**Electro-Thermal HVDC Gas-Insulated Line (GIL) Simulations**

1. **Introduction**

The requirement for the electrical energy is increasing day-by-day around the globe, which demands to transport the electrical energy efficiently. The transition to green energy causes a need to transmit the energy over long distances (e.g. Off-shore wind parks in the North Sea to industry in the south of Germany). Energy can be transmitted through High Voltage Direct Current (HVDC) and High Voltage Alternative Current (HVAC). During the transmission of the electrical energy if there is any additional losses (inductive loss, capacitive loss, radiation loss, skin-effect) with the ohmic-losses, it leads to high reactive power losses, which could be seen in HVAC transmission of the energy. Hence, transmission of energy was under gone by HVDC. For transmitting such high-voltage current, a system should be cost efficient, safer, reliable, etc., which could be seen in a transmission system, Gas Insulated Transmission Line (GIL). GIL is a compact system to transmit the electrical energy with high power ratings or high-voltage, which is an alternative for the overhead transmission lines. Different field control techniques (FCT) with the combination of conductivity model or/and permittivity model (σ/ε) for HVDC GIL, is estimated in the following work.

1. **GIL**

GIL has a metallic enclosure, where the angular space in the enclosure is covered with the insulating gas, insulating gas can be of SF6 (Sulfur hexafluoride) or mixture of SF6 and Nitrogen. The support insulator or spacer or disk (insulating material) holds the high-voltage conductor in the central position. In the present work, HV conductor:- Copper, Insulating gas:- SF6, Spacer:- Epoxy resin, 313.15K, 320kV, Temperature gradient (Δ*T*):- 20K, with the dimensions of GIL to be as shown in fig-2.

The presence of SF6 gas holds the biggest benefit of the GIL, as SF6 has high di-electric constant compared to air besides advantages like reliability, low electric loss, non-toxic, non-flammable etc., When high-voltage is given to the insulating materials (SF6, spacer), there is an electric filed stress produced. In GIL, electric filed stress can be seen at triple points, i.e., between gas, spacer and conductor/enclosure. The electric field stress at the triple points should be reduced by applying FCT or else it can lead to system failure or partial discharge.

x

**HV**

**320kV**

**313.15K**

**GND**

**0V**

**293.15K**

**SF6**

**Spacer**

z

**0.05m**

**0.3m**

**0.1m**

**1m**

**0.1m**

**0.6m**

**SF6**

**0.45m**

**HV conductor**

**Grounded enclosure**

**Gas**

**Gas**

**Spacer**

Fig-3:- Structure of GIL with triple points

1. **Approach**

Derived from steady state equation for negligible magnetic field with Gauss law with Electric field of electroquasistatic equation can be determined as,

= 0

where, ε = is the permittivity, with dielectric constant to be of = V/m, is the electric conductivity. Depending on the voltage state, the electric conductivity or permittivity is decisive for the electric field. At the DC state (resistive), the electric conductivity is decisive, . Under the DC state, variation of the time slowly in electroquasistatic field resulted in accumulation of charge within the insulating materials (SF6 gas and spacer), which adds up on an additional electric field, i.e., transient capacitive electric field (equivalent to field under AC condition), to the externally applied electric field by the conductor, leads to permittivity being decisive . These DC conditions are simulated in COMSOL Multiphysics software in stationary field and in transient field and there effects are observed.

1. **Stationary Simulations**