Tensile Test and Finite Element Analysis of Flat Steel Wire Armoured Submarine Fiber Optic Composite Power Cable

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ABSTRACT

With the rapid development of marine power transmission, flat steel wire armoured submarine cables will have many potential application prospects. Based on the first large-length 500kV XLPE optical fiber composite submarine cable project on earth, two kinds of flat metal wire armoured submarine cables are designed and developed independently, subsequently their armouring process has also been verified. At the same time, tensile test and simulation calculation is carried out to analyze the stress on two cable types. The result shows that: a) According to the process verification result, the work scope of flat wire armor is proposed. Meanwhile, different flat wire armor materials will have significant impacts on the armor formation process. b) The reliability of simulation parameters for flat wire armor submarine cable has been verified, which are almost consistent with test results. The further research shows that the armour bedding and outer serving can play a good buffer protection role in submarine cable, whose strain deformation are larger than other components. In addition, compared with whole components, optical fiber's performance is little unaffected due to the deformation of optical cable is smaller, c) the larger deformation fluctuation and stress concentration effect will be caused at the loading end of the flat steel wire armor layer thus, reliable measures should be taken during cable laying.

KEYWORDS

500kV;XLPE;flat steel wire;tensile test;FEM

0 INTRODUCTION

During installation and laying, submarine cables need to be subjected to the large tension, which does not only come from the self-weight of suspended section, but also the additional dynamic force generated by cable ship's vertical movement. Load-bearing elements are mainly composed of armored layer, which is generally used to provide sufficient mechanical protection to prevent cable from external damage caused by offshore installation equipment, underwater equipment, fishing gear, anchorage device and so on. In addition, during laying onshore landfall, submarine cable armor layer is generally towed ashore by a winch or traction device[1-2] to ensure the movement of overall cable. In summary, it is necessary to investigate the armor type of submarine cable to verify its operation stability. If armoring type is not reasonable, it will directly lead to laying difficulties increasing, and the cable is very vulnerable to mechanical damage under this situation. Moreover, its electrical performance will be affected too.[3-4].

At present, round or flat wire armoring forms are generally adopted in submarine cable's design and manufacture [5]. Among them, round wire armoring type has been widely applied in cable engineering, whose mechanical properties have been studied in depth[6-14]. Many engineering projects can also prove its reliability[15-17]. However, flat wire armored structure is limited because of manufacturing process factors, so it is rarely used at present. Furthermore, there is also a lack of mechanical performance test and simulation research. But this armored type will have potential application advantages in the future with developments of dynamic submarine cable, deep-submarine cable and other products.

According to above background, this paper has designed and developed two types of armored fiber composite submarine cable samples, flat copper wire armored type and flat steel wire armored type, which relied on the world's first 500kV EHV XLPE insulated AC submarine cable project in Zhoushan, China. And process verification was also realized at the same time. Then, taking flat steel wire armor cable as an example, a tensile test and finite element simulation study were carried out to analyze tensile stress state and verify safety and stability of flat steel wire armor structure.

1 DEVELOPMENT PRODUCT PARAMETERS OF SUBMARINE CABLE

According to materials used, high voltage single-core AC submarine cables are generally classified into two types, galvanized steel wire and copper wire armoring. Among them, steel wire's mechanical properties are better, which can meet general usage requirements for submarine cable. However, steel wire is a magnetic material, whose magnetic field concentrated around conductor will cause current loss and extra heat. Nevertheless, Copper wire is a non-magnetic material with low resistivity and high corrosion resistance, which can improve current-carrying capacity significantly. Semi-hard copper wire can be used to ensure similar armoured tension with steel wire.

Structures and parameters for two kinds of 500kV XLPE fiber composite submarine cable samples developed in this paper are shown in Tab.1. Among them, each cable has two symmetrically distributed G.652D optical units inside, which are used for monitoring of strain, temperature state and fault location during operation[18-19]. This unit adopts stainless steel tube structure, coated with PE sheath, which is placed between PE sheath and PP Inner cushion layer of submarine cable. And filling