New technologies for controlling cable geometry during curing process

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ABSTRACT

We present a new technology for XLPE cable core manufacturing in VCV lines. Results show that significantly better roundness can be achieved for all HV & EHV cable constructions. We discuss theory and experimental data on cable roundness for both standard and new technology. We present an experimental process model having a local process optimum for new technology.

Experiences of using the new crosslinking technology in submarine cable production for several cable constructions as well as comparisons to traditional VCV lines are presented. Benefits of the new technology for VCV line productivity are shown based on real life experience.

KEYWORDS

XLPE, HV, EHV, VCV, submarine, roundness, ovality

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INTRODUCTION

Manufacturing of extruded high and extra high voltage cables has been done in vertical continuous vulcanization (VCV) lines with dry curing process for many decades. High voltage cables have stringent quality requirements due to high electrical fields experienced in their service liftetime.
One of these requirements is high geometrical quality in terms of roundness. Optimal roundness together with correct concentricity quarantees even insulation thickness around the circumference of the cable core. If the roundness is not optimal, this needs to be compensated by increasing insulation layer thickness which leads to material overconsumption.
On top of wasted material, unoptimal roundness may cause problems in subsequent processes, such as lead sheathing. Especially submarine cables must be water tight, which means the cable core needs to be round enough to ensure water tightness between the cable core and lead sheath. Other metal sheathing options have even higher requirements for roundness, compared to lead.
Good roundness is also required when manufacturing flexible factory joints or fitting premoulded joints to the cable core.
Traditionally cable geometry concerns have been solved by manufacturing the cables at a conservative production speed and mild process conditions. In this paper we present a new crosslinking technology that increases VCV line productivity while also improving cable core geometry.

NEW CROSSLINKING TECHNOLOGY

How it works

We present a new method for starting the curing process in an efficient and quick way. A traditional curing tube consists of a heating zone from 4 to 6 meters long with temperature settings typically from 300 to 450 °C degrees. When producing high and extra high voltage cables, these temperatures often have to be limited due to cable geometry quality concerns as discussed in the authors previous work [1].
The new innovation focuses on impulse-like heating of the extruded cable core. We have constructed a system where the beginning of the curing tube comprises of several shorter zones capable of achieving higher temperatures than a normal curing tube. The system typically has 2 high temperature zones no longer than 0.5 or 1.0 meters and a third zone from 3 to 5 meters with active heating and cooling. This arrangement makes it possible to emit high radiation power capable of heating the cable surface up to 300 °C in the time span of less than 45 seconds. After the rapid heating up to the target temperature the cable enters a relatively neutral part of the tube where the heat applied to the surface has time to conduct deeper to the insulation layer. During the short high temperature treatment of the cable core surface a thin layer of material is rapidly crosslinked. This fully crosslinked layer right at the beginning of the curing process is the key part in achieving remarkable improvements in core geometry and CV line productivity to be discussed in later section.[2]
These process conditions have not been possible with traditional CV line constructions due to long lengths of tubes as well as limitations to setting temperatures. Manufacturing of the curing system requires special materials capable of withstanding temperatures up to 600 °C in the pressure vessel.
This new crosslinking technology system illustrated in figure 1 replaces the first curing tube of a traditional VCV line and imposes no changes to subsequent parts of the CV line. The extruded cable core undergoes a traditional curing and cooling process after the MRC zone. Modularity of the design makes it easy to retrofit existing lines.