Simulation of Marine Lift Operations with Focus on Structural Response Control

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Motivation

As the oil and gas industry are moving into deeper and deeper waters to find oil the use of subsea modules becomes more common. The understanding of forces and responses in marine operations is important to be able to install and maintain the modules. The overall goal is to increase the time window to do the marine operations.

Task

My task is to investigate the use of the program USFOS to do crane lift simulations. This program is not commonly used for this, as its main purpose is to calculate loads and capacity in fixed marine structures. Such as jacket plat- forms. However the program can calculate forces on and responses of hanging structures. This way it is possible to make a crane simulation in USFOS. According to DNV (2011) chapter 3,the typical phases of a subsea lift is:

- lift off from deck and maneuvering object clear of transportation vessel
- lowering through the wave zone
- further lowering down to sea bed
- positioning and landing.

The lowering through the wave zone was investigated in this thesis.

Typical subsea equipment

Manifolds are often in system with each other, protected by a tubular frame. AkerSolutions (2014*b*)

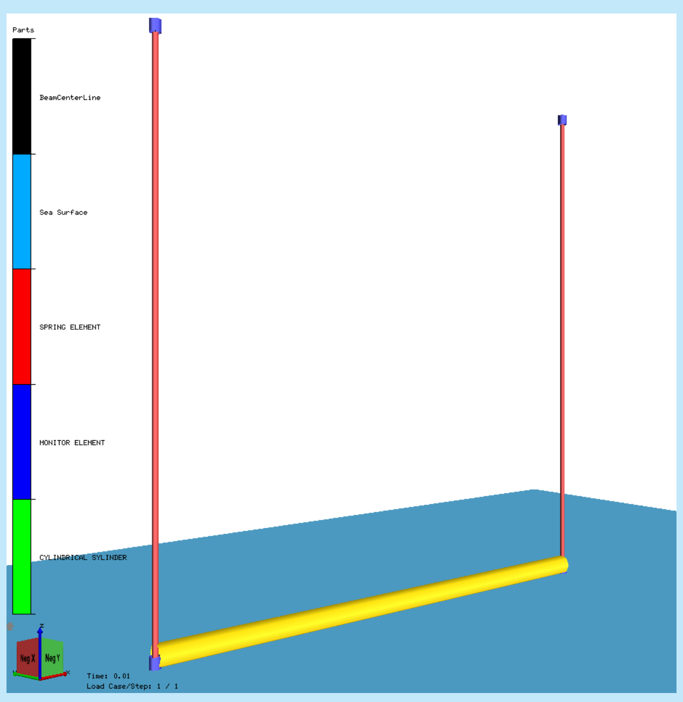
Large subsea modules with power and processing equipment inside a protective frame. AkerSolutions (2014*a*)

The typical Tie-in connection is a spool. It connects different modules within short distances. It consists of a rigid pipe.AkerSolutions (2014*c*)

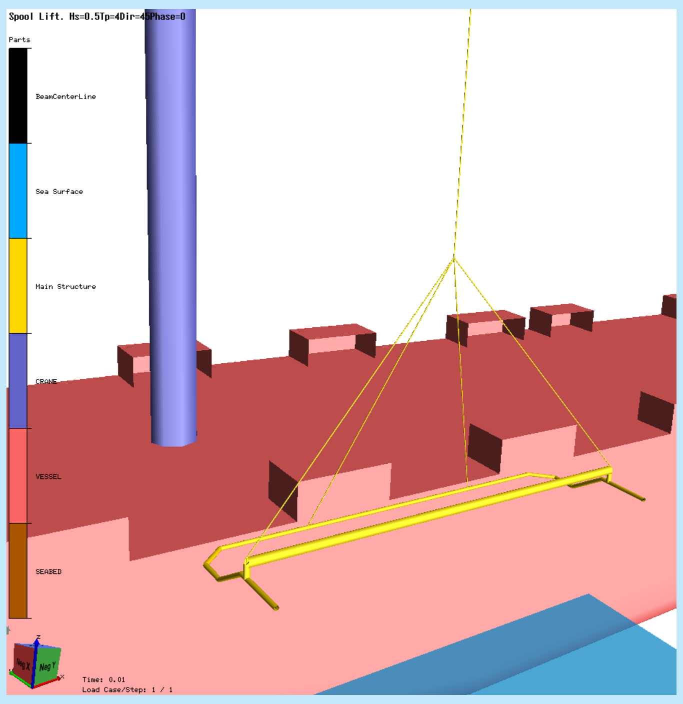
Models

In this thesis the spool module is investigated. Two different models were made for simulation:

- Simple model
- Advanced model



Simple model. Tubular member 45 m long with 2 m i diameter. Suspended by two springs.



Spool with a spreader beam. Suspended by single spring with 4 slings.

- The simple model was used to verify the following uses of USFOS.
  - Drag
  - Weight in air and water
  - Slamming
  - When the largest force in 3 hour sea state occurred.
  - Use of "spool wave" function in USFOS
- The advanced model was used in limit studies, to find the limiting sea state for the module.

References

AkerSolutions (2014*a*), 'Power and processing figure'.
URL: *http://www.akersolutions.com/Global/Subsea/Subsea products/Product images and documents/Power processing boosting/AkerSolutions_Power_and_processing_320.jpg*

AkerSolutions (2014*b*), 'Small manifolds system'.
URL: *http://www.akersolutions.com/Global/Subsea/Subsea products/Product images and documents/Manifolds/manifoldsstructures320x320.jpg*

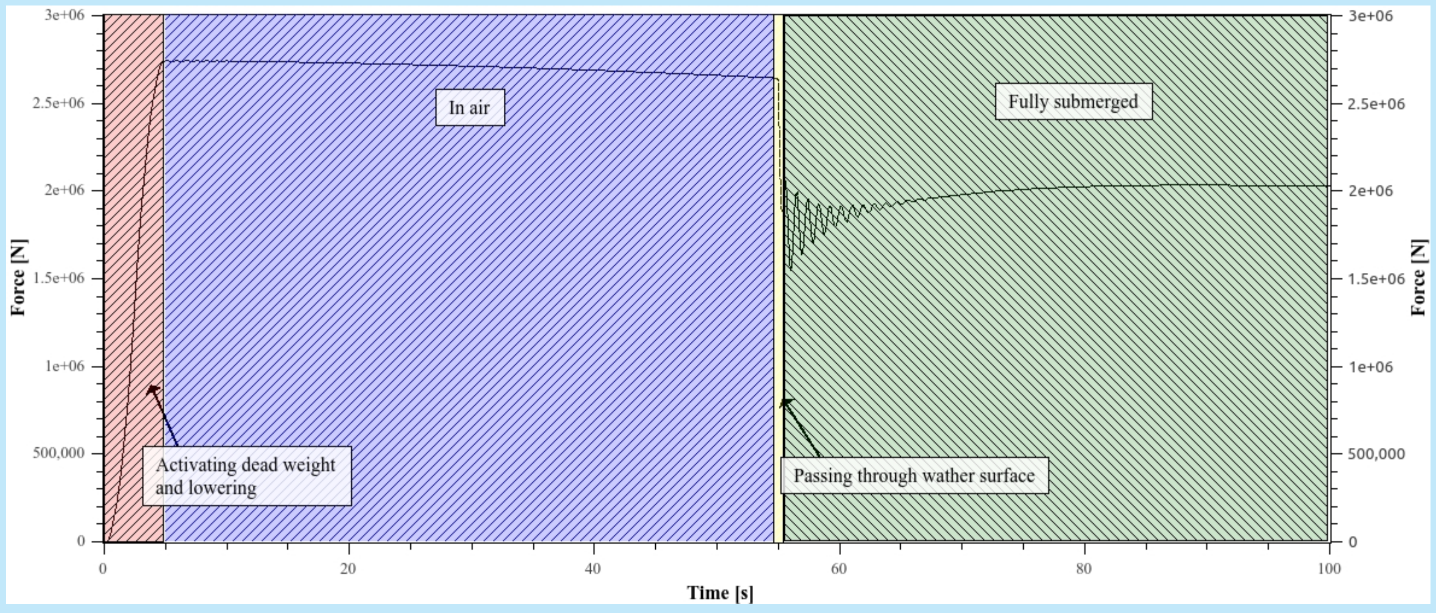
AkerSolutions (2014*c*), 'Tie-in connection systems figure'.
URL: *http://www.akersolutions.com/Global/Subsea/Subsea products/Product images and documents/Tie in connections tooling/VCS internet 320x320.jpg*

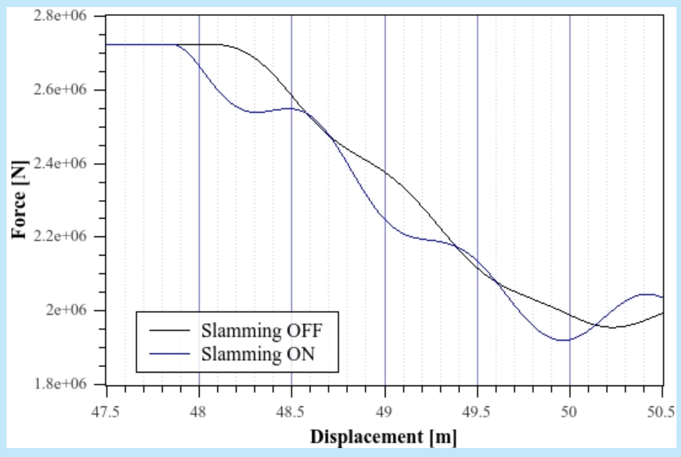
DNV (2011), 'DNV-RP-H103: Modelling and Analysis of Marine Operations', (April).

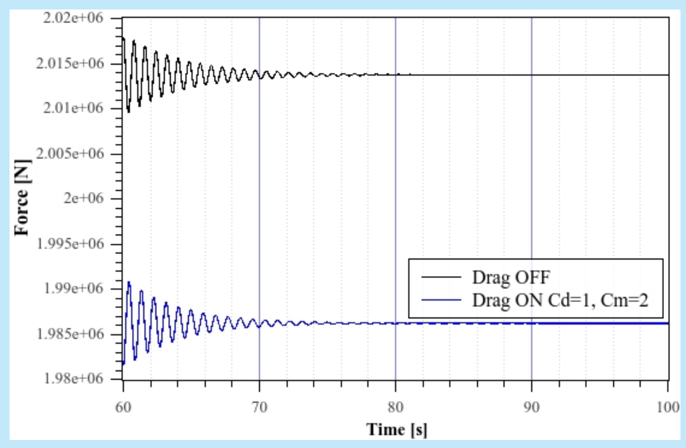
Simple model

The forces were read from a monitor element set in the end of the spring element. There were four phases in the force history. From these all the results for the verification were found.

- First phase: The deadweight is activated and lowering starts.
- Second phase: Hanging in the air. Reading the weight in air.
- Third phase: Passing through the water zone. Reading the effect of slamming.
- Fourth phase: Reading drag effect and the weight in water.

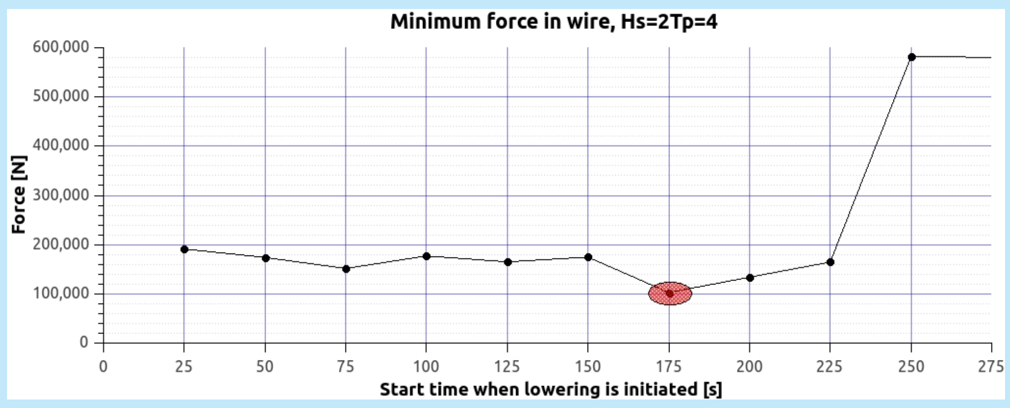


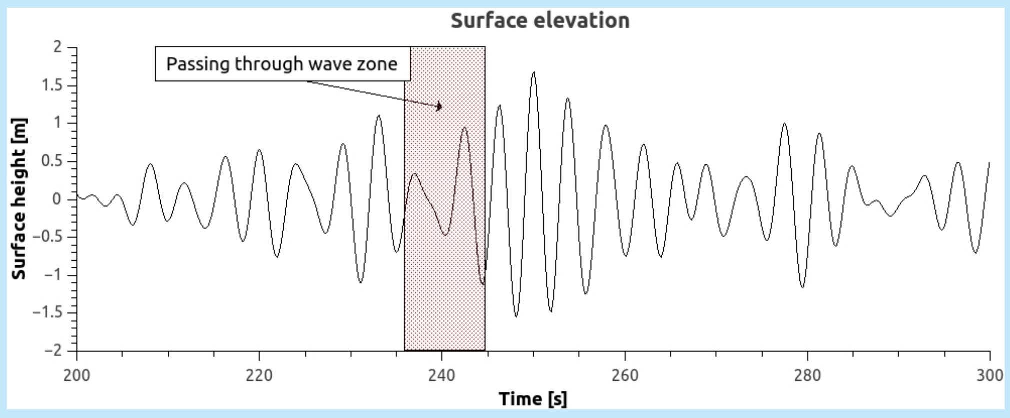




Advanced model

The "spool wave" function in USFOS provided the largest wave in a 3 hour sea state. Analyses starting 250 seconds before the largest wave had hit the module secured that the initial motions of the module were correct when the module hit the water surface. When the the module should be lowered is plotted below.





The lowest and largest forces were registered for a range of different sea states in the JONSWAP spectrum. Since the sea was irregular, the simulations were done several times to establish a probable force.

Significant wave height(H_s)	Spectral peak period (T_p)
1	4 and 12
2	5 and 16
3	5 and 16
4	7 and 15
5	7 and 15

When finding the limit of operation for the module, forces in the wire were checked against slack (minimum force). Plotting in gumble paper gave the probability of exceeding the given minimum force: