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Review On Dynamic Behaviour of Moored Twin Hulls FPSO

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ABSTRACT

The development of floating offshore structures have been successfully and rapidly in many years. Many researchers has studied the dynamic behavior of of moored floating production storage and offloading structure. This paper investigated the dynamic behavior of catenary anchor leg moored twin hulls floating production storage and offloading which subjected to sea waves, in order to get insight knowledge on its dynamic behaviours due to various turret locations with different loading conditions. The comparison of the dynamics behaviour to the FPSO and it mooring lines are important when choosing potential development and optimal options. The research founded that it currently no information is available for the comparison of the dynamic behaviour of the internal turret moored of twin hulls FPSO at different loading conditions with various turret locations under the action of wave.
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KEY WORDS: *Moored Twin Hulls; FPSO; Turret Location; Dynamic Response.*

NOMENCLATURE

FPSO	Floating Production Storage and Offloading
FSO	Floating Storage and Offloading
CALM	Catenary Anchor Leg Mooring
TLP	Tension Leg Platform
FSRU	Floating Storage Regasification Unit
DWT	Deadweight Tonnes
RAO	Responded Amplitude Operator

1.0 INTRODUCTION

Offshore structures have been in use successfully for many years and rapidly developing. They serve the same purpose in the oil and gas production as well as the storage system. There are two common the types of offshore structure which are fix structure and floating structure. These floating structures include Tension Leg Platform, Semi-submersible platform, Floating Storage and Offloading, and also Floating Production Storage and Offloading.

Since the offshore drilling are being discovered in deep sea area the fixed structure are not practical because it have significant heave, pitch and yaw motions in large wave. Good stability characteristic as a drilling platform was make the floating structure attempt to replace traditional fixed jacket platforms. These movable structures have the maneuverability ability to be used in several fields, but the cost effectiveness is the main advantages of movable structures.

FPSO is vessel used by the offshore industry for the processing and storage of oil and gas. A FPSO vessel is transportable platform which designed to receive oil or gas produced from nearby platforms or subsea template, process it, and store it until oil or gas can be offloaded onto a tanker or transported through a pipeline. FPSOs are preferred in frontier offshore regions as they are easy to install, and do not require a local pipeline infrastructure to export oil and gas.

The vessels often take the form of traditional tankers. In addition to dedicated vessels that are designed for FPSO, oil and gas tankers can be converted to an FPSO vessel which also makes them an economical and flexible option. The vessels are moored in place either via a single point or by spread mooring which involves the vessel being anchored via multiple points on the sea floor. This allows them to operate in both deepwater and ultra deepwater environments which are designed to take into account local weather situations and can even be detached from moorings which make them ideal in extreme weather conditions.

Turret is a typical single point mooring system for FPSO. Turret also is the major component used for station keeping in harsh environments; heavy sea, high winds and strong current which the risers coming from seabed are connected. The most important function of turret is weathervaning which allows vessel to rotate freely around turret.

Floating production vessel have the principal characteristic of remaining at substantially stable position, presenting movements when they experience environmental forces such as the wind, waves and currents. In floating structure design, it is important to determine its motion and behavior when subjected to waves [65].

According to the research from T.R Kannah and R. Natarajan (2006), it has been illustrated that the position of the turret location plays a vital role to determine the behavior of the FPSO and also its mooring lines forces when subjected to environmental impact [86]. Throughout this research, it tries to investigate the influence of turret location to the dynamic behavior and the mooring lines force of the floating production system. This study is made to access the optimum operational capability of the FPSO system due to the dynamic behaviour and mooring lines force condition.

This paper reviewed the development of Floating Production Storage and Offloading structure using Catenary Anchor Leg Mooring.

2.0 REVIEW ON INTERNAL TURRET MOORED OF TWIN HULLS FPSO

It has been forecasted that between 2013 and 2017, 91 billion dollar will be spent on floating production systems, an increase of 100 percent over the preceding five year period [25]. With global economic growth in 2014 projected to increase to 3.5 percent from 2.9 percent in 2013, world oil demand is forecast to rise by one million barrels per day, compared with 900 000 barrels per day in year 2013 [38]. This massive growth in the floating production sector has come as a result of the rapid evolution that gives the impact to the future development of FPSO.

IEA (2012) forecasted that oil and gas demand will rise from 3.3 trillion cubic meters in 2010 to 5.0 trillion cubic meters in 2035, an increase of 50 percent [40]. This situation has driven the market for FPSO to fulfill the demand. As a result of this situation the new concept of twin hull FPSO has emerged. This novelty is achieved by joining together two FPSO which the process facilities along with the storage and crew living quarters are located on deck. This twin hull concept allows adequate space for the process facilities with the necessary space between sections of equipment to satisfy safety requirements, while providing sufficient oil and gas storage capacity.

The environmental loads on moored structures, namely due to wind, current, and waves, are of a main concern when determining vessel motions and evaluating mooring design [99]. Turret-moored FPSO systems are sensitive to the effect of waves, wind and current. In the recent years, considerable research is being carried out on turret moored FPSO system operating at offshore locations. An internal turret moored FPSO system is an attractive concept for both production facilities and offshore storage [86].

In an internal turret moored FPSO system, the turret structure is built inside the tanker's hull and it is attached to the sea-bed by catenary anchor leg mooring (CALM). The spider part of the turret located at the vessel keel level includes bearings, allowing the vessel to rotate freely around its mooring legs in response to changes in environmental excitation and system dynamics. In the case of internal turret moored FPSO system, the vessel motions and mooring forces are mainly governed by the location of the turret so as to maintain optimal operating conditions.

Many research have been done up to now about the single point mooring for monohull FPSO. Thiagarajan and Finch (1998, 1999) conducted an experimental investigation of the vertical motions of a turret moored FPSO in wave using different positions of the mooring along the length of the model [89, 90]. The results show that the mooring location affects the vertical motions and accelerations of the FPSO. Bernitsas and Papoulias (1986) conducted the study on the yaw and stability of single point mooring [53]. Yaw of turret moored vessels in regular waves was investigated by Liu et al. (1999) [51]. O' Donoghue and Linfoot (1992) performed the model test in irregular waves and reported the effect of turret position and mooring load characteristics [62]. Jiang et al. (1995) extensively reported the horizontal motions and mooring line loads of single point moored tanker [44]. Cho (2012) and Cho et al. (2013) studied the motion behavior and stability of turret moored floating body and two bodies including sloshing [16, 17]. Recently, Seok et al. (2013) conducted the model test and stability analysis for a turret moored Floating Storage Regasification Unit (FSRU) [74]. Model tests are performed in regular waves. The results of model test show that the possibility of large yaw in irregular wave can be predicted by the regular wave tests.

Based on the review of these existing literatures, it is found that no information is available for the comparison of the dynamic behaviour of the internal turret moored for twin hull FPSO system at different loading conditions with various turret locations under the action of wave. Hence, the present study investigation has been programmed for a typical turret moored FPSO system by catenary anchor leg mooring (CALM) which subjected to sea waves, in order to get insight knowledge on its dynamic behaviour due to various turret locations with different loading conditions. The comparison of the dynamics behaviour to the FPSO and it mooring lines are important when choosing potential development and optimal options. This research will analyses and highlight the optimal turret location to the new potential concepts of twin hull FPSO. It also will highlight areas where effort is best focussed to mitigate the marine risks.

End of the research is targeted to propose a correction method which is applicable to linear diffraction theory in order to evaluate the motion response of selected moored floating structure. The linear diffraction theory estimate the wave force on the floating body based on frequency domain and this method can be considered as an efficient method to study the motion of the large size floating structure with acceptable accuracy. The effectiveness of this diffraction theory apply on large structure is due to the significant diffraction effect exist on the large size structure in wave [48]. In this study, twin hull FPSO will be selected as an offshore structure model since this structure is one of the new concept structure used in deep water oil and gas exploration area.

To achieve this objective, a programming code will develop based on diffraction potential theory. By comparing the numerical result predicted by using diffraction potential theory to experiment result, it is obtained that the motion prediction by diffraction potential theory has an acceptable accuracy mostly, except for heave motion when the wave frequency near to the structure natural frequency [76 ~ 82].

As presented in a previous paper, the diffraction potential theory is less accurate to predict the structure heave motion response when the wave frequency closer to structure natural frequency. At this situation, the heave response calculated by the diffraction potential theory will be overshooting compare to experiment result due to low damping executed by the theory and then follow by the large drop which give and underestimating result compare to experiment result before it is returned into normal tendency [82].

In order to correct the over-predicting phenomenon made by the diffraction potential theory, the previous research was trying to increase the damping coefficient by adding viscous damping into the motion equation [80]. From that study, the viscous damping is treated as extra matrix and added into the motion equation separately. This addition viscous damping was estimated based on the equation provided by Nallayarasu and Prasad (2012).

By adding the extra viscous damping into the motion equation, it can be obtained that the significant over-predicting of heave motion when wave frequency near to the floating structure natural frequency was corrected and it is close to the experimental result compared to executed result by diffraction potential theory alone [77]. However, the under-predicting of the heave response by diffraction potential theory in a certain wave frequency region still remaining unsolved by adding the viscous damping to the motion equation as discussed in the previous study [77].

Siow, et al., (2014b) conducted the researches which focus on the effect drag force and viscous damping in estimate the semi-submersible heave response using diffraction potential theory [80]. To able the numerical solution to calculate the extra drag force and viscous damping, they applied the drag term in Morison equation. Accuracy of the modification solution also checked with the previous semisubmersible experiment result which carried out at the towing tank belongs to UniversitiTeknologi Malaysia [3, 80]. The experiment is conducted in head sea condition and slack mooring condition for wavelength around 1 meter to 9 meters. In the comparison, they obtained that the non-agreed heave response tendency near the structure natural frequency predicted by diffraction potential theory can be corrected by involving the drag effect in the calculation.

3.0 CONCLUSION

Dynmaic behavior of morred twin hulls floating production storage and offloading has been reviewed. The research founded that it currently no information is available for the comparison of the dynamic behaviour of the internal turret moored of twin hulls FPSO at different loading conditions with various turret locations under the action of wave.

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