National Institute of Technology Rourkela

Synopsis Seminar

Seminar Title	: Advanced Techniques for Condition Monitoring and Degradation Assessment of Transmission Line Outdoor Insulators
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Venue	: Seminar Hall (Room No.EE-401)
Date and Time	: 23 Jul 2025 (4:30 PM)
Abstract	: Outdoor insulators are essential for high-voltage power transmission systems as they support the conductors while isolating them from the ground and other conductive objects. Their performance and lifespan depend heavily on the insulating materials used, which are influenced by factors such as electric breakdown, dielectric imperfections, electrode materials, surface conditions, applied voltage, and environmental factors like pressure, temperature, humidity, and over-voltages. To tackle these challenges, it&rsquos essential to evaluate insulation materials&rsquo physical and electrical properties. This can be achieved through partial discharge (PD) measurements, hydrophobicity assessments, and advanced condition monitoring using deep learning techniques. Pressure variation significantly impacts PD phenomena in insulation materials. Low pressure reduces the density of the surrounding medium, facilitating ionization and increasing PD activity. Conversely, high pressure induces mechanical stresses that can alter the molecular structure of insulation, making it more prone to cracks and voids that initiate PD. Understanding this relationship is essential for predicting insulation failure and ensuring the reliability of electrical equipment. This study collected statistical features of PD signals from silicone rubber (SiR) insulation under varying electrode arrangements and pressure conditions to train machine learning models using data resampling techniques. Phase-resolved PD (PRPD) images were generated to train a convolutional neural network optimized with a particle swarm optimization algorithm. Additionally, few-shot learning models for PD classification were explored using continuous wavelet transform-based scalogram images to represent PD signals in the time-frequency domain, moving beyond traditional PRPD plots. Environmental factors like temperature, humidity, and over-voltages can damage insulators, making early detection crucial for optimal performance. Traditional inspection methods, such as manual and helicopter-based approaches, are costly and time-consuming. A custom dataset was created to address limitations in public datasets like insufficient data, uneven class distribution, and lack of image diversity. Various image pre-processing techniques and advanced deep learning models were employed to accurately classify, detect, and segment insulator defects. This study also leverages deep learning techniques and IoT-integrated UAV systems for real-time condition monitoring. Polymeric insulators are increasingly replacing porcelain and glass insulators due to their lightweight and hydrophobic properties. However, the loss of hydrophobicity can lead to water channel formation, initiating dry band arcing and flashover. Thus, accurately identifying hydrophobicity classes is essential for assessing surface aging in polymeric insulators. This feature can be analyzed through surface droplet formations, which vary with alcohol concentration in distilled water. The study overcame manual feature extraction challenges with deep learning advancements by automatically learning and extracting features from images, such as texture, shape, and patterns. It proposed a novel approach using a masked autoencoder-based vision transformer to accurately classify the hydrophobic condition of polymeric insulators. Additionally, a web application was developed to streamline the inspection team&rsquos decision-making process.