Characterization and modelling of interface between Epoxy Resin materials and different gases for HVDC GIS cable termination development

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ABSTRACT

GIS cable terminations present a complexity of geometry and material assembly that makes their design challenging. The interfaces between materials, and more specifically at the GIS side – that is between the epoxy composite and the gas – are investigated for HVDC application. This study shows dielectric measurements on which modelling of the interface are based and raises the question of gas replacement in such terminations.

KEYWORDS

HVDC GIS termination; alternative gas; epoxy composite; DC conductivity.

INTRODUCTION

HVDC land and submarine cables are fundamental for long distance power transmission and integration of renewable energy. Their interconnection with HVDC Gas Insulated Switchgear (GIS) should be ensured through cable GIS terminations. Those accessories have a certain complexity as they present different insulating materials in close contact with each other.

In the aim of developing a HVDC Gas Insulated Switchgear (GIS) cable termination as shown as an example in Fig. 1, all the insulating materials and the interfaces in the accessory need to be carefully studied. Among them, the gaseous insulation of the GIS is in direct contact with both metallic parts and an epoxy material. The choice of materials, both the insulating gas and the epoxy composite, is critical in the development process. This becomes particularly necessary in order to reach voltage up to the envisioned 640 kV DC. In addition to this challenge, there is a strong trend to limit the use of SF_6 due to environmental concern. Moreover, alternative gases, like natural origin gases and fluoronitrile based mixtures, are more and more used in GIS applications and should be studied in this type of accessories.

In this perspective, this paper presents the characterization of gaseous and epoxy composite materials that is a critical step toward the modeling of the related interfaces.

The data extracted from the measurements of the solid and gaseous insulation can be used in simulations to identify matching materials and optimize the development of a HVDC GIS cable termination.

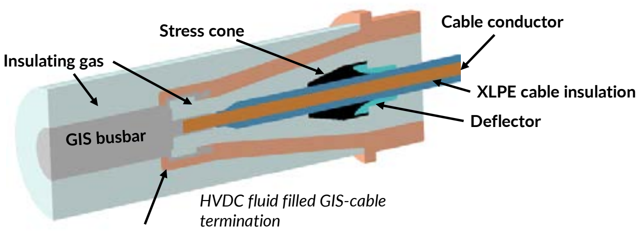

Fig. 1: Schematic view of a fluid-filled GIS termination.

OBJECTIVE OF THE STUDY

The design of an accessory requires to predict the electric field distribution. The specificity of a GIS cable termination is the variety of materials and therefore physical processes to take into account in order to be able to predict the electric field distribution in all conditions of operation, including transient conditions.

Scope of the study: the epoxy gas interface

The interface between epoxy and gas is one of the most challenging interfaces to deal with. In fluid filled equipment this interface is not only on concerns in the GIS side but also in the inner part of the termination. In GIS side this interface is significantly influenced by the metallic enclosure where charge injection takes place. However, it is important to consider that other materials, such as cable insulation material, elastomeric material, and any grease at the interface, also have a significant impact on the final electric field distribution of the GIS termination. In this study, we have focused specifically on the epoxy gas interface associated with the metal electrode (GIS side), limiting the scope of our investigation.

Methodology

The initial stage of the study is the identification of critical parameters that significantly influence the electric field distribution. In the case of AC, the electric field distribution is primarily governed by the permittivity, which exhibits relatively stable characteristics. However, in DC, the electric field distribution is primarily influenced by the conductivity, which is dependent on various parameters as evidenced in Fig. 2.