Master Thesis in Marine Technology – 2017
Designing an Offshore Liquid Bulk Support Vessel using System Based Ship Design Methodology

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Objective

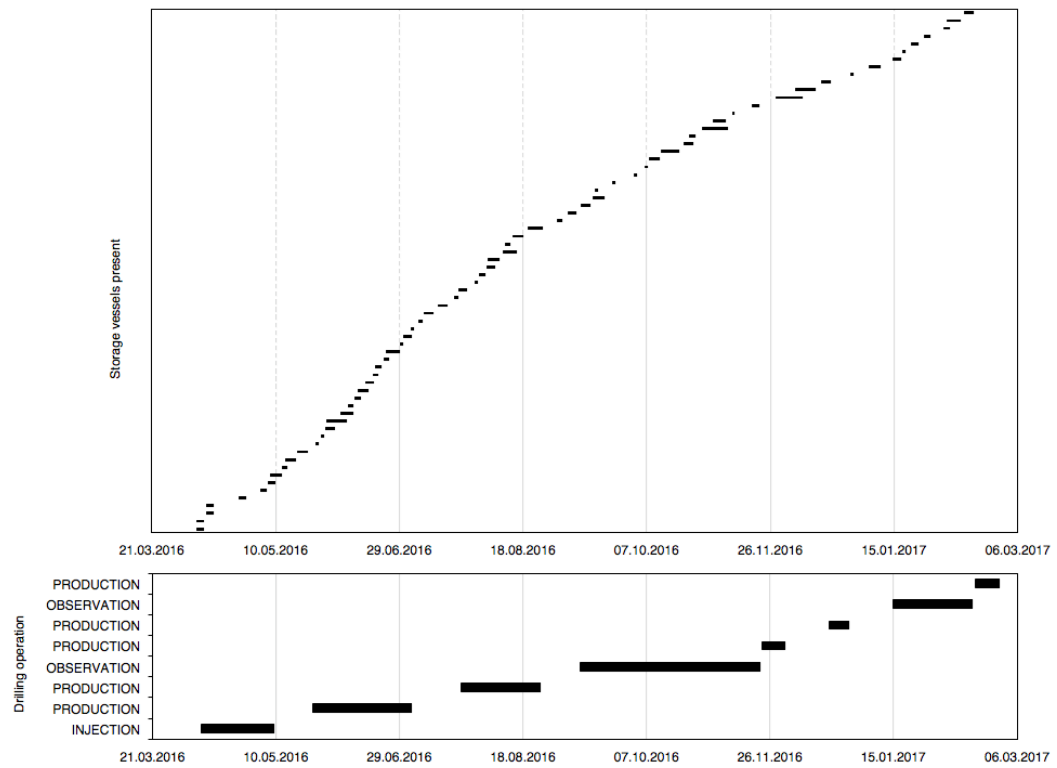
The overall objective is to design an offshore liquid bulk support vessel that reduce transportation of oil-based drilling fluids between offshore drilling units and onshore facilities. Dedicated storage vessels present on the field today have the potential to not only store oil-based drilling fluids but also perform processing and improvements on the fluid while present on the field standby. The drilling fluid can then be used in a new drilling operation without the need for onshore treatment.

Introduction

Today platform supply vessels are used to transport drilling fluids in liquid bulk tanks from onshore storages to offshore installations. On the return trip; wastes and used drilling fluids are transported to shore for disposal and storage, respectively. Used drilling fluids are either; treated onshore and stored to be used in a new drilling operation, or sent to a recycling facility for disposal. The cost of oil-based drilling fluids is substantial and reusing the drilling fluid is profitable for the drilling operators. Although drilling operators follow a drilling plan, operations almost never progress according to the drilling plan and thus planning the logistics are difficult for the operators. Due to high uncertainty regarding drilling fluid demand during drilling operations, additional support vessels are needed in addition to the original routed vessels. Dedicated storage vessels are present next to the platform during drilling operations to assist the operation with storage space for drilling fluids and equipment.

Market situation

Analysis of vessel and drilling activity at the drilling platform "Oseberg Øst" shows that during drilling operations, storage vessels (PSVs) are frequently visiting the platform to support the drilling operation, as shown in the figure. In the time period between March 2016 and March 2017 eight wells were drilled at Oseberg Øst. During this period one or several dedicated storage vessels were present at the field in 92 % of the time with an average stay time of 83 hours. According to drilling fluid engineers, these vessels are already storing drilling fluids during drilling operations and by installing equipment onboard, one can increase the quality of the drilling fluid offshore, which will increase overall drilling productivity. When the platform is done with the fluid, drilling operations nearby can use the same drilling fluid after being processed. A total of 52700 tonnes of oil based drilling fluid (OBM) was used at the Oseberg field in 2016. 48% of this mass were sent back to shore after use. 250 loads of OBM were delivered or picked up at the Oseberg field alone in 2016. Tests done at another installation shows that installing a drilling fluid treatment system can reduce the return-OBM from 48% to 29%, reducing the overall need for OBM transport.



Methodology

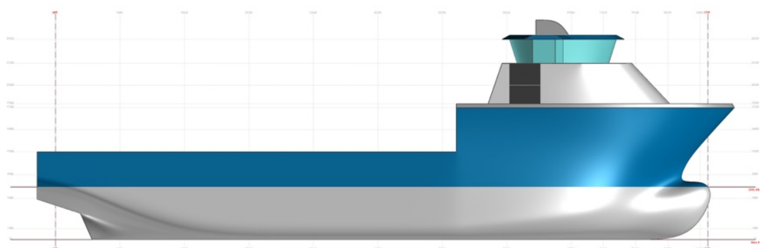
The system based ship design (SBSD) methodology, developed by Kai Levander is used in this thesis to create a vessel design. First the market situation is evaluated by analyzing platform supply vessel movements and operations at the shelf during drilling operations. Then drilling operations are investigated to identify potential functions that can increase reuse of drilling fluids. This will serve as an input to upcoming steps in the design process and will determine what kind of functions that are required to be installed in the vessel.

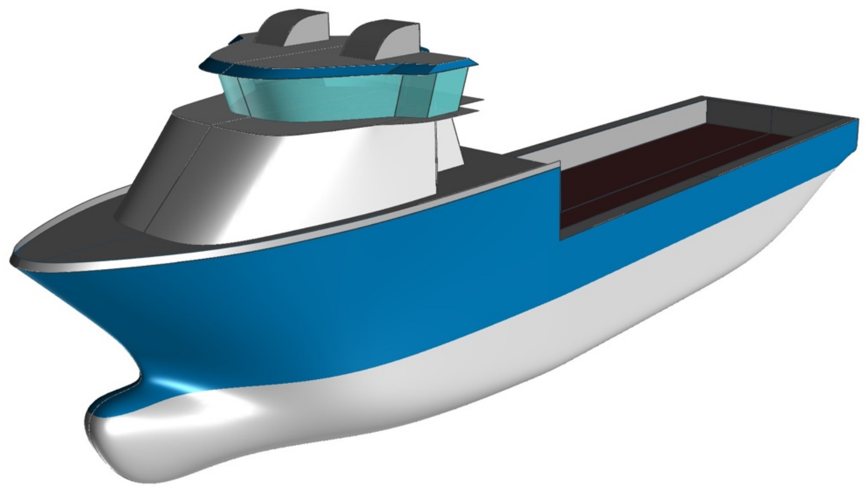
Based on the market evaluation, vessel systems are selected and the vessel hull is developed by building the hull around these systems. Systems space- and weight requirement determine the gross tonnage and displacement of the vessel and main particulars can now be decided.

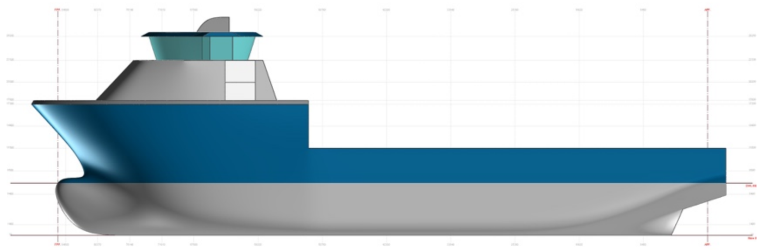
The main dimensions and vessel coefficients developed now serve as input to the 3D-modeling and general arrangement drawings of the vessel. When a 3D-model of the vessel is made, hull lines are exported from the 3D-model into a 2D-drawing software to draw the general arrangement. Vessel resistance, propulsion, stability and operational profiles are then calculated and evaluated to determine the vessel performance.

3D Modelling

A 3D model is made using DELFTship marine software. The hull is built "around" the systems needed in the vessel (based on the vessel mission). The hull lines are made by comparing the volumes needed in this design with similar vessels already built (SBSD method). These lines are later exported to AutoCAD for creating GA drawings. The model is also used to predict the center of gravity and perform stability analysis.







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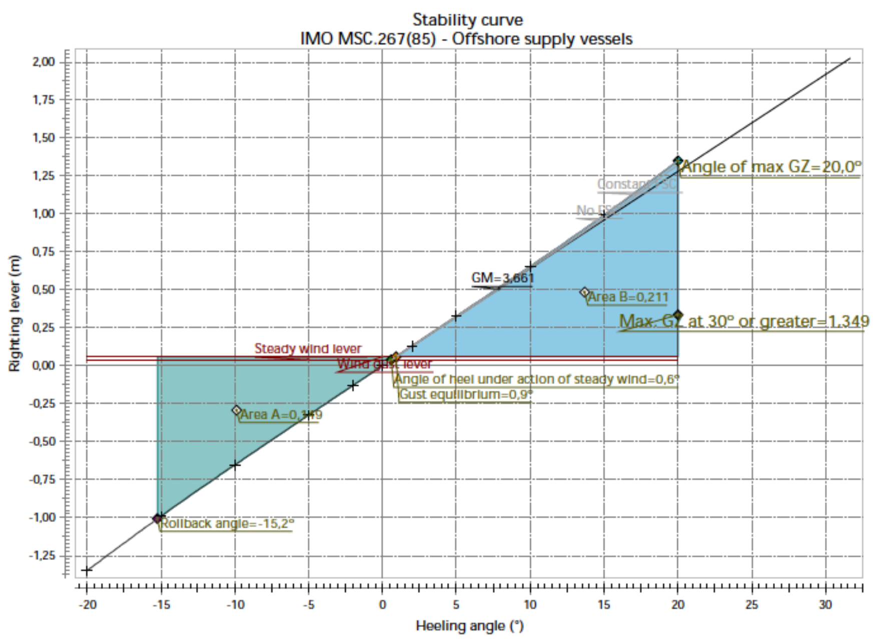
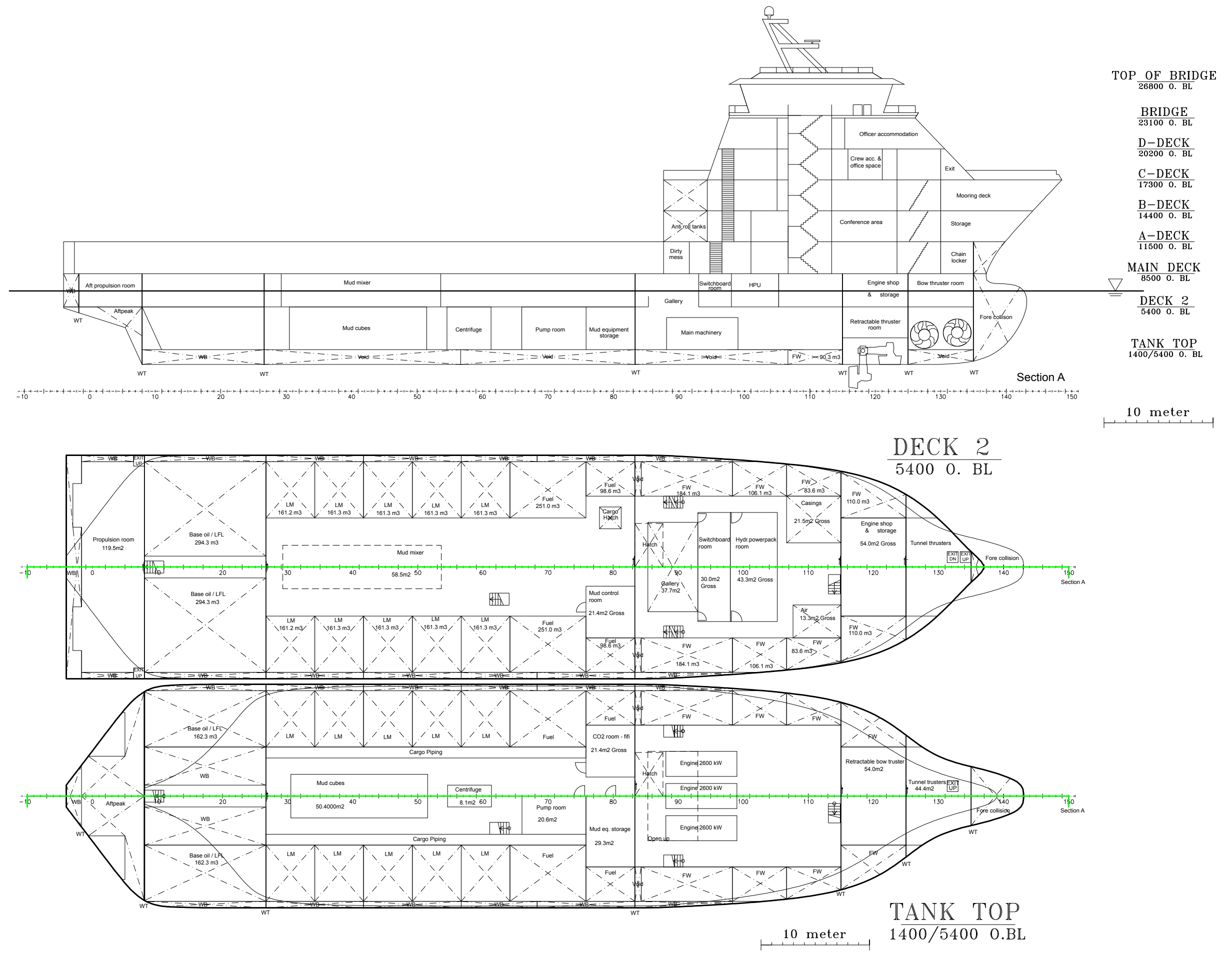


Software

DELFTship - 3D modeling and stability analysis
AutoCAD – General arrangement drawings

General Arrangement Drawings



Results

The drilling fluid treatment system onboard the vessel consists of four solids control machines (three mud cubes and one centrifuge) and a mixer unit and located on the tank top and 2nd deck, respectively. The system is connected to ten multiuse-tanks that are used to store treated drilling fluid, contaminated drilling fluid, and wastes from the drilling fluid treatment process. The total capacity of the system is 1600m3. Results from the performance calculations shows that the vessel, when sailing in service speed (12 knots), will have a total resistance of 236,6 kN, where 15% of the resistance is due to the azipull propulsion system. Propulsion calculations shows that the required installed propulsion effect is 5100 kW with two propellers with a diameter of $3.05m$. To adjust for increased resistance due to rough sea, degradation etc. a sea margin of 30% is set. Total propulsion effect is then 6630 kW. Intact stability is analyzed in four loading conditions, here only represented by the initial metacentric height: $3.66m$, $4.03m$, $6.14m$, and $6.71m$ in the loading conditions; max loaded, average operation, lightweight with ballast water, and lightweight, respectively. The stability curve for max loaded vessel is presented to the left. Analyzing the vessel operational profiles, total installed machinery is set to be 8700 kW, with three main (2600 kW), one auxiliary (700 kW), and one emergency generator (200 kW).

Conclusion

The principal particulars for the vessel is, presented in the table to the table to the right. Intact stability analysis in four loading conditions shows that the vessel is within the IMO requirements for offshore supply vessel stability. Drilling fluid design and properties are complex. No evaluation of the performance regarding the treatment process has been possible to discover during this thesis. This is due to complexity and due to high uncertainty in the drilling fluid quality after being used in a drilling operation. Further analysis of the solids control and mixing system should be made.

PRINCIPAL PARTICULARS		
Length over all	91,5	m
Length between perpendiculars	85,6	m
Length waterline	88,2	m
Breadth	20,5	m
Draft	6,9	m
Depth to main deck	8,5	m
Deck area	945	m2
Accommodation	25	persons
DWT	6300	tonnes
Drilling fluid cap.	1600	m3
Displacement	9700	tonnes