Marine Operations in the Aquaculture Industry with focus on Safe Wellboat Operations

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Introduction

Through several decades the offshore petroleum industry has developed rules and regulations which ensures that marine operations are carried out with use of high competence, and with the lowest possible associated risk for personnel, equipment and the environment. In the aquaculture industry, the marine operations are challenging the limit of what humans, fish and equipment can handle. The thesis will assess whether the aquaculture industry can learn from the petroleum industry's handling of marine operations.

Objective and Scope of Work

The overall objectives are listed as:

1. Identify gaps in regulations related to planning and execution of marine operations in the aquaculture industry.
2. Establish a numerical model of a wellboat operation in SIMA.
3. Determine operational limits based on simulations. Discuss the variability and sensitivity of changes in weather parameters and the degree of pre-tension in the mooring lines.

Aquaculture Regulation Remarks

- The NYTEK regulation, which refers to NS 9415, is one of the most important regulations that the aquaculture industry must follow. The main focus in this standard is to prevent fish escapes. Neither NYTEK nor other central regulations include how to plan and execute marine operations sufficiently.
- DNV-OS-H101 "Marine operations, General", could have been used as a basis for developing a similar regulation for the aquaculture industry.
- A supervisory body should be appointed to control and verify that the regulations are being obeyed.

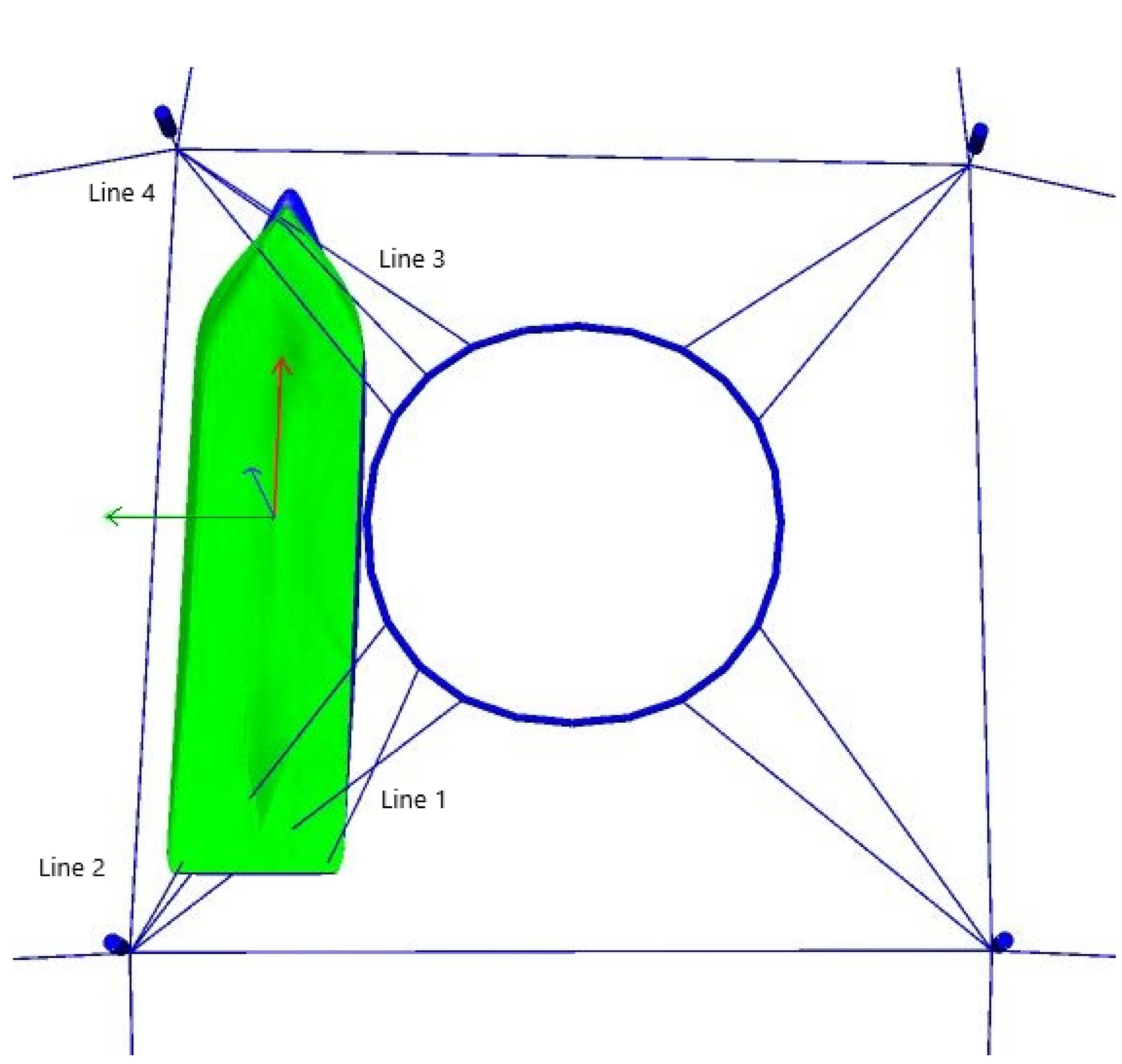
References

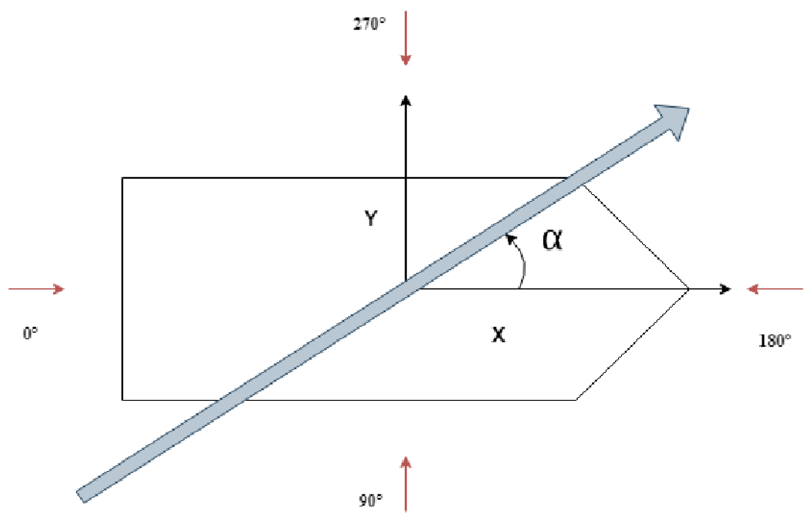
[1] Harald Ormberg, Kjell Larsen (1998): *Coupled analysis of floater motion and mooring dynamics for a turret-moored ship*, Applied Ocean Research, Vol:20, pages:55-67

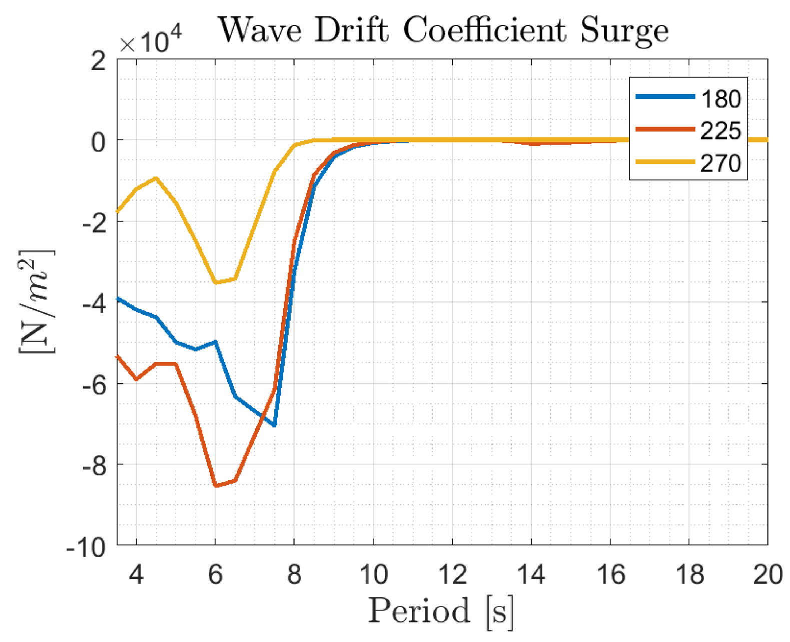
Acknowledgements

I would like to thank my supervisors *Kjell Larsen* and *Pål Lader* for their encouragement and inspiration during the master thesis, and *Martin Søreide* for providing essential information about the aquaculture industry. Phd candidate *Carlos Eduardo Silva de Souza* deserves acknowledgement for guidance and good help with the software SIMA. Finally, I would thank *SINTEF Ocean* for providing the wellboat model.

Numerical Model in SIMA







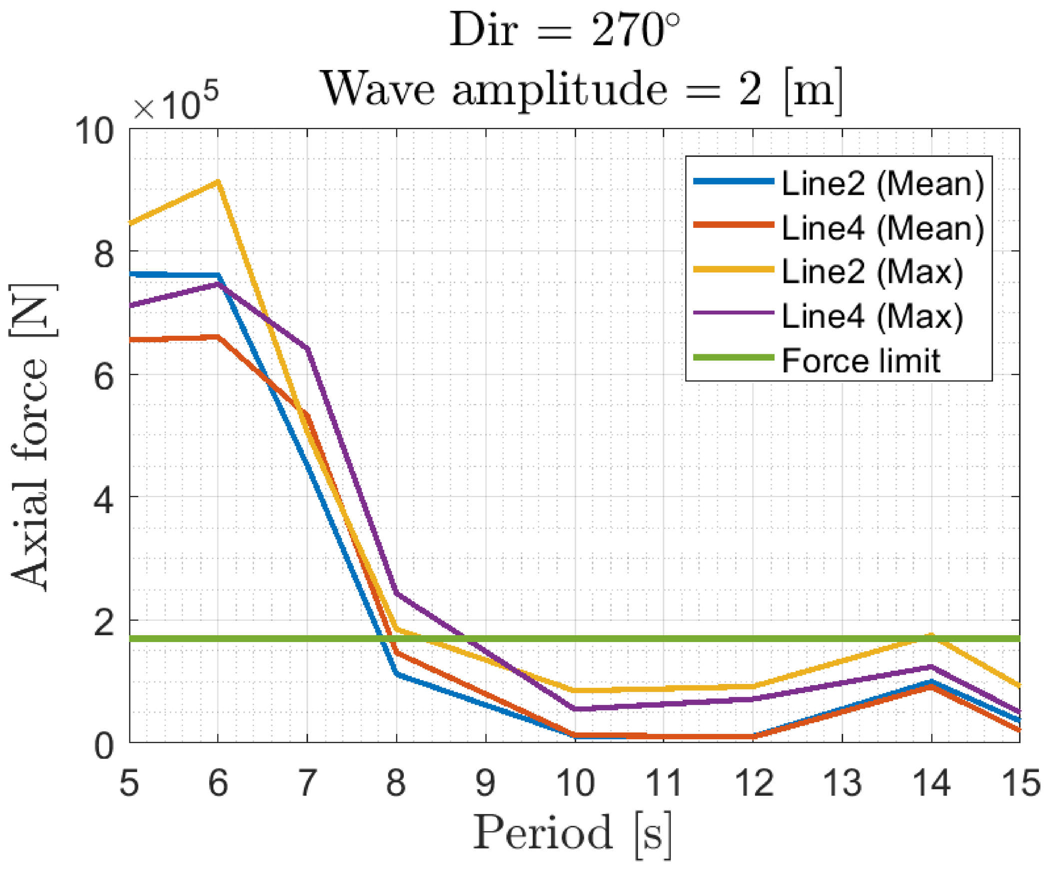
In the thesis a coupled SIMO-RIFLEX model is analysed. This means that the equation of motions (Eq.1) for the entire system including both the wellboat and the cage system are calculated simultaneously [1]. The wellboat was moored to the cage system by using four lines. Several measures was performed to verify that the model were within reasonable values, and to detect the system properties. By examining the wave drift, wind and current coefficients, the RAOs, decay and pull-out test, reasonable values were confirmed.

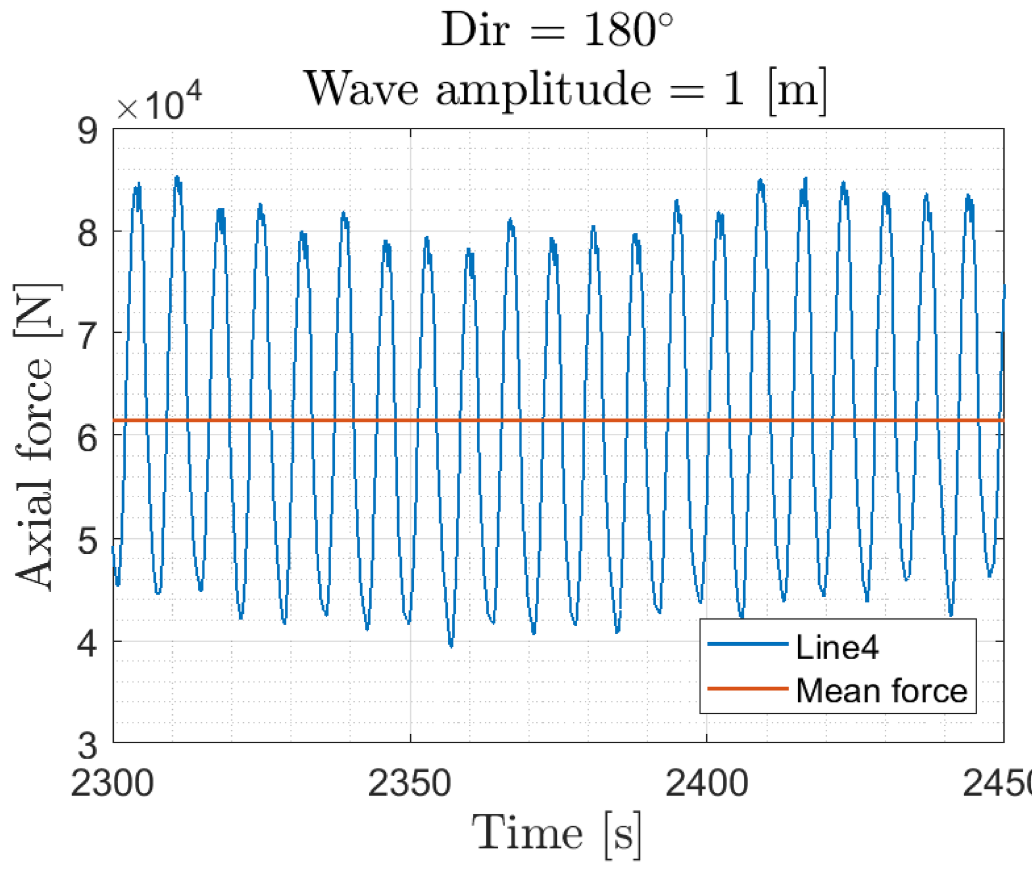
$$(M + A(\omega)) \cdot \ddot{r} + C(\omega) \cdot \dot{r} + D_l \cdot \dot{r} + D_q \cdot \dot{r}|\dot{r}| + K(r) \cdot r = Q(t, r, \dot{r}) \quad (1)$$

Simulations was performed to examine the operational limit's sensitivity to changes in the weather loads by varying the following parameters; weather directions, wave amplitude and period, and with or without wind and current. The breaking strength of the vessel's mooring lines with a safety factor of three was chosen as design parameter for determining the operational limits. The industry do not have any specified procedures on how mooring lines should be pre-tensioned, other than providing sufficient tightening. The operational limit's sensitivity for different applied pre-tension is therefore also discussed.

Results and Conclusion

The operational limits are sensitive to short wave periods due to large wave drift forces. The wave drift forces are dependent on the wave amplitude squared, thus an increase in the amplitude will cause a significant increase in these forces. To maintain sufficient safety when the wave amplitudes are high, the period must be long, as the wave drift forces approach zero for long periods. The operational limits are sensitive to changes in the incoming load direction from waves, wind and current. For the directions analysed in the thesis, the results suggest that the system is most vulnerable for bow sea, and least exposed in head sea. If the system is exposed to wind and current in addition to waves, the total mean forces acting on the system will increase, thus reducing the operational limit. Nevertheless, when operational limits are to be established, the results show that the wave forces are most prominent. The system's natural periods must also be considered, as corresponding wave periods can cause a significant increase in the vessel's response.





Operational limits shall take uncertainties in the weather forecast into account, by applying alpha factors. The operational limits established in the thesis has not considered alpha factors, as these factors are not developed for the industry. Results from the sensitivity analysis of pre-tension suggest that the system is not particularly sensitive to the amount of applied pre-tension.