Development of submarine MV-AC power cable with aluminum conductor

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ABSTRACT

A single armored MV-AC submarine power cable with an aluminum conductor was developed for offshore renewable energy, interconnections between offshore platforms, islands and shore. For the cable design process an intended installation in water depths up to 300 m and the application of additional cable protection methods such as rock dumping for on-bottom stabilization were considered.

A type test has been successfully performed on 3x 800 mm² 19/33 (36) kV XLPE submarine power cable with an aluminum conductor. The qualification program was performed under consideration of the CIGRE Electra 171, CIGRE TB 490, IEC 60502-2 and CENELEC HD620-10C standards.

KEYWORDS

Submarine MV-AC power cable, subsea, offshore, aluminum conductor, XLPE insulation, type test, qualification, 300 m water depth, impact loads

INTRODUCTION

The reduction of construction cost is one of the biggest demands for today's offshore renewable energy sector. The need of cost reduction is not limited to the energy conversion system itself, it includes the interconnections between the single platforms and the connection to shore. Consequently cost of submarine power cable for infield- and export-connections needs to be reduced through the reduction of both production and material costs. Both the conductor material selection and the submarine power cable design play crucial roles and need to be reviewed under consideration of all relevant industrial standards such as IEC and Cenelec [1,2]. However, during that process all other major requirements have to be considered as well. Specifically, the cable design needs to be qualified to withstand high tensile loads and holding forces during cable installation as well as high impact forces during operation. The latter is a glaring need for all offshore renewable energy systems where scour formation or on-bottom stability are a major concern. In this case, additional cable protection methods such as rock dumping, concrete mattresses or others are required. In addition, the cable design is be suitable for installations in water depths of up to 300 m.

The following sections outline the development considerations and qualification process for a MV-AC submarine power cable with aluminum conductor. The cable is developed for interconnections between offshore platforms, islands and shore.

MATERIALS SELECTION

Copper conductors are commonly used in submarine cables due to its very good conductivity. However, the high demand of copper material results in a very high market value. This was set to above 6000 $/ton at the beginning of April 2015.

Aluminum has lower conductivity compared to copper resulting in the need to select larger conductor cross sections. Despite the larger conductor cross section, cost reduction is achieved due to the lower material price of aluminum compared to copper. At the beginning of April 2015 the market value for aluminum was oscillating around 1770 $/ton. Due to that market value difference aluminum is a cost-effective replacement for copper as conductor material. During the selection conductor material, both the electrical and mechanical material properties were reviewed for all aluminum alloy candidates to select the alloy which satisfies all specified requirements.

Submarine power cable costs are mainly driven by the conductor material selection. However, other submarine power cable components such as the armoring layer, bedding layer or outer serving concept would also have a significant impact on cable price.

Typical armor wire materials of submarine cables need to have good mechanical properties. Especially a high e-modulus and a high tensile strength are required given the fact that the armor layer shall support a mayor portion of the applied tensile load. Galvanized steel is the typical armor wire material used in submarine cables. Copper, nickel or titan are some of the possible replacement candidates although they share the drawback of limited mechanical properties and higher material acquisition costs compared to steel.

The bedding and outer serving layer shall damp external forces which act on the submarine cable such as impact and pressure forces during cable handling and operation. Two different bedding layer and outer serving concepts are used for submarine power cables: extruded polyethylene jackets or stranded polypropylene (PP) yarn layers. Extruded PE jackets exhibit slightly superior mechanical functionality than PP yarn. Though it requires at least two additional productions steps. On the other hand, both PP yarn layers can be applied during the armoring process. Consequently PP yarn would be the cost effective solution compared to extruded PE jackets as bedding and outer serving layers.

CABLE DESIGN

A schematic drawing of the submarine power cable is shown in Fig. 1. The MV-AC submarine power cable is a three core design combined with fibre optic cable elements and PE fillers. All elements are laid up with a periodically reversed lay direction, forming a round and circular cable assembly. Although the assembly is dimensionally stable, additional binder tapes and yarns