Innovative thermoplastic polypropylene based cable system for HVDC applications

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ABSTRACT

Polypropylene based thermoplastic power cables are receiving increasing attention also for HVDC applications, where absence of crosslinking by-products represents a relevant benefit with regard to manufacturing process as well as in-service operation. This paper deals with the R&D work carried out for launching HVDC thermoplastic cable technology based on new polypropylene based insulation system and semiconductive compound. This paper also focuses on full size cable production and electrical testing program. A loop was finally installed and successfully submitted to a 400 kV DC type test according to CIGRE TB 496 recommendation for operational conditions at conductor temperature of 90˚C.

KEYWORDS

Polypropylene, Thermoplastic, HVDC, Cables.

INTRODUCTION

HVDC XLPE cable technology benefits from a significant track-record with many operational land and submarine links.

However, despite well-established market acceptance, some technical limitations still persist.

XLPE cable technology requires degassing process, demanding a long-lasting thermal treatment with unavoidable impact on manufacturing time. Moreover, the drawback of scorch phenomena, even well-controlled, represents an intrinsic technical limit and reduces manufacturing campaign length.

Polypropylene (PP) based thermoplastic power cables are therefore receiving increasing attention for HVDC applications due to some peculiar aspects such as very low degree of space charge accumulation and excellent electrical properties. Thermoplastic cable technology represents a breakthrough in the field of power cables thanks to several advantages in terms of intrinsic material properties, extrusion technology, providing superior cable performances.

This paper deals with the R&D work carried out for launching HVDC thermoplastic cable technology based on new thermoplastic insulation system and new semiconductive compound. Material formulations have been developed and fine-tuned to achieve the selected targets of electrical and physico-chemical properties.
This R&D activity was carried out by corporate R&D labs based in Lyon, where an international team independently developed materials, extrusion process and carried out testing programs for basic electrical characterization of materials.

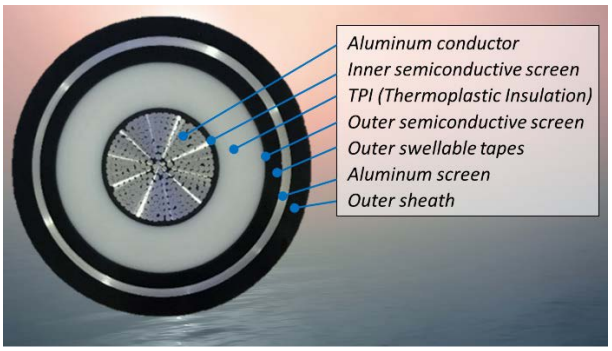

Fig. 1: 400 kV 90 °C HVDC PP prototype cable

Thermoplastic insulation (TPI) based HVDC prototype cable, 1600 mm^2 Al conductor, 20 mm insulation thickness was manufactured in a vertical extrusion line. Fig. 1 shows a cross section of 400 kV DC thermoplastic prototype cable.
The testing program was then carried out by Calais corporate electrical laboratories with the goal of assessing the electrical reliability and by carrying out a type test referred to CIGRE TB 496 procedure.

MATERIAL DEVELOPMENT

Insulation

Polypropylene presents numerous advantages as a candidate for the insulation of extruded HVDC cables. Compared to XLPE technology, its abilitity to be recycled, a simpler manufacturing process (no curing & degassing steps), the absence of polar chemical species release and finally a possibility for higher operating working temperature can be highlighted.

However, to guarantee the performance of HVDC cables with this PP-based insulation, it is key to master its physico-chemical and electrical performances.

This is why a specific R&D work was carried out to develop both insulation and semiconductive compound able to withstand all the targeted properties. Indeed, in addition to the already listed requirements (electrical, mechanical & thermal), material compounds have been developed enabling their use as insulation system of extruded HVDC cables of 20-25 mm insulation thickness with satisfying rheology behavior and stiffness.

The polypropylene insulation compounds were prepared at lab scale on a Berstorff twin-screw extruder ZE 25A-42D at proper melting temperature profile and screw speed.