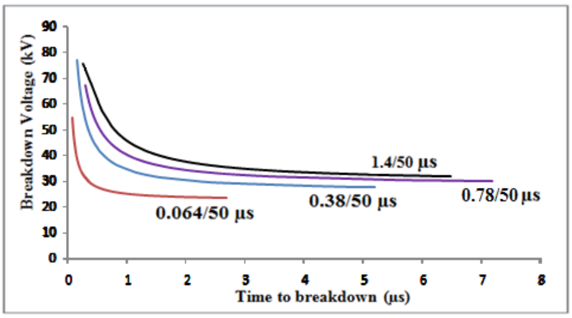

Fig 2. v-t characteristics of OIP for different wavefronts

Impulse strength of transformer insulation under repeated impulses

Apart from overvoltages of different shapes, the repeated switching operation of the disconnectors in a short period of time causes cumulative stresses in internal points of the winding and leads to failure of the transformer winding. The insulation gets deteriorated when it is subjected to repeated applications of impulse voltages even below their BIL rating. The voltage-number of impulses the insulation can withstand (V-N) characteristics will be useful in evaluating the effect of frequent surges on transformer insulation. V-N characteristics of insulation are obtained experimentally for few waveshapes (Fig.3) and modeled using exponential model. The V-N characteristics are also experimentally obtained for the CIGRE Working Group C4.302 represented waves. The effects of the front time and the tail time on the detoriation of insulation are also analyzed using the Degree of Polymerization under repeated impulse.

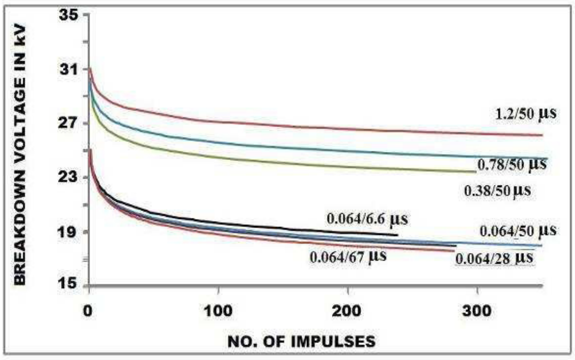

Fig 3. V-N characteristics of OIP for different Impulse waveshapes

Applications of High Voltage Engineering

The use of high voltage engineering has increased in many folds in diversified areas like, in-activation of microbes, food preservation for extended shelf life , production of nano- fibers for textile applications, assisted germination of hard and soft seed coat for increased yield .

Food Preservation

High intensity pulsed electric fields (PEF's) in food applications, such as fruit juices, is gaining popularity as a non-thermal sterilization technology alternative to the conventional method.PEF method involves the application of a high electric field (15–80 kV/cm) across a certain electrode geometry that contains the liquid food. Liquid foods namely, milk and juices of orange, apple, tomato, pine apple and papaya inoculated with gram negative(e.coli) and gram positive (bacillus subtillis) have been treated with high electric fields by varying the process and product parameters. The reduction in the microbes when compared to the control sample (untreated) of orange juice is shown in . Fig 4.

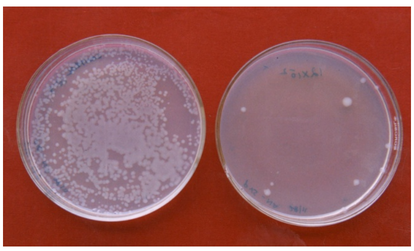

Fig 4. Reduction of E.coli concentration after treating orange juice with high electric fields.

Production of NanoFiber

The electro spinning process has been largely used by industries to produce filters, membranes, optical and electronics applications. Recently it is gaining momentum in production of both conducting and non conducting nanofibers used in textile industries. An attempt has been made to produce ployaniline (conducting) and polyacrylonitrile (non- conducting) nanofibers of various sizes ranging from 50 to 400 nm (Fig.5) by adjusting various electro-spinning parameters along with the Department of Textile Engineering. The electrical and thermal properties of the nano fibers thus produced are analyzed.

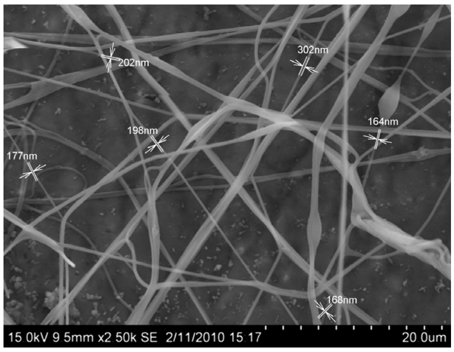

Fig 5. SEM image of Polyaniline conducting nanofiber

Agricultural Application

When the seeds of the paddy are treated with electric fields in the range of 20 kV/cm , improved germination rate and growth rate with increased yield are possible. The paddy seeds are treated with lightning impulses and an increase in germination rate and growth rate are observed when compared with that of untreated seed (Fig.6). Research work is in progress to

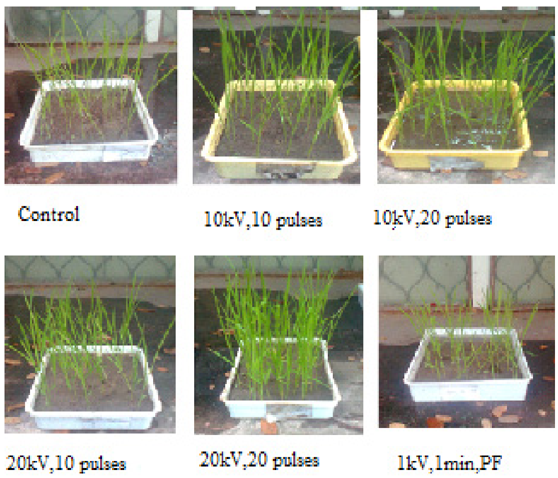

Fig6 Germination rate of Paddy on 17th day

optimize the shape of the impulse, magnitude of the electric field and the number impulses to increase the germination and growth rate.

Investigation on dielectric and thermal properties of nano dielectrics

The dielectric and thermal properties of different dielectric materials with various types of nano fillers (such as Alumina, Zirconia, Titania, and Silica) are analyzed. The nano fillers are added in different wt% with the dielectrics for analysis at different temperatures and frequencies.

The dielectric properties such as breakdown strength and partial discharge levels are measured as per standards. The parallel capacitance, admittance, loss tangent and quality factor of the nanocomposite samples are measured for different temperatures and frequencies using Dielectric Spectroscopy and thermal degradation is investigated using Thermo Gravimetric Analyzer. The appropriate percentage of the nano fillers are suggested for different dielectric materials like polyamide enamel, transformer oil and polyurethane (cable) based on the experimental analyses.

CONCLUSION

The High Voltage Laboratory in College of Engineering, Guindy, has a blend of academics, research and industry collaboration complementing each other. With many number of PG students and research scholars we are able to venture into the diversified areas of high voltage engineering and look forward for collaboration from other research institutes to strengthen our expertise in high voltage engineering.

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