Master Thesis in Marine Technology—2015

Fatigue Assessment of OSCV according to DNV standard.

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Objective and Scope of Work

The objective of the project is to assess the expected fatigue lifetime of longitudinals at typical end supports for an Offshore Service Construction Vessel (OSCV) designed by VARD Design AS, according to DNV classification Notes No. 30.7 - Fatigue Assessment of Ship Structures. As a part of the work, the operational pattern is investigated to get an indication of the long-term sea environment, in addition to how frequently the vessel is at sea where dynamic loads occur.

Introduction

Fatigue cracks and fatigue damages have been known to ship designers for several decades and a lot of data based on experience have been made available by among others the classification societies /1/. However, in the last decades there has been a major development of the Offshore Service Construction Vessels where high tensile steel has been introduced to increase the dead weight, but also to increase the allowable stress level. In the same period the average main dimensions have increased, leading to greater wave induced hull girder moments.

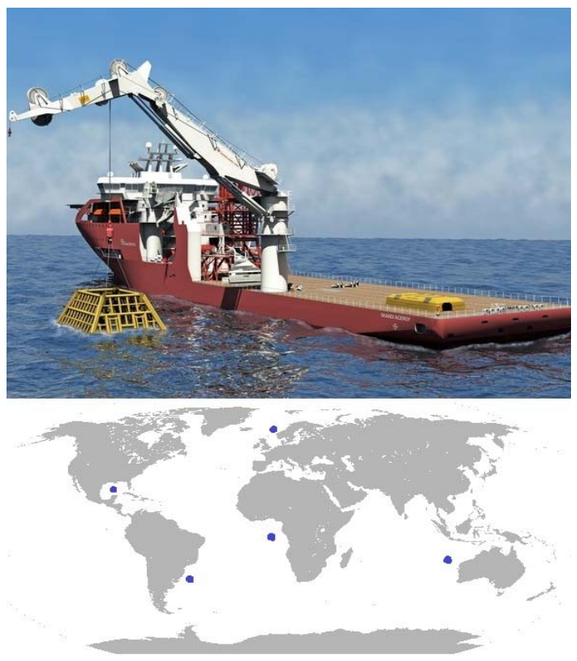


Figure 1— Operational Profile of Offshore Service Construction Vessel /2/

This development have made it interesting to check the expected fatigue lifetime of the structure, and research shows that this has not been done before for such vessels. The history have shown that undiscovered fatigue cracks in merchants may lead to more extensive structure failures due to the lack of redundancy since the vessel often is already tuned to the maximum with respect to stresses /1/. It should be noted that full utilization of the hull material happens in ballast arrival when the peak tanks (ballast) are fully loaded, and mid tanks (fuel oil) are almost empty /4/.

However, due to the operational profile of the vessel it is claimed that fatigue is not an important design issue for the vessel. This is based on the operational limits, e.g. the significant wave height. In addition, it often takes weeks and months to mobilize (prepare) the vessel for the next mission /4/. So, compared to traditional ships that are expected to spend about 15 % /1/ of their lifetime at ports where dynamic loads do not occur, the OSCV is claimed to spend even more, but how much is uncertain.

Fatigue Assessment Methodology

The fatigue assessment of the ship is based on SN curves and estimation of cumulative damage (Palmgren—Miner's rule). In such case the major effort lies in the work to calculate the long-term strass range which is entered to the SN curve to find the number of cycles before failure.

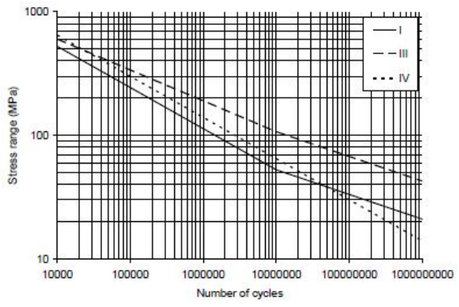


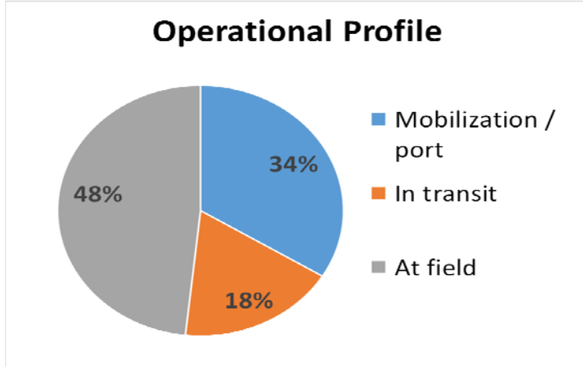
Figure 2—SN curves

In this project a simplified method, according to the DNV classification note, is applied with respect to long-term stress range that is postulated and assumed to follow a Weibull distribution. The initial stress range is based on dynamic loads as specified in the rules, but reduced to a probability level of daily exceedance. This approach may give accurate results compared to direct analysis (hydrodynamic model).

The FEM software Sesam GeniE is applied in order to find the hot spot stresses. The details that are modelled are end supports of longitudinals in main deck and bottom, in addition to deck openings. To ensure the right stress distribution towards the areas in question, a major part of the ship is modelled. This approach will also enable the shear lag effect and the right boundary conditions.

Operational Profile Study

In the diagram to the right shows the time spent and at sea and ports of an operating OSCV /3/. The diagram also distinguish between *at field* and *in transit* since it is important to see how frequently the loading conditions are used.



This is because the dynamic wave loading on the hull varies with the draught and load distribution, thus important to consider all frequently used loading conditions in fatigue evaluation.

The diagram confirms the assumption that the time at port (34 %) is significantly higher than for traditional vessels that are assumed to spend 15 % at port /1/. However, this is only based on one sample. Such data should be based on more samples.

Analysis and Results

Mean stress effect

Calculations shows that the typical end support of longitudinal in the bottom are subject to mean stress effect, i.e. the mean stress of the stress range is in compression and the magnitude is higher than half the stress range. This is due to the fact that the stillwater hogging moment is the driving factor for the hull girder scantling, thus great compression stresses in bottom. Consequently, the stress range is reduced by 30% for welded joints and 40 % for base materials /1/. Therefore, it is the details in main deck - where mean stress is in tension - that are of interest and assessed by a refined analysis.

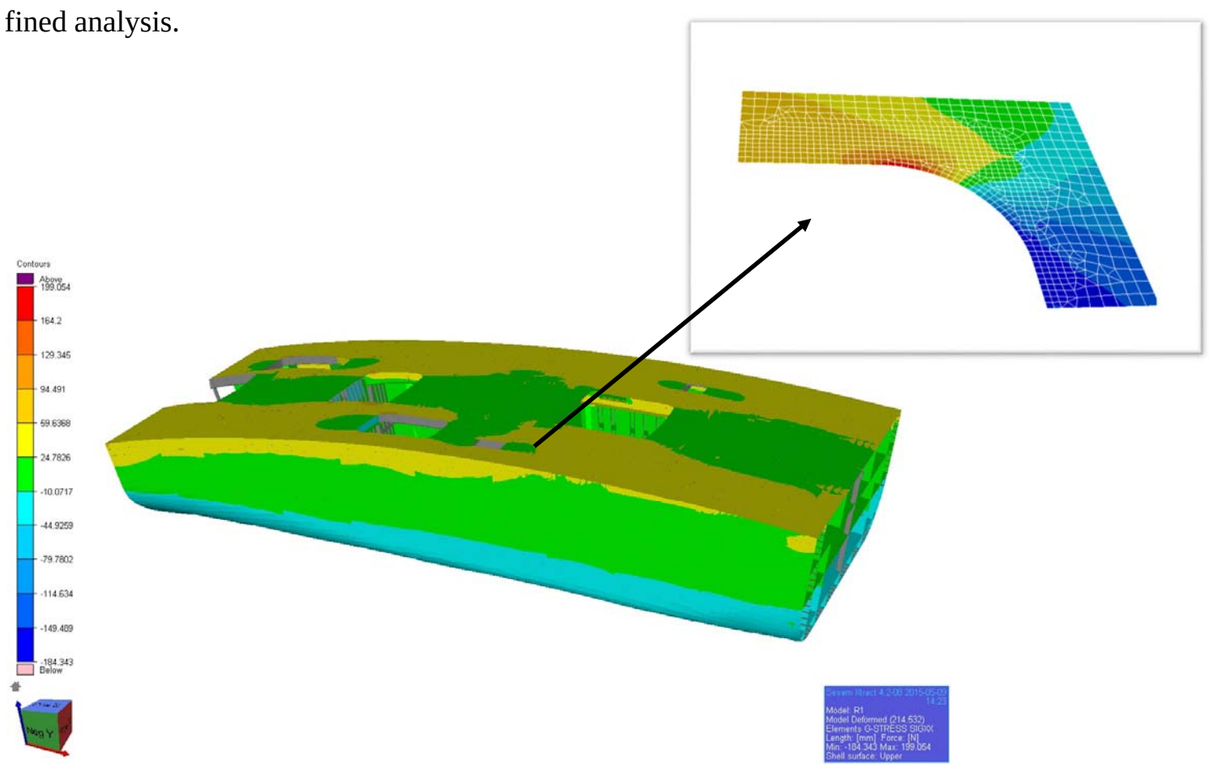


Figure 3 — Global FE model where wave induced vertical hull girder moment is applied, including local model of rounded hatch corner in main deck

Discussion and Conclusion

No conclusion have been made yet since final results is not finished yet. However, temporary and simple estimations have been carried out so far.

According to the classification note the method applied herein is assumed to give a good indication as to whether fatigue is a significant criterion for design, or not. So, if the results shows a fatigue life significantly higher than the standard limit of 20 years /1/, the conclusion may be that the design is satisfactory with respect to fatigue, and consequently FLS is not the driving factor for OSCV design.

To conclude on this issue and assess values with respect to fatigue life of the evaluated details are important for VARD Design.

References

/1/ - DNV Classification Notes NO. 30.7—Fatigue Assessment of Ship Structures.

/2/ - http://www.smsc.no/custom-simulations/lifting-operations .

/3/ - Espen Venge, DOF Management AS.

/4/ - Lars Erik Nygård, VARD Design AS