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ANALYSIS OF TOWED SUBSEA PIPELINES IN RANDOM SEA

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INTRODUCTION

Offshore pipelines are conventionally installed using either lay barges or reel barges. In the first case, prefabricated pipeline segments of around 12 m in length are welded together on the barge as the pipeline is being laid. In the second case, up to 25 km of prefabricated pipeline is wound on a large diameter reel and the laying operation consists of unwinding the reel and straightening the `pipe. The reel barge method avoids the need for large scale offshore welding operations but has the disadvantage of being applicable only to relatively small diameter pipelines. A third approach, which is applicable to pipelines of arbitrary diameter, is to fabricate the pipeline on shore and then tow the resulting lines to the offshore site.

In planning a pipeline tow, care must be taken to ensure that the pipeline will not be damaged by either wave action or the manoeuvring which occurs at the launch and final installation stages.
In this paper, the response of a long towed pipeline to random spreading seas is considered. A dynamic model was used according to the type of Tow method and nonlinear response of the pipeline is carried out in both time and frequency domains. Distribution of bending stress that made with random waves and related to wave excitation was shown to analyze the motion of the pipeline. The responses of the pipeline mooring system related to wave excitation was done to analyze the motion of the unit with its mooring system.

Fig. 1)Pipeline Tow Method

MODEL PERFORMANCE

An OrcaFlex winch model is used for simulating the connection between the tug and tow wire at each pipeline end. Wave conditions are defined by regular waves for the strength design check and sensitivity analysis during tow. Irregular waves according to the JONSWAP energy spectrum are used during the fatigue analysis. The density distribution (JONSWAP) is calculated by the formula

$$S(f) = \frac{\alpha.g^2}{(2\pi)^4.f^5}.\exp\left[-\frac{5}{4}\left(\frac{f}{f_p}\right)^{-4}\right].\gamma^{\exp\left[\frac{-(f-f_p)^2}{2\sigma^2 f_p^2}\right]} \quad (1)$$

The main parameters for defining the spectrum are the significant wave height, spectrum peak period and γ.

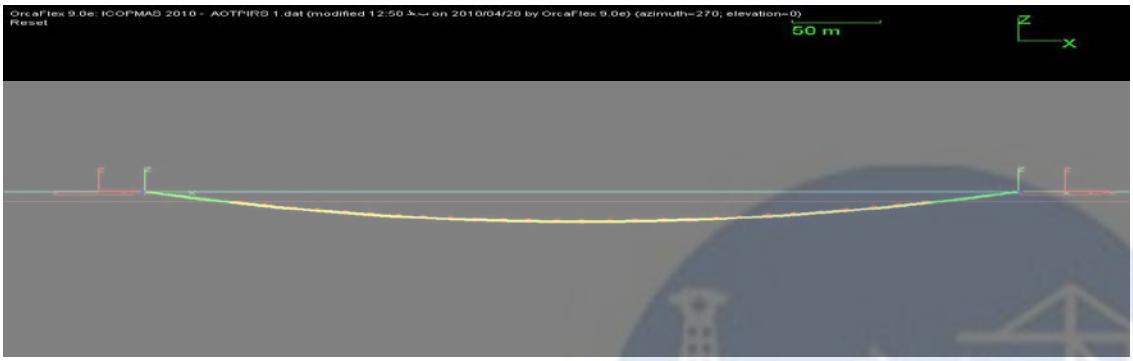

Fig. 2 Configuration and components of Towed Pipeline

STATIC ANALYSIS

Static analyses are performed in order to set the Van Misses stress. The values of Stress distribution for the static tow configurations are used as input in the dynamic sensitivity analysis.

SENSITIVITY ANALYSIS

Sensitivity analyses are performed in order to set the worst wave heading and peak period.

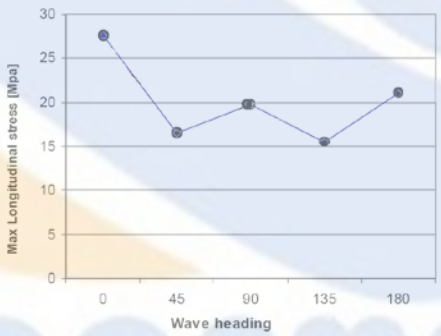

Fig. 3 Maximum Longitudinal stresses of Towed Pipeline

FATIGUE ANALYSIS

The stress time series are calculated based on the stored force time series (axial and bending stresses) and the pipeline parameters using specified S-N curves. The S-N curves are found in DNV-RP-C203. The fatigue damage for the deepwater pipeline is calculated for a specified number of points on the pipe circumference. The irregular sea state is simulated for 60 minutes to obtain a stable statistical basis for the fatigue damage calculations.

Conclusion

The researches on the nonlinear dynamic response of the towing pipeline can provide a basis to optimize the mooring design. The governing criteria for these investigations are the resistance against local buckling, tow wire tension and fatigue damage.

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