Structure design and test verification for HV dynamic power cable above 110kV

Pan **PAN**[1,2], Haitao **WANG**[1],Ming **HU**[1], Shuhong **XIE**[1], Tianyi **ZHANG**[1],and Mingbo **Zhou**[1]
[1]Zhongtian Technology Submarine Cables CO.,LTD.China
[2]School of Naval, Architechture, Ocean and Civil Engineering, Shanghai Jiao Tong University,China
panp@chinaztt.com, wanghaitao@chinaztt.com, hum@chinaztt.com, xiesh@chinaztt.com, zhangtianyi@chinaztt.com, zhoumb@chinaztt.com
☐ **Young Researcher** (Proved full-time engineering and science university researchers and Ph.D.students under 35 YO)

ABSTRACT

Carbon Trust launched the High Voltage Dynamic Export Cable Competition as a part of the Floating Wind Joint Industry Project(Floating Wind JIP). The basic, high-level requirements of the dynamic export cable are 3-phase AC ranging from 132kV(620A) to 220kV(750A). Compared to conventional static HV submarine cable, the main differences for dynamic export cable are corrugated copper sheath acting as a moisture-blocking barrier to prevent moisture ingress towards the cable core, even layers of armor wires providing strength and fatigue resistance, and thick outer PE sheath to provide corrosion and abrasion protection. Electrical and mechanical analysis were performed to verify HV dynamic cable's engineering practicability. With detailed inputs of floating substation platform and ocean environmental parameters, dynamic analysis for cable and associated accessories were carried out, demonstrating the dynamic cable system could preserve enough fatigue resistance after 20 year service life. Several small and prototype dynamic cable samples with corrugated alloy copper sheath were manufactured to verify production feasibility, and one of the most suitable alloy coppers was finally selected after the trial-experiments as a result of excellent electrical and fatigue performance.

KEYWORDS

Hight Voltage Dynamic Cable; Copper-Nickel alloy; Corrugated Sheath; Fatigue Test.

0 INTRODUCTION

In the near further, commercial-scale floating wind farms will require floating offshore substations and high voltage dynamic export cables hanging through the water column to transmit renewable power back to shore.

Due to development of mature material and manufacture facilities, dynamic submarine cables are available from a variety of manufacturers generally up to 66 kV, however, large-scale floating offshore wind farms will require dynamic export cables with voltage levels rating up from 132kV to 220kV. There has been no evidence that the 'wet' design of HV cable could support the suitable structure design for such high voltage.

Dynamic cables are distinguished from typical 'static' subsea cables in which dynamic cables are subjected to in-service motions due to waves and current action as well as motion of the floating structure from which it is suspended[1,2]. Static high voltage subsea cables connecting bottom-fixed offshore substations to onshore also experience limited motion during their operation, but the magnitude would be comparatively low. Insulation of HV static subsea cable is composited of superclean cross linkable polyethylene (XLPE) and protected with extruded lead sheath to block water ingress thus avoiding water-tree, however, the lead sheath would appear crack under repeating environmental loads when used in dynamic situation[3,4]. Lacking of HV water tree retardant (WTR) insulation material, there exists notable gap in the market for suitable HV dynamic cables. This represents a potentially significant challenge and a potential bottleneck to prospective commercial floating wind projects.

To develop HV dynamic power cables for export purposes in floating offshore wind farms, this paper focus on the proper material research and structure configuration design for metallic sheath of HV dynamic cable cores.

1 CABLE STRUCTURE DESIGN

The target floating substation locates in the northeast of Scotland, the detail location is 58.404°North 0.733°West. The two lengths of high voltage dynamic cables are arranged parallel in a lazy-wave configuration under the substation. The electrical requirements of dynamic export cable are outlined in the below table. Through a comprehensive evaluation, the 220kV cable with a 500mm^2 conductor cross-section area is chosen for the HV export cable. A detailed electrical and mechanical analysis is carried out to verify its engineering applicability.

Table 1 Electrical requirements of export cable

No.	Parameter	Requirements
1	Cable voltage levels	Preference is for 220kV or higher, but voltage levels between 132kV and 220kV will also be considered
2	Indicative ampacity levels	220kV – 750A 132kV – 620A
3	Transmission mode	3-phase AC
4	Target design life	25 to 30 years
5	Cable configuration	Single or double lazy wave

According to Table1, the preliminary cross section of export dynamic cable is shown in Figure 1, in which a prime design for the annular pattern corrugated pure copper tubular sheath considering electrical performance and fatigue life, comprising of t (thickness)=0.6mm, p (corrugation pitch)=16mm, A (amplitude)= 4.5mm.

Double layers of flat galvanized steel wire armors are applied over the armor bedding to act as mechanical cable protection, and anti-corrosive compounds like bitumen would be used between the armor wires.