Assessment of Fatigue Damage Initiation in FPSO’s Oil Offloading Line in West Africa

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ABSTRACT

In this paper, the fatigue damage of OOL (Oil Offloading Line) is assessed based on S-N curve and Miner linear criterion. The numerical model of the offloading system is established by OrcaFlex including FPSO and CALM (Catenary Anchor Leg Mooring) buoy. And two OOLs built by 6-DOF lumped mass model are connected to the right side and left side of FPSO and CALM buoy, respectively. By analyzing the fatigue contribution of different waves in West Africa Sea and the influence induced by the OOLs’ self-characteristics, it is discovered that the surge motion of the CALM buoy is a main initiation of the fatigue damage, and the wind sea has much greater effect on the fatigue damage than swells. In addition, it is found that the fatigue life of the OOL can be improved by increasing its tension, which gives practical reference in engineering design.

KEY WORDS: Oil Offloading Line; fatigue assessment; S-N curve; FPSO; CALM buoy; West Africa.

INTRODUCTION

The development model of FPSO + Oil Offloading Line (OOL) + CALM buoy + shuttle Tanker has been widely used in oil exploitation of West Africa (Wang et al 2010). Fig. 1 shows a typical layout of West Africa deep water oilfield. All such kinds of export systems are based on the concept of a large surface buoy, in most cases shaped like a flat cylinder. The buoys are anchored to the sea bed by an array of semi-taut mooring systems and support several or generally two mid-water offloading lines suspended below the wave zone (Hovde 2005).

As the only connection between the FPSO and the CALM buoy in the offloading system, the OOL has received considerable attention on its fatigue characteristics. Normally the export line is “w-type” suspended in the water shown as Fig. 2a, or “u-type” shown as Fig. 2b which is considered a better strength and fatigue performance (Chaudhury 2002). For the fatigue assessment of the oil pipeline, there are some conclusions can be referred. Specifically, the fatigue damage mainly occurred in the vicinity of the CALM buoy (Odru 2003), the calculation is based on spectral analysis but only considered the first-order movement of the floating body. The fatigue life of OOL can be improved by increasing its effective tension, and the shuttle tanker working condition should be considered (Montbarbon, S et al 2005). Furthermore, the flexible joints between pipeline elements are key structures, and the fatigue of the joints need to be paid more attention. The OOL’s fatigue damage is aggravated with the increase of the joints stiffness (Wang Bo 2014).

Fig. 1 Typical layout of West Africa deep water oil field

Fig. 2 OOLs arrangement types

SEA ENVIRONMENT IN WEST AFRICA

Waves in West Africa have distinctive geographical features. The waves are milder, with smaller wave height, and have obvious direction