Numerical analysis of methane degassing from XLPE Insulated cable: role of cable conductor

D.-J. **YOUN**, Jingfa **LEE**, Shuyu **SUN;** KAUST, (Saudi Arabia), dongjoon.youn@kaust.edu.sa, jingfa.li@kaust.edu.sa, shuyu.sun@kaust.edu.sa

Yabin **SUN;** Dow Wire and Cable, (China), SYSun@dow.com

Jerker **KJELLQVIST,** Jozef **Van DUN**, Dow Wire and Cable, (Switzerland), jerker.kjellqvist@gmail.com, JJVanDun@dow.com

ABSTRACT

The role of the cable conductor during the cable degassing process was studied by a numerical model based on Fick's Laws. The diffusion coefficient of the cable conductor was inversely calculated based on in-situ data of the methane concentration. The result indicates the diffusion coefficient of the conductor is large enough to admit some amount of the methane transferred from the XLPE possibly due to free spaces within the conductor. Such amount of the methane in the conductor can flow back to the polymer layers, and thus this methane transport phenomenon must also be considered in the degassing analysis.

KEYWORDS

XLPE insulation; degassing; methane; Fick's Laws; inverse calculation; cable conductor; diffusion coefficient

INTRODUCTION

As demands of power cables with a crosslinked polyethylene (XLPE) insulation have greatly increased in recent years, the cable degassing process has become ever more important. Specifically, methane is the most important byproduct that must be properly removed during the cable degassing process due to its flammability [1,2,3]. The byproduct degassing from such cables have been analyzed by a number of researches to quantify and optimize the rate of the methane removal from the cables. Smedberg et al. [4] demonstrated different analytical techniques to measure the byproduct concentration from the cable samples and compared them based on the accuracy and convenience. Sun et al. [5] and Sun and Person [6] estimated the diffusion coefficients of the XLPE insulation under various temperatures by applying a slab model and found a good match with their methane concentration data experimentally measured by a gas chromatography. In addition, Andrew et al. [2] summarized the general understanding about the byproduct degassing process not only to discuss about the measurement techniques for the degassing process but also to present how the degassing efficiency can be affected by degassing conditions such as the cable design and temperature.

Such studies have clearly provided fundamental knowledge and understanding regarding the degassing process, but our current understanding about the cable degassing is still far from its maturity, and more technical efforts are needed especially for the cable components other than the XLPE insulation. As shown earlier, most of the researches have focused only on the XLPE insulation, and the other components, namely conductor and semiconductor, have received very scant attention. The lacking information about semiconductor is quite reasonable because of their much smaller volume compared to the whole cable structure so that their effect on the degassing efficiency can be minor. Additionally, the cable conductor is mostly made of copper, which does not allow any methane transported within the media due to the extremely low free space and diffusion property. However, the cable conductors are usually made as a multi-component structure which includes not only the copper strand but also additional conductor filling composite that surely has different diffusion property compared to the copper stands. Due to the multi-component structure with varying diffusion properties, thus, the role of the entire cable conductor must be carefully determined and considered in the cable degassing analysis.

Smedberg et al. [4] showed several methane concentration data measured from XLPE specimens collected from three different locations of a fresh cable, namely near the inner semiconductor, in the middle of the insulation, and near the outer semiconductor, and several sets of the methane concentration data along the thickness of the XLPE insulation are presented in Fig. 1.

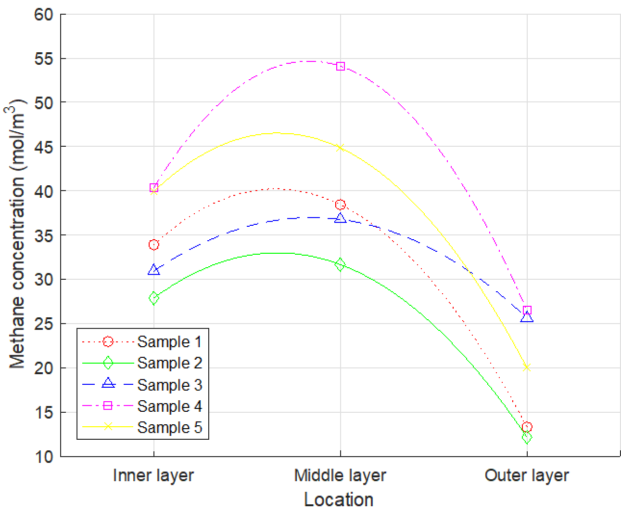

Fig. 1: Methane distribution data measured from the fresh XLPE insulated cables (the data is from Smedberg et al. [4])

As presented in Fig. 1, the minimum and maximum concentrations were found from the outer side and the middle of the XLPE insulation, respectively, while the concentration measured from the inner side of the XLPE is intermediate. This methane concentration data obviously indicates that some amount of the methane was transferred to the cable conductor. If the cable conductor completely blocks the methane diffusion from the insulation, the external surface of the cable is the only available boundary to release the methane, and therefore, the maximum concentration must be found near the inner XLPE layer,