

Simulation of Dynamic Positioning of a FPSO and a Shuttle Tanker during Offloading Operation

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ABSTRACT

The use of Floating Production storage and Offloading (FPSO) units for the production and storage of oil is quite common in deep water. The produced crude oil is normally transported by a shuttle tanker. During offloading the tanker has to keep certain position with a mooring system or dynamic positioning (DP) system. The dynamic positioning system is able to demonstrate excellent performance of keeping the desired position and heading of vessels in the presence of external disturbances, especially in deep water. In this paper, a heading control DP System supplied by Siemens onboard a FPSO is simulated by Oceanic's SML simulation software. The PID algorithm was developed to derive the command load from the ship response (motions, wind force and current load) and then to find the command of each thrusters and controllable pitch propellers. The proposed controller is robust with respect to modeling errors and variations in the intensity and direction of environmental forces. The linking of the SML simulation software to Siemens DP controller is described and simulations to verify the DP controller response to various environment conditions are presented.

KEY WORDS: FPSO Offloading, Dynamic Positioning, Maneuvering Simulation, PID Algorithm

INTRODUCTION

In recent decades, the use of ship-type offshore units for the production and storage of oil has become a common method. Located permanently at a certain place at sea, the Floating Production Storage and Offloading (FPSO) vessels have become the major floating production units. The produced crude oil is normally transported by a shuttle tanker. During the offloading operation, the change of the FPSO heading relative to the tandem moored shuttle tanker are very important. During offloading the tanker has to keep certain position with a mooring system or dynamic positioning (DP) system. The DP system for station keeping has advantages compared with mooring system in deep water condition.

In certain combinations of weather and loading conditions the FPSO

heading may change at a rate such that a shuttle tanker astern of the FPSO is unable to maintain alignment astern. Misalignment of the shuttle tanker from the FPSO is known as fishtailing. Excessive fishtailing results in suspension of offloading operation. It is noted that in most cases FPSO heading changes during offloading have no problem for shuttle tanker station keeping and no heading control is required. However when significant changes in wind speed and direction occur, the actual rate of heading change of FPSO may be quite large. There should be a limit imposed on the rate of heading change so that a shuttle tanker can make corresponding change to maintain astern of the FPSO. DP system is able to achieve above goal.

In this paper, a numerical model was developed to provide initial evaluation and testing for the Siemens supplied DP system onboard the FPSO. The simulation program was linked to Siemens DP controller and simulations were carried out to verify the DP controller response to various environment conditions. The software is also developed to provide a working training simulator for the operator.

MATHEMATICAL MODELS

Ship Simulator

SML (Ship Maneuvering Laboratory) is a PC-based computer code to simulate the maneuvering of a ship or any floating body. It solves rigid body motion in three (surge, sway, and yaw) or four (including roll) degrees of freedom using a time step solver. The time domain simulation model is solved in earth fixed coordinate system.

In the simulation of ship maneuvering, two right-handed coordinate systems are employed. In the space-fixed coordinate system, OXYZ, the OXY plane coincides with the baseline of the ship and the Z-axis points vertically downward. In the ship-fixed coordinate system, $O_s X_s Y_s Z_s$ the origin O_s is at the midship section and intersects the longitudinal plane of symmetry on the baseline of the ship; the $O_s X_s Y_s$ plane coincides with the keel when the ship is at