Measurement and modeling of surface charge accumulation on insulators in HVDC gas insulated line (GIL)

Boya **ZHANG** (1), Qiang **WANG** (1), Guixin **ZHANG** (1)
1 - Tsinghua University, Beijing, China, zhangby13@mails.tsinghua.edu.cn, wqtsinghua@163.com, guixin@mail.tsinghua.edu.cn

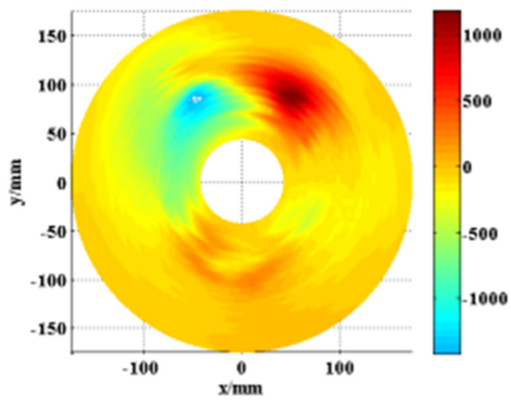
The development of electrical transmission systems all over the world will involve the installation of HVDC systems to bridge the growing geographical distance between energy generation and consumption. Further, the connection of new renewables such as offshore wind farms to the grid has to be done with DC technology as long as AC sea cables are not possible. Alternative to overhead lines, gas insulated line (GIL) is an optimum technology for bulk electric power transmission at high or ultrahigh voltage and can be installed underground or in tunnels with low environmental impact, which makes this technology interesting for the future.

However, DC voltage causes many problems in dielectric stability of the insulating system. Unlike the quasi-static displacement field under AC voltage which is determined by the permittivity of the insulating materials and the given electrode arrangement, the stationary resistive field under DC voltage is dominated by the volume and surface conductivity of the insulating materials. The surface charges will accumulate particularly at the interfaces between different materials and thus influence the dielectric stress of the insulation system significantly. Especially in situations of polarity reversal, the flashover voltage can be reduced considerably in the presence of accumulated charges. The mechanism of surface charge accumulation has not yet been fully understood. Therefore, the surface charge phenomenon on the insulators in GIL has to be revisited for future HVDC applications.

For this purpose, a surface charge measurement system is established using the electrostatic probe method based on a 220kV GIL unit. The surface charge distributions on a cone-type insulator made of Al_2O_3 filled epoxy resin are obtained under different voltage duration, voltage polarity and voltage amplitudes. Some phenomena is studied in this paper and the possible sources of surface charges are discussed.

Meanwhile, a simulation model is used to calculate the surface charge accumulation and stationary field distribution on the gas-solid interface of the insulator in the GIL unit under DC voltage. The model takes into account both the dielectric properties of the insulator material and physical processes in the surrounding gas including the charge carriers' generation, drifting, recombination and diffusion.

With this paper, the authors would like to contribute a better understanding of surface charge accumulation phenomenon and its mechanism in HVDC GIL. The results in this paper may be useful for the design and optimization of HVDC gas insulated system.



Example: Distribution of surface potential on the GIL insulator under negative DC voltage