MARINE RISER VORTEX INDUCED VIBRATION (VIV) SUPPRESSION DEVICE

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ABSTRACT

Vortex-Induced Vibration (VIV) is a common phenomenon that occurred in the oil and gas industry and become one of the main concerns for the engineers while designing the riser system. Thus, this research represents the analysis of the vortex-induced motion of the circular cylindrical by using the Computational Fluid Dynamics (CFD) ANSYS CFX. The simulation was carried out in two-dimensional with the stationary condition. The bare cylinder was used as the reference for this research while the graph Strouhal number versus Reynolds number as the validation. The validation by using the Strouhal number is the common practice for the stationary circular cylinder simulation and Strouhal frequency obtained from this research was $St \approx 0.2$. The simulation process was executed by using the ANSYS CFX Solver to simulate the cylinder and to identify the vortex shedding and also its magnitudes. The turbulent model used in this simulation is Detached Eddy Simulation and the vortices created at the back of the cylinder as well as the flow separation can be monitored through post-processor. Generally, when the fluid flow passed through the bluff body, it will excite by the forces and caused the vortices shed. These vortices will separate periodically asymmetrically from either side of the body caused the time varying non-uniform pressure distribution around it. This non-uniform pressure will create in both inline and transverse to the flow. By having the idea of parallel plates attached to the cylinder, it will help the flow separation become streamline as well as reduce the VIV on the marine riser. In addition, the Reynolds number is believed will give some significant effect on the behavior of VIV.

ABSTRAK

Getaran vortex yang disebabkan daripada silinder adalah fenomena biasa yang terjadi di dalam industry cari gali minyak dan gas dan ia menjadi salah satu kebimbangan utama kepada para jurutera semasa mereka bentuk system riser. Sehubungan dengan itu, kajian ini menyatakan analisis tentang getaran yang disebabkan oleh silinder bulat dengan menggunakan pengkomputeran bendalir dinamik (CFD) ANSYS CFX. Simulasi ini telah dijalankan di dalam dua-dimensi dengan keadaan yang statik atau pegun. Silinder yang terdedah telah digunakan sebagai rujukan untuk kajian ini manakala graf nombor Strouhal lawan nombor Reynolds digunakan sebagai pengesahan. Pengesahan menggunakan nombor Strouhal adalah amalan biasa yang sering dilakukan untuk simulasi silinder bulat yang pegun dan kekerapan Strouhal yang diperolehi untuk kajian ini adalah St ≈ 0.2. Proses simulasi telah dilaksanakan menggunakan penyelesaian ANSYS CFX untuk mensimulasikan silinder and untuk mengenal pasti penumpahan vortex dan magnitudnya. Model bergelora yang digunnakan dalam simulasi ini adalah 'Detached Eddy Simulation' dan vorteks yang terhasil di belakang silinder termasuklah aliran pemisah boleh dipantau melalui catatan pemproses. Secara umumnya, apabila cecair mengalir melalui badan 'bluff', ia akan dibangkitkan oleh daya-daya dan akan mengakibatkan vorteks tersisih. Vorteks-vorteks ini akan terpisah secara simetri berkala daripada kedua-dua belah badan disebabkan oleh masa-masa yang berubah dan tekanan yang tidak seragam disekitarnya. Tekanan yang tidak seragam ini akan menghasilkan kedua-dua sebaris dan melintang kepada aliran. Denagn adanya idea menggunakan dua plat secara selari yang dilekatkan dibelakang silinder, ia akan membantu aliran pemisah menjadi selaras dan sekaligus dapat mengurangkan VIV terhadap riser marin. Tambahan pula, nombor Reynolds dipercayai akan memberi efek yang ketara terhadap tingkah laku VIV.

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INTRODUCTION

1.1. Introduction

Nowadays, oil and gas exploration has been growing tremendously; the oil production companies and its facilities are moving forward to untapped the oil and gas reserve. Marine risers are one of the marine facilities that attached to the platform or floating vessels which have been used as transportation means for hydrocarbons resources as well as for drilling operation as shown in Figure 1.1. The conditions of sea states, the currents, and waves, the weather together with the hurricanes, are the big challenges harshly decrease a drill rig's operation magnificently. Based on research by Taggart et al. (2008), in the Gulf of Mexico (GoM), drilling and completion operation and resulting cost to operate can be very high due to the high loop currents and series of hurricanes. This statement has been supported by Grealish et.al which mentioned that GoM is one of the regions that has this high current profile, known as loop currents and cold core eddies.

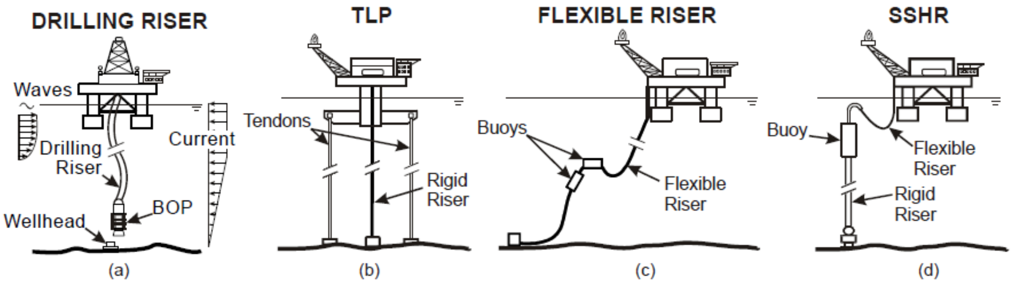

Figure 1.1: Example of riser: (a) drilling riser during the installation, (b) rigid riser, (c) flexible riser, and (d) hybrid riser configuration called Self-Standing Hybrid Riser. (Murai M. & Yamamoto M. 2010)

One of the critical part concerning in offshore industry is the riser, which connects the platform to the wellhead at the seabed. Risers are long and flexible structure and caused the critical ratio L/D tends to be very large. This problem always occurred especially in the deep ocean areas compared to the shallower water. Typically, more than 50% of the riser is covered, with the recent riser installation employing up to 100% with suppression device

The applications of riser for drilling and production activities are subjected to large forces, due to the waves and currents of the sea state. Generally, a slender structure like marine risers is susceptible to the vortex induced vibration (VIV), which can cause severe oscillation and lead to the fatigue as well as total damage to the structure. The resonance will occur when the frequency of excitation of vortices is at or close to the natural frequency of the structure. Thus, the large amplitude of oscillation may have induced between the flow and structure's motion which can cause the lock-in phenomenon.

The VIV phenomenon was found to be a problem in the offshore industry, formerly there are two approaches to address this problem, namely: modify the design of riser to eliminate the VIV or employ the usage of VIV suppression devices. In order to change the natural frequency of the structures are largely impossible and impractical, thus the VIV suppression devices can be deployed to disrupt the formation of vortices. There are many types of suppression devices in the market including helical strakes, fairings, vane and shroud. Helical strakes and fairings are known as most effective and preferable commonly used by operators and company. Although the VIV can be suppressed by the strakes or fairings, the cost related to the hardware and installation is high. Hence, the research on the riser VIV has been rising in the oil and gas industry to achieve the safe and economical design.

1.2. Problem Statement

The current will cause vortexes to shed from the sides of the riser. Donald et al. (1998) mentioned in their research that these vibrations will lead to fatigue failure of the riser. Under steady current flow, cross flow vibrations of risers have two immediate consequences which are increased in fatigue damage and increased in line drag. Deepwater riser will fail to meet the fatigue design criteria due to VIV. To counteract the fatigue impact, VIV needs to be suppressed. There is two option whether redesign the riser which relatively expensive or by adding VIV suppression devices to reduce the vibration.

A lot of work or research has been carried out for suppressed the marine riser VIV. Many types of suppression devices have been introduced to overcome this problem. However, there is not much detailed study in numerical or experiment being done using the flat plate as a suppression device. This research will investigate this problem.

1.3. Purpose Statement

The purpose of this research is to validate the effectiveness of parallel plates as suppression device in order to minimize the Vortex Induced Vibration (VIV).

1.4. Objective

The objectives of this research are:

1. To study the efficiency of parallel plates as VIV suppression device that able to reduce VIV on the marine riser.
2. To evaluate the effect of plate lengths and gaps on different Reynolds number.

1.5. Scope of Research

This research is focusing on minimizing the occurrence of VIV in the marine riser by designing suppression device with parallel plates. The literature review of the art of VIV for marine riser has been carried out throughout this research. CFD software ANSYS CFX is used to study the ability of the different plate lengths and gaps for reducing VIV. The stationary bare riser is used as a reference and to validate this research we will use the graph and calculate the Strouhal number.

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