Small Water Plane Area Solutions To Access of Offshore Wind Turbines

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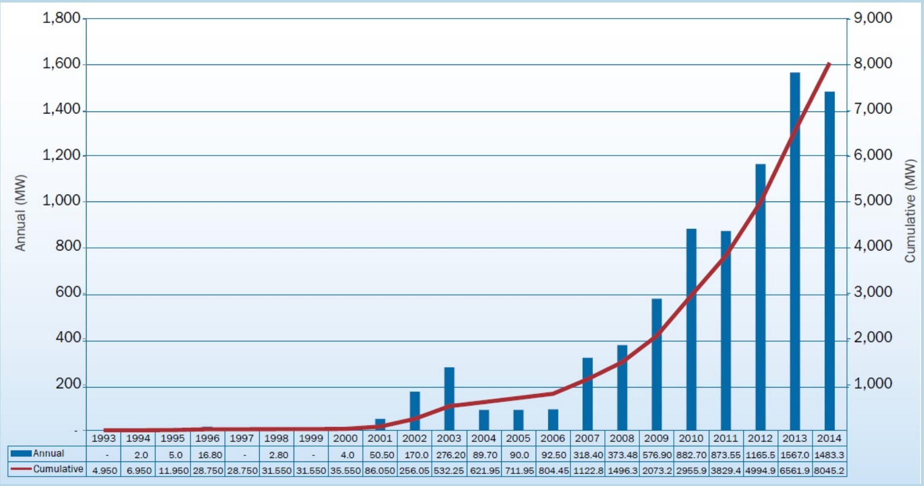
Introduction

In Europe 2014, 536 wind turbines were erected offshore, an average of 5.9 MW connected to the grid per day. 63.3 % of the installed capacity is installed in the North Sea[2]. This new and emerging market represents an opportunity for Norway to make use of our knowledge about marine operations in the North Sea from the petroleum industry.



Fender docking

Due to its simplicity and lack of vulnerable expensive parts, fender docking is popular in the offshore wind industry today. On the picture below you can see a catamaran from Windcatworkboats AS doing a access.

Key assumptions

The key assumptions made in the method proposed by [1] are the following.

- Fender Dynamics neglected
- The vessel is capable of applying a constant normal thrust into the fender at all times
- 1.order wave loads are dominant, i.e current,wind etc is neglected
- No hydrodynamic interaction with wind turbine
- Linear potential theory

Discussion of results

The differences between the results obtained by the Matlab program and the SIMA model was quite extensive. For 5 and 7 seconds peak period in head sea the results from the frequency domain was conservative. For 9 seconds peak period in head sea , no definite conclusion could be made. While for quartering and beam sea the results from the Matlab program was found to be quite non-conservative compared to the SIMA-results. The tendency in the SIMA simulations was that the vessel usually slipped upwards. This points to that the assumption that the vessel is capable of applying a constant normal thrust into the fender at all times neglecting the vertical and horizontal force contribution is questionable. If the vessel have a pitch angle of 5 degrees, and the bollard thrust is 200 kN there will be a additional 17 kN vertical force that will need to be restrained by the friction force in the fender. This effect is neglected in [1], and is the main suspect as the reason to the large deviations between the results from SIMA compared to those obtained in the frequency domain method.

References

[1] MingKang Wu: *Numerical analysis of docking operation between service vessels and offshore wind turbines*, Ocean Engineering, Oktober 2014

[2] Giorgio Corbetta, Ariola Mbistrova *The European offshore wind industry - key trends and statistics 2014*, European Wind Energy Association , January 2015

Scope

Due to regular maintenance and unexpected repair needs, a wind turbine needs to be accessed by technicians about three times a year. In an immature industry, no one has still developed and implemented a sufficiently robust way to transfer personnel and spare parts to the turbine. This has proven to be a costly problem for the industry. Another problem is the way to analyse and compare different access concepts, time domain simulations as used widely in offshore industry is time consuming and expensive as you in principle should run one for each combination of peak period, significant waveheight and direction of the seastate for each concept. Therefore MARINTEK's MingKang Wu in 2014 proposed a way to calculate the limiting significant wave height for all combinations of peak periods and directions in the frequency domain.

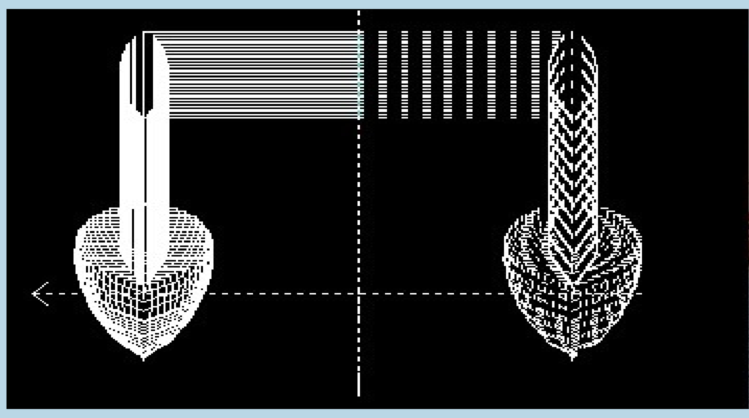
Today the standard in the industry is to have a single limiting Hs, independent of direction or period. As every student in marine engineering knows, the response of a floating vessel depend heavily on the period and direction of the seastate. So instead of a single limiting Hs, one can argue that each vessel should have a limiting Hs for each combination of wave period and direction it might encounter.

At Doggerbank, an offshore wind farm partly owned by Statoil and Statkraft the moderate seastates where access is realistic in general have peak periods in the area 5 to 9 seconds. Having a small water plane area vessel designed to have low responses in this frequency area, such as a SWATH or a small semi-submersible might prove to be the robust access solution the industry have been looking for. So this thesis have three focus points:

1. To validate the frequency domain method proposed by [1] with time domain simulation in SIMO
2. To explore what parameters that should be included in the accept criteria for making access
3. To explore the potential of a small water plane area concept with respect to weather data from Doggerbank

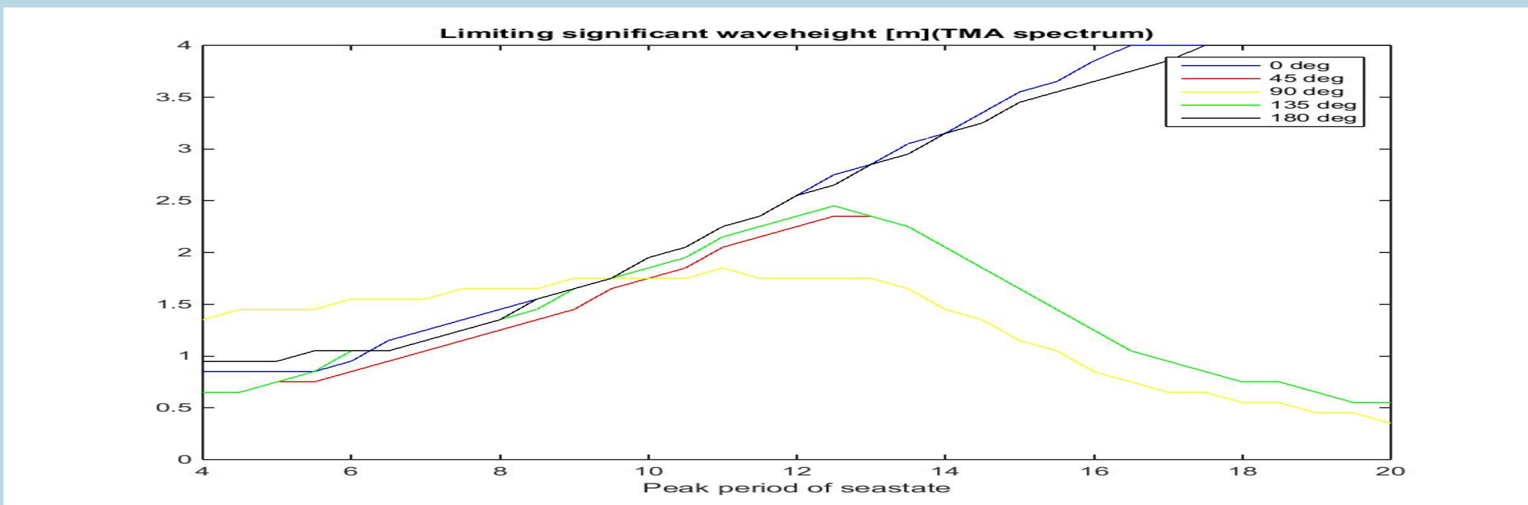
Choice of concept

Due to it's superior velocity to a semi-submersible, I have chosen to analyze a concept SWATH inspired by the FOB swath used by Oddfjell Wind AS. This was created and analysed in VERES to obtain the hydrodynamical data.



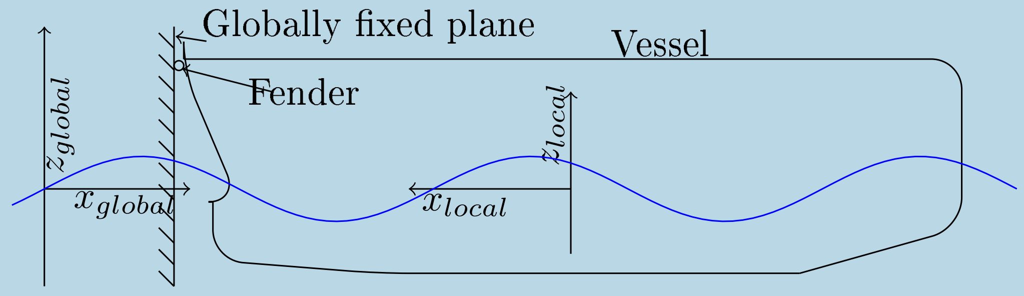
Results

The following plot of limiting significant waveheight was produced with the frequency domain method scripted in Matlab. We observe that the limiting significant waveheight varies significantly with period and to some extent of the seastate direction.



Verification in SIMA

To verify the results found by the self written Matlab program a model was established in SIMA with the same hydrodynamic data imported from VERES. The model is shown below, the fender modelled is a D-shaped fender from Longwood Marine Fenders.



The results from the time domain simulations suggests that the vessel are far more vulnerable to beam and quartering seastates than head sea. In the case of limiting significant waveheight, the SIMA simulations suggest that it depend significantly on both direction and peak period.

Conclusion

With respect to the focus points of this thesis, I have not been able to verify the method proposed by [1].It seems to be a too simplified method, with too many questionable assumptions. About what parameters that should be included in the accept criteria, it seems clear that both direction and peak period of seastate should be included. The producers of classical workboat catamarans claims that their vessels can access an offshore wind turbine in Hs up to 1.5 m without considering Tp nor wave direction, comparing this with the results from the Matlab program and SIMA the SWATH concept analysed can not outperform this. One should nevertheless have in mind that as this is not a design thesis the concept investigated is not optimized and that a optimized vessel surely would outperform the SWATH considered here. As well the limit of 1.5 m Hs might only be valid in favourable seastates, this belief is supported by wind farm owners reporting of workboats not being able to perform as promised in all seastates.