Nondestructive ultrasound technology for quality assurance in power cable production

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ABSTRACT

Starting from an investigation about ultrasonic monitoring of the cross-linking, the question about the minimum detectable defect size came up. Therefore a study was started, which focused on the defects inside the cable insulation during extrusion and the hot-oil-test. For this article a 18/30kV XLPE cable core was modified with buttom holes of specified sizes. After several variations and optimization of test setups, ultrasonic hardware and signal evaluation, defects down to 100µm could be detected.

KEYWORDS

XLPE power cables; Transparity test; Hot-oil-test; Ultrasound; Non-destructive testing; Minimum defectsize.

INTRODUCTION

The amount of solid insulation materials in high voltage equipment is evermore increasing. The primary task of the insulation system is to provide a safe electrical insulation during a service life of up to several decades. Therefore, the production of the insulation system has to fulfill very high quality standards, since even small defects can dramatically reduce the electrical strength and service life.

In recent years, ultrasonic testing has shown to be a suitable method for the nondestructive testing of a variety of high voltage equipment containing a solid insulation system. The essential advantage lies in the simple sample preparation for ultrasonic testing and the non invasive measurement. So, ultrasonic technology is used in the production line for monitoring the thickness of every layer of the cable core. Moreover, the eccentricity of the conductor is an important aspect, ultrasonic monitoring systems can control today. First concepts were implemented to use ultrasonic technology for monitoring the core insulation regarding defects and inclusions during the extrusion process. The advantage lies in the early information about the quality of the cable's insulation system. But till now, there is no documented information about the minimum detectable size of inclusions inside the insulation system. The theoretical estimation using formulas from the literature, gives a hint, but it does not consider the progress in today's opportunities of evaluating and analyzing the measurement data. Consequently, there is a need for verifying measurements to define the minimum detectable size inside power cable insulation systems.

PRELIMINARY INVESTIGATIONS

During further research projects dealing with the cross-link-monitoring, defects at the inner semicon layer (ISL) were detected with ultrasonic technology (UT) beside the high eccentricity of the conductor [5]. Figure 1 shows the scanning result over the circumference.

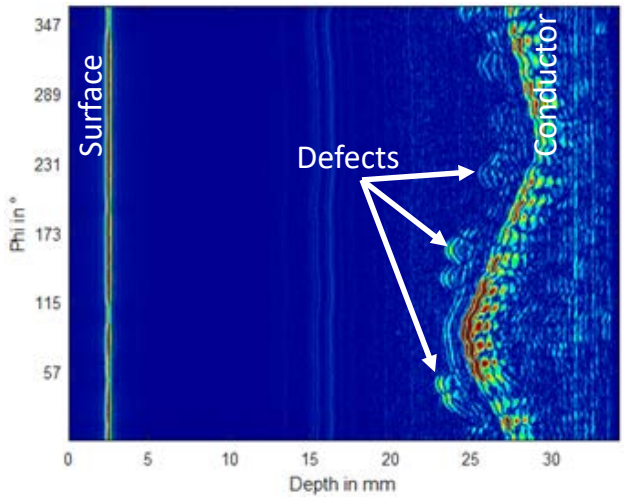

Fig. 1: Result of the ultrasonic scan of a cable sample

Inside the insulation layer (ISO), next to the ISL, a lot of inclusions can be seen. After cutting the sample, a high number bubbles at the ISL became visible (Fig. 2). So, the ultrasonic scanning results had been verified.

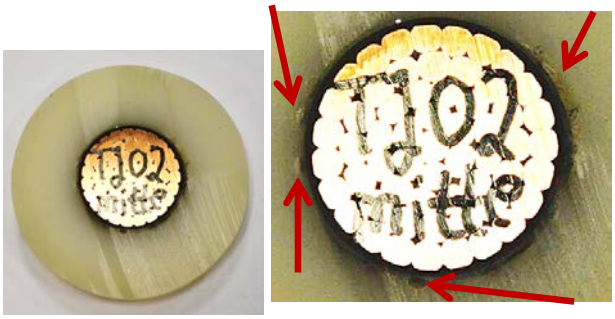

Fig. 2: Bubbles at the ISL after cutting

Although these defects were quite large from dimensions up to 1 mm, the question had to be answered, which minimum size of defects could be detected by ultrasonic technology.

Moreover the idea was born, to support the hot-oil-test performing UT-Scans for objective, faster and more automated monitoring of the quality of the extrusion process. Compared to the hot-oil-test the ultrasonic scanning has no need for special sample preparation like peeling the outer smicon (OSL) (cf. Fig. 8).

The detection of defects in solid materials using ultrasonic technology is mainly influenced by the wavelength of the UT-impulses inside the material. The wavelength λ is depending on the sound velocity of the material and the frequency of the impulse and can be calculated with

$$\lambda = c / f \qquad (1)$$

In literature [1,2,3] the minimum detectable size can be