Evaluation of Wellhead Fatigue of Drilling Risers

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A study on the effect of top-tension

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AkerSolutions

Introduction

Oil and gas exploration is moving to more remote areas and greater depths. In addition, there is a demand for a higher recovery rate for each well. As a consequence, the time the drilling rig is connected to the well has increased. This leads to higher loads on the wellhead and an increased risk of failure of the wellhead. Wellhead Fatigue has therefore recently become a focus area in the industry and a Joint Industry Project (JIP) on Structural Well Integrity was initiated. The outcome was a unified Wellhead Fatigue Analysis Method (DNV, 2011).

Objective & Scope

A common assumption in the field of wellhead fatigue analysis is that maximum applied tension/overpull will lead to the highest fatigue damage. But, some drilling companies, Aker Solution among others, has observed that this assumption is not always correct. The objective of this thesis is therefore to investigate the effect top tension has on Wellhead Fatigue.

Therefore a global load model is to be established in SIMA/RIFLEX according to the Wellhead Fatigue Analysis Method for each case. An eigenvalue analysis and a regular/irregular analysis should be performed. To investigate physical effects that governs the response, moment histograms and relative fatigue calculations is to be carried out and investigated, focusing on the role of tension.

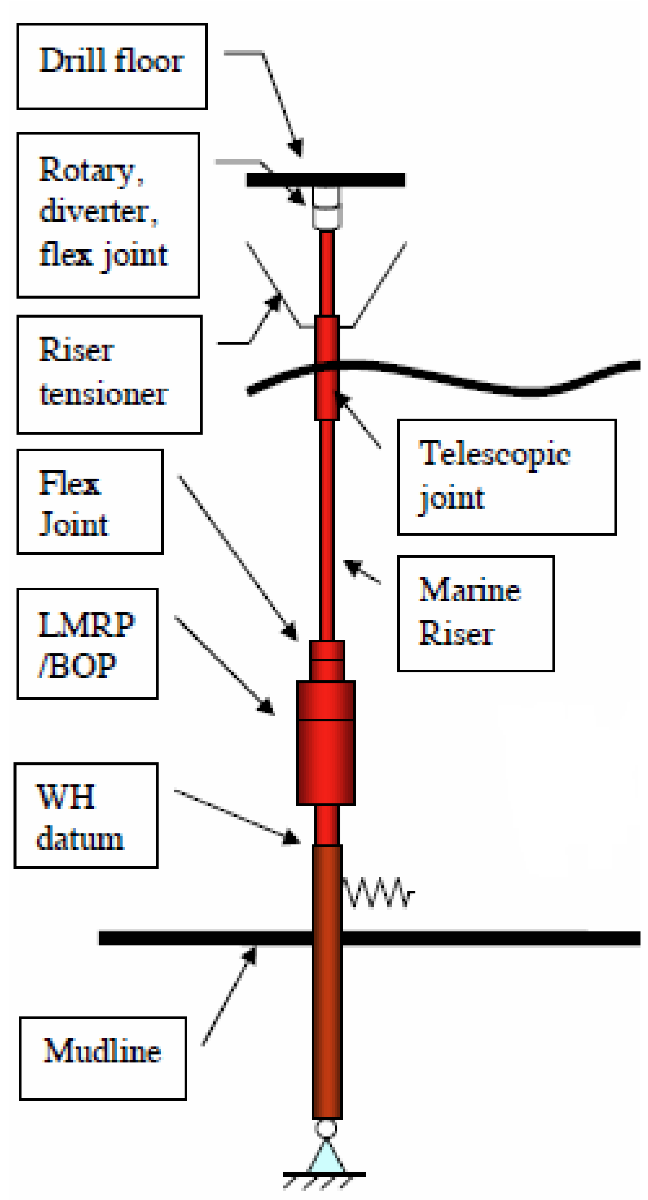

Figure 1 Riser Model (DNV, 2011)

Modelling & Analysis

To obtain the loading on the wellhead a global load analysis is carried out in SIMA/RIFLEX. To investigate the effect of top tension different cases is investigated:

- 5 different water depths
- 9 different tensions, with an overpull range of 25 - 100 t
- 3 different wellhead stiffnesses

The riser model is built by input data given by Aker Solutions and the riser stack-up can be seen in Fig. 1. The simulations are run using time domain analysis.

From the global load analysis time series of the bending moment on the wellhead are obtained. Then calculation of bending moment histograms and fatigue damage is carried out using MATLAB.

Presentation & Evaluation of Results

When comparing the bending moment histograms for the different overpulls (Fig. 2) it is observed that for the lowest overpulls, the peak in number of cycles and peak in bending moment range increases in magnitude. It is therefore expected a high fatigue damage for the lowest overpull, as each high moment cycle will give a large contribution to fatigue. For the overpulls around 80 ton it is observed a lower peak and bending moment range, therefore less fatigue damage is expected. 100 t overpull is located between the two extremes, thus expecting higher damage than for 80 t, but less than for 25 t.

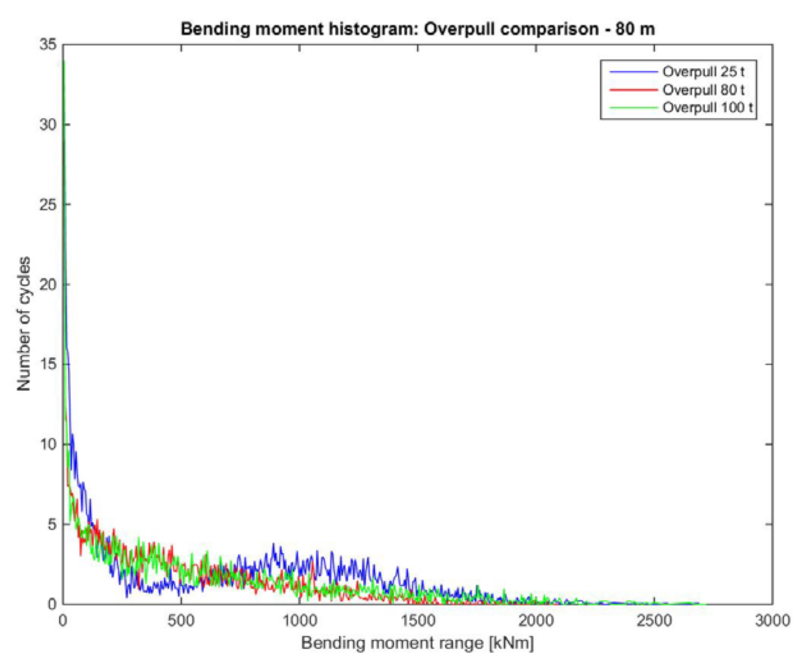

Figure 2 Bending Moment Histogram. 80 m Water Depth. Overpull Variation

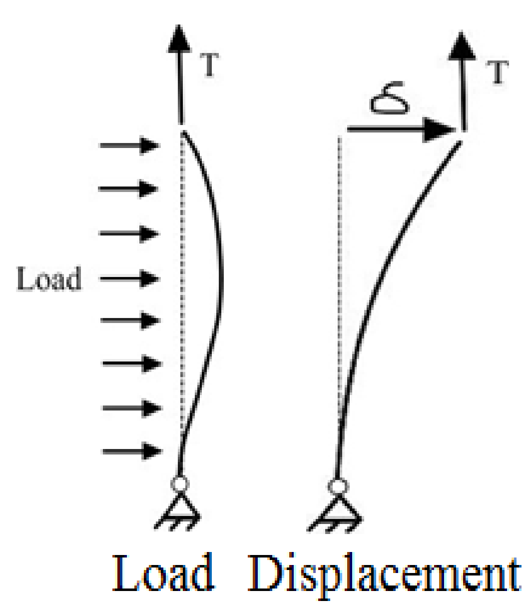

Figure 3 Analytical Model - Phenomena's governing riser behavior

Presentation & Evaluation of Results

The fatigue damage is calculated for the different water depths and overpulls (Fig. 4).

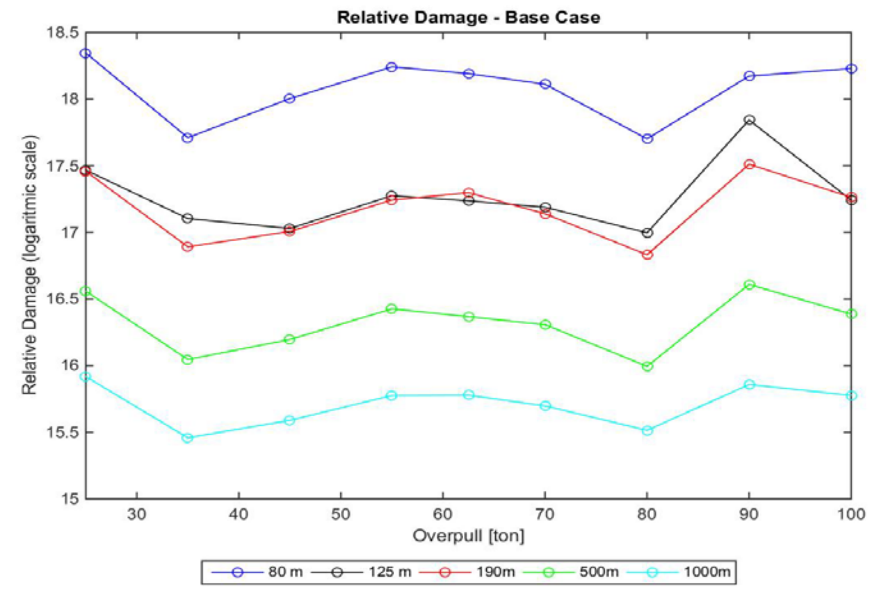

Figure 4 Fatigue Damage - Variation in Water Depth and Overpull

The fatigue damage reduces for increasing water depth, which is expected as the displacement of the rig is equal for all depths, leading to a smaller movement (and thus loads) on the wellhead for greater depths. In addition, it is seen that the largest damage occurs for the endpoints. For the lowest overpull, the riser is allowed to have big displacements, leading to large moments on the wellhead. For the largest overpulls the system is very stiff, leading to large loads on the wellhead. Two different phenomena's govern the behavior of the riser: Displacement- and load controlled behavior (Fig. 3). A trend line can be established based on these phenomena (Fig. 5

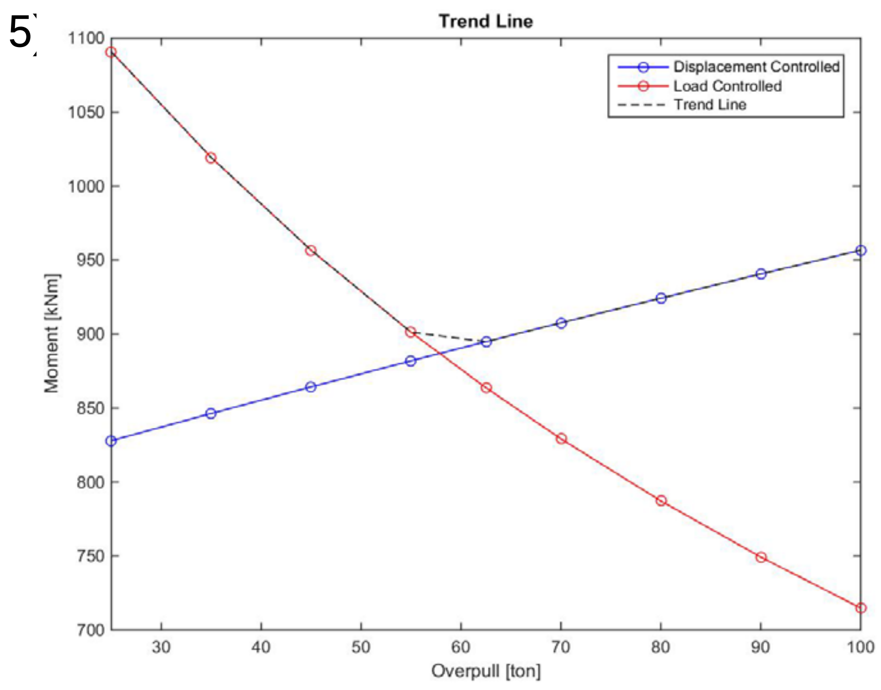

Figure 5 Trend Line

Conclusion

- The damage varies with overpull, and it is not necessarily the largest overpull that gives the highest fatigue damage.
- Selecting the most beneficial overpull may result in reduced fatigue damage.
- The riser is governed by both a load- and a displacement controlled phenomena.
- The damage is expected to mainly follow the trend line, but combination of modes may lead to especially beneficial/ unbeneficial loads acting on the structure.

References

DNV (2011). Wellhead Fatigue Analysis Method: JIP Structural Well Integrity. Report no/DNV Reg No.: 2011-0063/ 12Q5071-26, DNV.