Integral sensing of HV cable joints – monitor operation and predict failures early

Ruben **GRUND**, Jens **HOHLOCH;** Pfisterer, (Germany/Switzerland), ruben.grund@pfisterer.com, jens.hohloch@pfisterer.com

Rosalie **ROGERS**, Anja **KAMMLER,** Clemens **POHL**; AP Sensing (United Kingdom/Germany), rosalie.rogers@apsensing.com, anja.kammler@apsensing.com, clemens.pohl@apsensing.com

Henrik **ROLAND**; Energinet, (Denmark), hrh@energinet.dk

ABSTRACT

Due to space restriction and visual appearance, cable systems are becoming an alternative to overhead lines, even in transmission networks. Furthermore, generally speaking, utilities and network operators tend to increase the power transmitted which could be required in regard to overload behaviour. This additional load increases the requirements on cables, as well as the relevant accessories. Nevertheless, safe operation is required and mandatory. This paper discusses the real life pilot installation of three joints equipped with the world's first-time use of complementary sensing technologies: Distributed Acoustic Sensing (DAS) and Distributed Temperature Sensing (DTS).

KEYWORDS

FOC, DAS, DTS, smart joint, hipot test, underground power cable, monitoring, temperature, acoustic

INTRODUCTION AND MOTIVATION

Energy distribution and transmission networks are constantly changing. This change is initiated by several factors, such as changes in energy generation from large power plants to several medium sized power plants.

Another additional aspect is power fluctuation which has become a widely discussed aspect. If there is sun and wind there is a lot of additional power but a few days of cloudy weather without a breeze requires additional backup generation. In this regard the expectation and our common approach in technology is another factor heavily influencing our network setup. There is no acceptance of energy disruption, a 100% continuous coverage of electricity at all time is expected.

These expectations in conjunction with the fluctuating sources, changes the requirement set for energy networks. Utilities need to plan for maximum single source load as well as 100% renewables. Therefore, there is a need to interconnect the distribution and transmission level, as well as to increase the capacity for energy transmission.

But how can this increase be managed? On one hand, one could add additional infrastructure. Interconnecting the mesh. At the same time bigger cross sections could be used to increase capacity.

Nonetheless these are huge investments that need time.

Considering the planning and structuring of existing networks, there are several potential methods to increase energy transmission. Particularly cable systems have been calculated and designed for a specific cause but usually are not run at full capacity. But why aren't these networks not run at full capacity?

A crucial factor limiting transmission power is the maximum permissible temperature of a cable system, usually limited at 90°C for XLPE-insulated cables [1], [2]. In normal operation, operators prefer to have some capacity left in order to handle critical situations. Thermal overload due to excessive currents may lead to critical changes in material properties and therefore shorten the service life.

During the project planning phase, cable transmission lines are designed in accordance with standards and technical guidelines with regard to a maximum limit current resulting from the maximum permissible temperature. Influencing factors such as cable structure, if necessary, accumulation of several cables laid in parallel (often three-phase circuits) as well as soil and ambient conditions are taken into account.

This method of system design is based on relatively roughly categorised calculations and empirical values, which in practice do not always apply completely or are deliberately assumed to be very conservative.

During operation, the network operator intends to operate the cable system within the limits. But future cable systems are designed closer to the limits, so there will be times when the operator will overload the cable for a limited period, e.g. due to high feed-in power from renewables.

Monitoring of decisive parameters (e.g. real thermal conditions) during normal network operation can therefore make a contribution to optimized capacity utilization. In addition, monitoring offers the possibility to detect characteristic changes at an early stage and to react to emerging problems, thus contributes to achieving a high reliability of the entire grid. If a fault occurs in the system, it is also an important tool for fault location and makes it possible to initiate repair measures rapidly and targeted.

If a cable system is in service information about temperatures is only available if an additional measurement system is applied. Often these sensors are optical fibres implemented in the cable's screen or armouring as seen in Figure 1. Additionally, optical fibres can also be used for measuring acoustic strain which can pinpoint cable faults to an exact location.

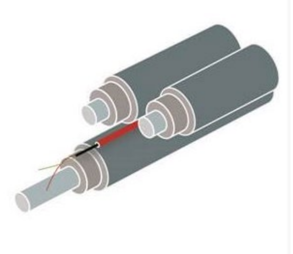

Figure 1: Setup of FOC with power cable

These fibres usually are not implemented in cable joints but in cables only. But cable joints are a crucial point of