PERFORMANCE OF CATENARY MOORING SYSTEM

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PERFORMANCE OF CATENARY MOORING SYSTEM

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To my beloved mother Setariah bt Ahmad with her sincere prayers afforded me to accomplish this work, to my dear supportive family members and my loving fiancé

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ABSTRACT

The number of deep water moored offshore vessels is growing rapidly, and hydrocarbon fields in water depths down to 3000 m are now seriously considered for floating production development. The exploration drilling or offshore floating production units with superior mooring capacity thus become a highly demand factor. Concerning on this booming drilling activity has driven this research to be carried out to analyze the mooring system requirement as well as the behaviour of the floating structure when experiencing external forces such as wave and current forces. The purpose of this study is to investigate the technical as well as performance analysis of the catenary mooring system from the perspective of a Spar platform drilling unit. The main part comprises an analysis and discussion on the mooring configuration, material and weight, length of mooring line required to resist the environmental loads and movement of the platform. This study will utilized the finite element approach and the analysis will be carried out by using M-File programming from MATLAB software package. The endeavour of this paper is to develop theoretical methods for evaluation of Spar oil platform response with catenary mooring lines and to carry out performance analysis of the catenary mooring lines between static and dynamic mooring system. The performance of mooring system is determined as the ability of the system to establish superior station-keeping capabilities for the floating platform, so to ensure that horizontal excursions of the platform are not so large as to cause damage to the production risers or the sub-sea equipment and subsequently enabling production and export risers to remain connected for the life of the field.

ABSTRAK

Pertambahan bilangan pelantar minyak laut dalam yang pesat membangun serta sumber hidrokarbon di ke dalaman laut yang mencecah sehingga 3000 m memerlukan pembangunan penggunaan pelantar apungan secara lebih teliti. Pelantar galian minyak atau pelantar apungan laut dalam dengan kapasiti ketahanan talian tambatan yang kukuh menjadi faktor penting di dalam industri galian ini. Kepesatan aktiviti galian ini menjadi faktor penyebab kajian ini dijalankan untuk menganalisa keperluan sistem tambatan begitu juga tindakbalas struktur pelantar apungan apabila berhadapan dengan daya luar seperti daya yang terhasil dari ombak dan juga arus. Kajian ini bertujuan untuk menyelidik aspek teknikal serta analisis prestasi terhadap sistem tambatan melengkung dari perspektif pelantar galian jenis Spar. Aspek paling utama mengandungi analisis dan perbincangan mengenai konfigurasi talian tambatan, jenis bahan dan beratnya, panjang talian tambatan yang diperlukan untuk mengatasi daya sekitar dan pergerakan pelantar tersebut. Kajian ini akan memanfaatkan pendekatan unsur terhingga dan analisis akan dilakukan menggunakan pengaturcaraan M-File daripada pakej perisian MATLAB. Penghasilan dokumen kajian ini adalah untuk mendapatkan kaedah serta teori yang digunakan untuk menilai reaksi pelantar Spar dengan talian tambatan melengkung di antara sistem statik dan dinamik. Prestasi sistem tambatan ini didefinasikan sebagai keupayaan dan kekuatan sistem tersebut mengekalkan lokasi kedudukan pelantar apungan. Ianya adalah untuk memastikan pergerakan mendatar pelantar tersebut tidak terlalu besar dan ini akan menyebabkan kerosakan pada riser penyedut serta peralatan lain dalam laut seterusnya membolehkan riser penyedut kekal berhubung sepanjang operasi penggalian dijalankan.

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LIST OF SYMBOLS

M_s	–	Moments
F_h	–	Horizontal force
WD, h	–	Water depth
$\vec{F}_{FK}$	–	Foude-Krylov force
SW	–	Wetted surface of the floating body
p	–	Pressure in the undisturbed waves
$\vec{n}$	–	The body's normal vector pointing into the water
F	–	Normal force/Froud Krilov force
ρ, ρ_w	–	Water density
C_D	–	drag coefficient of cylinder
A_w	–	Element wetted area
V_w	–	Wave velocity
dX	–	Segment length in x direction
dY	–	Segment length in x direction
L_W	–	Wavelength
T_W	–	Period of wave
F_D	–	Drag force
ω_W	–	Wave frequency
g	–	Acceleration due to gravity
ζ_a	–	Wave amplitude
k	–	Wave number
$\dot{u}$	–	Velocities of water particles in horizontal direction
$\dot{w}$	–	Velocities of water particles in vertical direction

U_C	–	Current velocity
M_s	–	Spar mass or moment of inertia
M_a	–	Added mass or added moment of inertia
$\{X\}$	–	Structural displacement vector
$\{\dot{X}\}$	–	Structural velocity vector
$\{\ddot{X}\}$	–	Structural acceleration vector
K_h	–	Hydrostatic restoring stiffness
K_m	–	Mooring Stiffness
$F(t)$	–	External forces
Δt	–	Delta time
t	–	Time
β , α , γ	–	Constant
$[A]$	–	Transformation matrix
m_{ij}	–	Added mass matrix
b_{ij}	–	Damping coefficient matrix
k_{ij}	–	Stiffness matrix
C_m	–	Added mass coefficient
x	–	Global x coordinates
y	–	Global y coordinates
z	–	Global z coordinates
X	–	Body X coordinates
Y	–	Body Y coordinates
Z	–	Body Z coordinates
K_{hy}	–	Hydrostatic stiffness matrix
D	–	Diameter of the Spar platform
S_{cb}	–	Distance from the keel of the Spar platform to its center of buoyancy
S_{cg}	–	Distance from the keel of the Spar platform to its center of gravity
T_d	–	Draft of the Spar platform

δ_x	–	Small displacement
C_{DT}	–	Tangential drag coefficient
C_{DN}	–	Normal drag coefficient
T	–	Mooring line tension
Φ	–	Inclination of mooring line
Rz	–	Resultant force in z direction
Rx	–	Resultant force in x direction
ΔL	–	Elongation of segment
L	–	Segment length of mooring line

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CHAPTER 1

INTRODUCTION

1.1 Background

The rapidly growing offshore activity in deepwater, i.e. between 1500 and 3000m creates a high demand on the exploration drilling or offshore floating production units with superior mooring capacity. The need to measure ocean currents throughout the water column for extended periods in order to better understand ocean dynamics was a driving force that led to the development of oceanographic moorings.

Mooring system design is a trade-off between making the system compliant enough to avoid excessive forces on the platform, and making it stiff enough to avoid difficulties, such as damage to drilling or production risers, caused by excessive horizontal excursions of the platform . This is relatively easy to achieve for moderate water depths, but becomes more difficult as the water depth increases. There are also difficulties in shallow water. Increasingly integrated mooring/riser system design methods are being used to optimize the system components to ensure lifetime system integrity.

The purpose of this study is to investigate the technical as well as performance analysis of the catenary mooring system from the perspective of a spar platform drilling unit. The study commences with a critical review on the subject of deepwater mooring system. The main part comprises an analysis and discussion on the mooring configuration, material and weight, dynamic mooring simulation result, anchoring system, installation and inspection, cost-effectiveness of the chain/wire/polyester catenary mooring system. The endeavour of this paper is to develop theoretical methods for evaluation of spar oil platform response with catenary mooring lines and to carry out performance analysis of the catenary mooring lines between static and dynamic mooring, single leg and multi leg mooring system.

1.2 Problem Statement

The number of deep water moored offshore vessels is growing rapidly, and hydrocarbon fields in water depths down to 3000 m [1] are now seriously considered for floating production development. With the requirement to operate in increasing water depths, the suspended weight of mooring lines becomes a prohibitive factor.

Physical and numerical modelling of such vessels with their extensive mooring lines and risers is a challenge to predict the ideal performance of catenary mooring system without ignoring cost effectiveness. Several parameters need to be considered:

i. Movement of platform
ii. Required length/weight of mooring line
iii. Suitable material
iv. Type of anchoring technique

At present, no physical model test facilities can accommodate all water depths and mooring line spreads that are being developed today thus making numerical modelling of deep water mooring systems poses large demands on computer power for verification of moored systems [1]. So the development of theoretical methods for evaluation of performance of catenary mooring lines using a developed computer program is a highly relevant matter.

1.3 Objective of the Research

To evaluate the performance of a catenary mooring arrangement for Spar oil platform design using developed computer programmed.

1.4 Scope of the Research

i. Analysis the performance of the catenary mooring between static & dynamic mooring, single leg & multi leg mooring system.

ii. Several parameters of performance of catenary mooring arrangement for spar oil platform design will be evaluate such as movement of the platform, the required length of mooring line to resist the environmental loads such as current, wave and wind force, suitable material for the mooring line and type of the anchoring technique.