ADVANCED CABLE SELF-REPAIR MATERIALS FOR SUBSEA AND UNDERGROUND CABLES

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ABSTRACT

The rapid growth of both offshore and undergrounded power networks present numerous opportunities but also additional risks for both on-shore and off-shore network operators and operators of offshore windfarms and interconnectors. Due to their location, accessing power cables for maintenance can be challenging or prohibitively expensive, meaning that otherwise minor damage can progress to failure, resulting in an expensive and time-consuming repair operation.

Gnosys has developed a range of technologies designed to autonomously resolve otherwise minor defects in power systems. These technologies are currently being demonstrated in minicable prototypes systems prior to testing in MV cable analogues.

KEYWORDS

Self-healing, self-repairing, power cables, polymers, materials, subsea cables

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INTRODUCTION

Underground cables (UGCs) are a vital aspect of power infrastructure across the developed world. They are of particular use in situations where overhead lines (OHLs) would either be considered unsuitable or not allowed, such as city centres (where safety may be a concern) or environmentally sensitive regions where there may be a demand to reduce visual impact. There is an increasing drive to underground networks throughout Europe, and some countries (such as the Netherlands) operate with fully undergrounded infrastructure.

UGC networks possess a number of advantages compared to OHLs, notably an excellent resistance to extreme weather. However, UGCs also have significantly higher material and installation costs compared to OHLs, which increase sharply with increasing voltage (ranging between 2:1 for MV UGCs and 20:1 for HV UGCs). Moreover, the location of UGCs often prevents routine maintenance, which means that otherwise minor defects can occur, over a period of years, to the point that the cable may fail. If this occurs, the difficulty in accessing the cable can significantly extend the process of locating and resolving the fault. It is estimated that resolving a fault on a UGC takes up to 25 times longer than a similar fault on an OHL. In addition, the process of excavating the cable can cause significant disruption, particularly if the failure occurs within an urban area.

An analogous situation also exists with subsea cables, functioning either as interconnectors (supplying electricity between countries or between mainland and island) or as array/export cables for offshore windfarms. Compared to underground cables, subsea cables operate in a more extreme environment, including high hydrostatic pressures, tidal currents (which can induce fatiguing and sheath cracking), and risks from third party damage including trawler nets and anchor drops. Due to the costs associated with construction and laying of offshore cables there is frequently limited (or no) redundancy in a given circuit. As a result, it is entirely possible that the failure of an export cable can result in the loss of supply from an entire wind farm, which in turn can lead to heavy fines being levied at the wind farm operator. In the event of a fault occurring, the repair process is more protracted and expensive than a comparative UGC fault, often requiring specialist ships and crew with high running costs, as well as periods of clement weather in which to conduct the repair. As a result, costs can frequently run to over £1m [1] although in extreme cases repair costs of over £60m have been reported [2].

In both cases, an elegant solution would be to incorporate a material that would be capable of autonomously responding to damage, or environmental changes (e.g. water ingress) associated with a damage event. The purpose of these materials would be to seal defects and prevent the ingress of water and prevent its migration, which is known to cause degradation of the cable insulation through water and electrical treeing in addition to electrochemical corrosion. This would be particularly valuable for subsea cables, where even a moderate reduction in cable failure rates would represent substantial savings for circuit operators, but it is anticipated that technologies developed for this market could be freely applied to both subsea and underground systems, where similar benefits would be realised.

We present here progress in a pair of technologies intended to provide this functionality, discussed in a previous JiCable conference [3]. The first is a water-swelling hydrophilic thermoplastic elastomer (h-TPE) that operates on a similar concept to currently used water blocking tapes, albeit with significantly enhanced performance. The second is an intrinsic self-healing material (SHM) [4] that can autonomously repair the polymer network in the wake of damage. Both technologies are now at the demonstrator stage and are being incorporated into bespoke minicable designs, with following steps being demonstration and trialling on MV cables.

HYDROPHILIC THERMOPLASTIC ELASTOMERS

We have investigated the development of 'cable repair' materials, with an initial focus on h-TPEs. These differ from self-healing materials in that the system is capable of