Ultrasonic extrusion quality monitoring of multilayer HV cables during production – 'A New Vision in Cable Monitoring'

Dr Gareth **HUMPHREYS-JONES;** Acuity Products Ltd, UK, gareth.h-jones@acuityproducts.co.uk

ABSTRACT

Whether it is in manufacturing existing cables more cost effectively or in designing new cable types, Extrusion Quality Monitoring and Control is a major key to success. This paper presents valuable information about extrusion quality that has never been obtainable before, and is now only available due to the introduction of advanced ultrasonic technology onto the production line. The remarkable fidelity of this new measurement technique not only provides new insights, but also opens the door to new areas of process understanding, cable design & development as well as material savings.

KEYWORDS

Ultrasonic, Extrusion, Quality, Measurement.

INTRODUCTION

Ultrasonic cable geometry measurement is now becoming established on the production lines of some of the world's top cable manufacturers, and the benefits of the very high fidelity and unique information that it provides is already being acknowledged and bearing fruit in terms of the optimization of extrusion line production techniques.

The aim of this paper is to make this knowledge available to a much wider audience, to provide not only an enhanced view of the actual structures that exist within cables, but also to highlight new and powerful production control techniques that are set to play a significant role in on-line production optimization and material usage control.

The operation of the ultrasonic equipment and the format of the results it produces are described in the following sub-section, after which sub-sections relating the characteristics of the cable layer width variations will be presented. Then a further sub-section will consider the stability characteristics of perhaps the most critical of the cable layer interfaces – the inner screen / insulation layer interface, whilst a further sub-section will then consider a totally new approach to monitoring and potentially controlling layer and interface stability, before the findings of this paper are finally summarized.

EQUIPMENT OPERATION AND RESULT FORMAT

The ultrasonic measurement technology, from which the results presented in this paper are derived, is embodied in the product known as UltraScreen, and all the results presented in this paper are derived from data collected from the different types of lines on numerous manufacturer's sites on which this equipment is currently deployed.

To understand the format of the results presented in this paper it is first necessary to understand some key points about the operation of UltraScreen on a production line. UltraScreen is normally positioned just after the end of the CV tube but before the caterpillar, and the extruded cable is pulled through the machine, passing through an internal water bath containing the ring of 16 ultrasonic transducers – as illustrated in Fig 1.

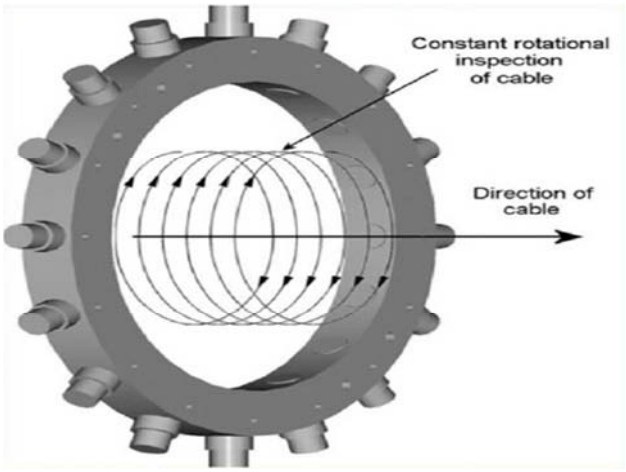

Fig 1 – UltraScreen Operation

As the cable passes though the machine the transducers are sequentially fired so that a complete circumferential set of 16 measurements is completed every 16ms. As ultrasonic analysis detects the interface between two different material types, the data set for each transducer provides the radial position of each of the four interfaces, (water / outer semicon, outer semicon / insulation layer, insulation layer / inner semicon & inner semicon / core) for that sector of the cable to an accuracy of ~10-20 micron. This data set is then used to calculate the widths of the three cable layers, and data from opposing channels is used to calculate the diameter of the cable across these sectors.

Thus, every 16ms the equipment produces a base measurement set of 16 widths for each of the three extruded layers and 8 diameter measurements. At a typical HV line speed of 1m/min, the 16ms scan time means that a new measurement set is taken every ~270micron along the cable over the whole production length of the cable. As part of its integration onto different customer lines, detailed statistical studies have been undertaken to compare the measurement accuracy of UltraScreen against off-line, optical measurement systems. These rigorous studies, which have been used to qualify the measurement system to end user clients, have concluded that there is no statistically significant difference between the on-line, layer width measurements produced by UltraScreen, and the results produced by the off-line, optical systems.

In this sense the measurement sets produced by UltraScreen every 16ms can be envisaged as a measurements of a 'cable slice' some ~270micron thick and, as the base measurement set is also be used to evaluate derived parameters like Concentricity, Ovality,