Chapter 16
Investigation of Impact of Various Oceanographic Variables on Offshore Platforms Behavior

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16.1 Introduction

The oil and gas business, being one of the world's most critical industries, contributes significantly to global gross domestic product (GDP). The extraction and refinery processes are extremely complex, requiring cutting-edge technology to transform oil and gas into finished products such as gasoline for vehicles and aero planes. The only method to reach an oil well and extract the oil is to utilize a drillship or oil rig to drill into the ocean floor.

Activities in the oil and gas value chain can be categorized into three groups which is upstream, midstream and downstream. The term "upstream" refers to the activities of the oil and gas sector that involve exploration and production. A high-potential location is chosen for resource exploration. These analyses are carried out using various techniques, such as infrared (IR) surveys, drill-and-sample assaying, electrical currents, and so on. Seismic surveying is another form of exploration, and it is definitely the most important of all geophysical exploration methods, primarily because it is capable of identifying subsurface structures on a wide range of scales, from large too small. Simple seismic methods are used to determine the shapes and

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physical qualities of the Earth's subsurface strata by analyzing sound waves that have travelled through the Earth and returned to the surface (Joshi et al. 2017).

The word "midstream" refers to the process of oil production between the upstream and downstream stages. Midstream operations also include processing, storing, transporting, and marketing crude oil, natural gas, and natural gas liquids, among other commodities. As a link between the upstream and downstream sectors, the midstream industry is responsible for the transportation and storage of oil and gas between upstream production facilities and downstream refining and processing facilities. Besides using the ship to transfer crude oil or natural gas, midstream can also be done via pipelines, trucks, or trains to the refineries (Devold 2015).

The third and last phase of the oil and gas value chain is known as downstream. Following upstream and midstream processing, crude oil or natural gas is transformed into a final product, such as kerosene, gasoline, diesel, etc., in an oil refinery. The operations of a petroleum refinery start with receiving crude oil from an oil tanker and storing it there in a crude oil tank; they then continue with all petroleum processing and refining operations; they then come to a close with storage before transporting the finished goods from the facility (Gulen 2016). Figure 16.1 shows the three stages of oil and gas production.

When it comes to offshore drilling operations which is the upstream process, offshore platforms are divided into two major groups or types: fixed platforms and moveable platforms. Furthermore, some oceanographic characteristics, such as water depth, wave frequency, and so on, must be addressed before deciding on the sort of offshore platform to be selected and used. For the extraction of natural gas or crude oil in shallow water, fixed offshore platforms are used. These platforms are built on concrete, steel, or steel-and-concrete legs that are fastened to the seabed (Sharma 2019). The second type of offshore drilling rig is a moveable platform or mobile offshore drilling rigs, which may be moved from one location to another. It is a

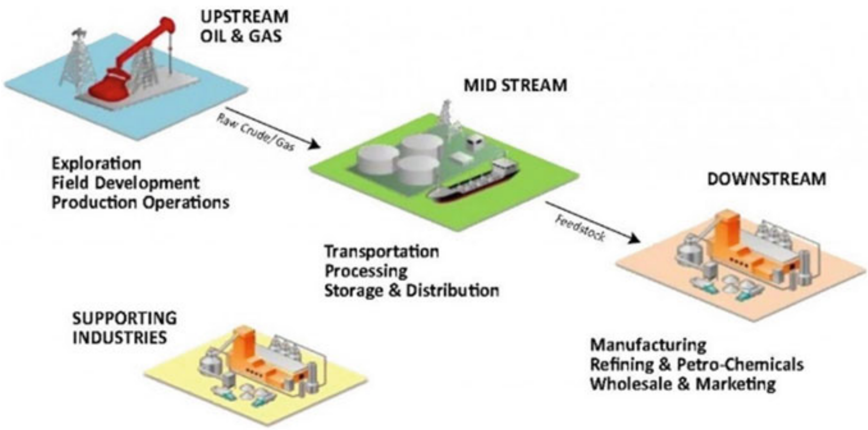

Fig. 16.1 Three stage of oil production (*Source* Petroleum Industry Structure 2016)

Table 16.1 Parameters

No.	Parameter	Number of variables
1	Type of offshore platform	3

mobile platform/rig used in the exploration process during drilling the oil well to extract the crude oil or natural gas (Sadeghi 2007).

16.2 Methodology

16.2.1 Parameter

Referring to Table 16.1, there are six main parameters that are used in this experiment. These parameters are constant on different types of oceanographic variables throughout the experiment. This parameter is the type of offshore platform which is used in the experiment. The type offshore platform that is used is the spar platform, jacket platform and semi-submersible platform. All three types of offshore platforms (see Table 16.2) that have has been used in this experiment have the same ratio due to the wave tank.

As shown in Table 16.3, the first oceanography variable is the depth of water. It has four different types of water depth, which are 0.6, 0.7, 0.8, and 0.9 m. The second variable is the wave frequency, which has four different types: 0.5, 0.7, 0.9, and 0.11 Hz. The third oceanographic variable is the wave amplitude. It has four different types of wave amplitudes, which are 0.02, 0.04, 0.06, and 0.08 m.

Next is the wave length, which has four different types starting with 0.4, 0.6, 0.8, and 1 m. Lastly is the number of mooring lines applied to the offshore platform, which are 4, 6, and 8. The offshore platform experiences a variety of distinct outcomes as a consequence of each of these oceanographic variables.

16.2.2 Preparation of Offshore Model and Wave Tank

This experiment uses an offshore model, which is described in Fig. 16.2. Every offshore platform model is put to the test separately using various oceanographic variables. In the wave tank, the offshore model is positioned in the middle. The wave tank is a specially designed tank for investigating wave dynamics.

It is sometimes used to show how an offshore platform or ship will react in different wave conditions. The wave tank utilized in this study can be found at Kemaman, Terengganu at the Kolej Kemahiran Tinggi MARA. The wave tank's blueprint was taken from the SOLTEQ wave tank (Model: WTS01). The wave tank is 10 m long, 4 m wide, and 1.3 m high. This wave tank is used to collect data for the experiment. Figure 16.3 shows the real wave tank that has been used for this experiment.

Table 16.2 Type of offshore platform model

No.	Type of offshore platform model	Name
1		Semi-submersible platform 1 m (L) × 1 m (W) × 0.25 m (H)
2		Jacket platform 0.27 m (L) × 0.27 m (W) × 1.6 m (H)
3		Spar platform 0.3 m (L) × 0.3 m (W) × 0.8 m (H)

Table 16.3 Oceanography variable

No.	Parameter	Number of variables
1	Water depth	4
2	Wave frequency	4
3	Wave amplitude	4
4	Wave length	4
5	No. of mooring lines	3

16.2.3 *Identify Software and Set Data Value*

To set the value of oceanographic variable, his experiment requires the use of multiple software tools, including the generated wave. The first is the HR Wallingford's HR

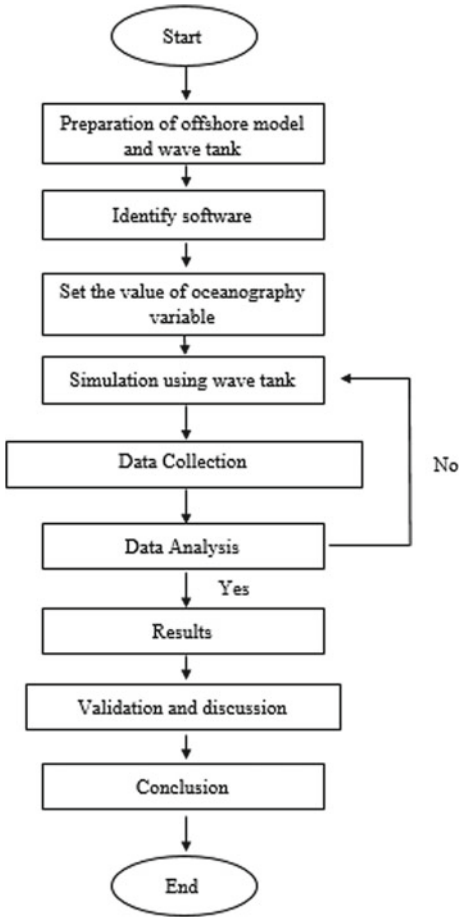

Fig. 16.2 Flow chart of this experiment

Merlin wave generation software. This software can be used to generate waves with a variety of different characteristics, such as wave frequency and wave amplitude, depending on the configuration.

In addition to the HR Wallingford software, the load cell calibrator system has been used in this experiment. This device is utilized to collect data from all of the offshore platform models utilized in this experiment. Using this device, data is collected as a result of the force generated by the wave striking the platform.

16.2.4 Simulation Using Wave Tank

Start the experiment once all preparations are complete. Figure 16.4 demonstrates the experiment's appearance.

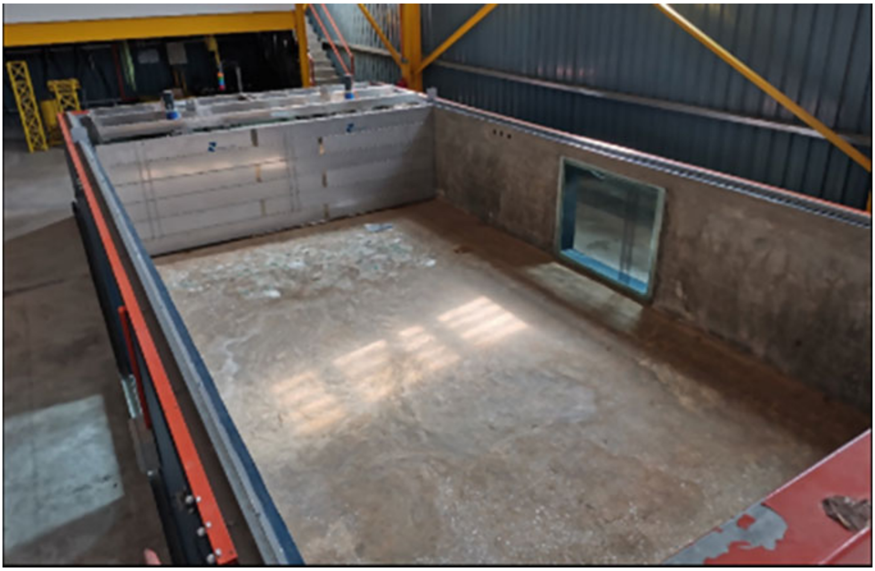

Fig. 16.3 Inside SOLTEQ wave tank at KKTM Kemaman, Terengganu

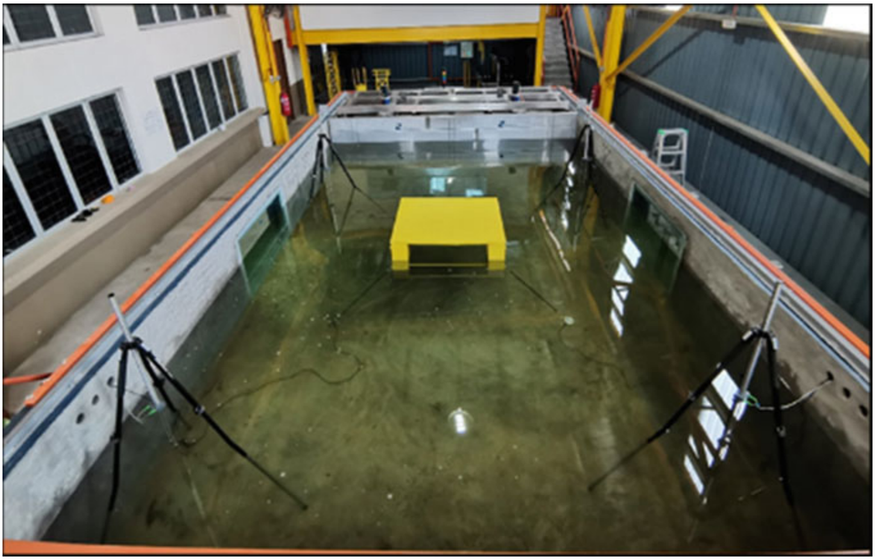

Fig. 16.4 Semi-submersible platform in the wave tank during the experiment

Table 16.4 Parameter

Time	LC1 (N)	LC2 (N)	LC3 (N)	LC4 (N)
10	− 0.66	− 0.73	1.12	0.44
20	− 4.94	− 0.45	4.66	3.94
30	− 0.87	2.14	4.39	− 2.63
40	− 1.71	− 1.27	5.46	6.28
50	− 3.33	− 0.45	0.16	0
60	− 3.79	2.06	2.11	3.21
70	0.38	1.18	1.59	− 5.26
80	− 3.88	− 0.24	3.59	3.94
90	0.76	1.72	1.46	− 1.46
100	− 4.18	− 1.75	2.83	4.09
110	− 1.49	2.38	4.7	5.4
120	− 4.02	− 1.99	2.49	− 0.29
130	− 2.34	2.83	5.04	− 0.29

16.2.5 Data Collection and Analysis

This test was done with all three kinds of oil platforms: semi-submersible, spar, and jacket. In 130 s, these oil platforms have been run five times with a fixed variable for each type of water depth, wave amplitude, wave frequency, wave length, and number of mooring lines.

The data from the experiment is recorded by the load cells 1, 2, 3, and 4 that are attached to each side of the model. Every 10 s, the data is shown in a table format.

The results shown in Table 16.4 of the experiment are given in newton units, which are a measure of force. Every load cell attached to the model measures how much force the wave is putting on it before the fix variable is set. Based on Table 16.4, the data is collected after the experiment has been done. Depending on the variables and type of offshore platform, each experiment has different results. Based on the parameters used in the experiment, all of the data is used to generate a graphical.

16.3 Results and Discussion

Figure 16.5 shows a graph where each line indicates the kind of oil platform model that was utilized in the experiment as the parameters. According to the graph, the SPAR and semi-submersible oil platforms are more stable than the jacket platform because their lines are close to the zero line. Because of the way they are made, SPAR and semi-submersible platforms are more stable than Jackets for water depth experiments in this situation. The SPAR platform is made up of a large, vertical, buoyant cylinder that can reduce the effects of waves on its structure. The same is

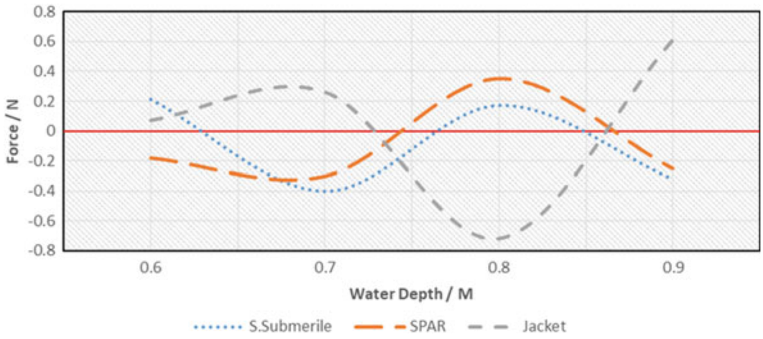

Fig. 16.5 Scatter graph for all platform reacted to different type of water depth

true for semi-submersible platforms, whose design is convenient than that of jacket platforms, which are better for working in shallow water.

As graph in Fig. 16.6 shows, the SPAR platform and the semi-submersible platform are less stable than the jacket platform. The reason for this result is that the jacket platform is made in a more cost-effective and strong way if large waves hit their structure. One of the oil platforms that is connected to the seabed is the Jacket platform. When the sea turns into a storm, the oil platform gets hit by waves with a high amplitude. When things are like that, the jacket platform is better than the SPAR platform and the semi-submersible platform.

Figure 16.7 shows the results of this experiment that the jacket platform is more stable when waves of different frequencies hit it. This is because the jacket platform is built to be stronger than the SPAR platform and is partly submerged. The structure of the jacket platform is attached to the seabed, which makes it more stable. When a lot of waves hit the SPAR platform and the semi-submersible platform at the same time, both platforms' stability and movement are affected, and not in a good way compared to the jacket platform.

At the start of this experiment, the graph in Fig. 16.8 show that all three types of oil platforms exhibited movement due to short wave durations between 0.4 and

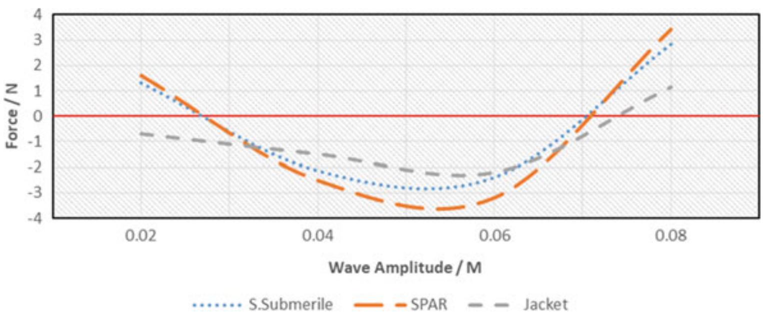

Fig. 16.6 Scatter graph for all platform reacted to different type of wave amplitude

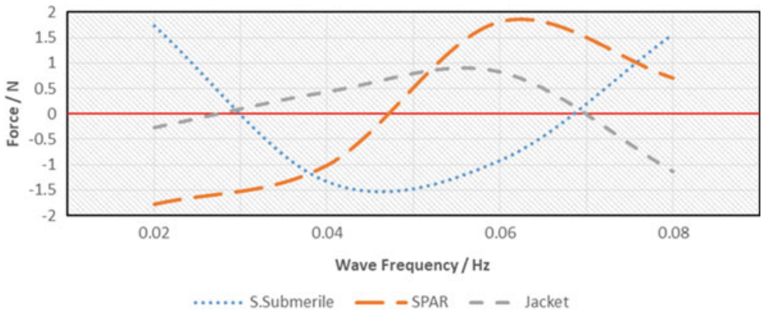

Fig. 16.7 Scatter graph for all platform reacted to different type of wave frequency

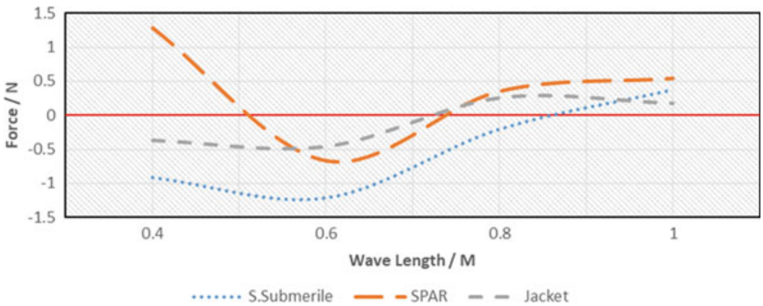

Fig. 16.8 Scatter graph for all platform reacted to different type of wave length

0.6 m. At wave lengths of 0.8 m and 1 m, however, all three types of oil platforms are more stable. The reason for this is that the wave's frequency increases as its length decreases. When there are more high-frequency waves, the oil platform will move more erratically. This condition describes the events depicted in Fig. 16.8.

At the start of the test, the graph in Fig. 16.9 shows that, when each oil platform had only four mooring lines. These results showed that all of the platforms moved around a lot and were not stable. But when the mooring line is added to 8, the oil platform model becomes more stable compared to the first experiment. When more mooring lines are attached to an oil platform, the platform becomes more stable and steadier. This was demonstrated in this experiment, and the jacket platform was the most stable oil platform in this experiment. The jacket platform is more stable than the other two because its structure is more stable and stronger. This lets it support the plant's weight better.

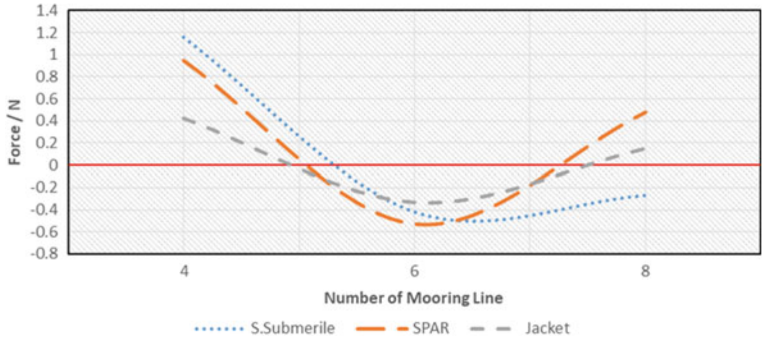

Fig. 16.9 Scatter graph for all platform reacted to different number of mooring line

16.4 Conclusion

The purpose of this research was to compare the capabilities of spar platforms, semi-submersible platforms, and jacket platforms in respect to certain oceanographic factors. These factors included the wave frequency, wave amplitude, wave length, water depth, and the number of mooring lines that were attached. Every sort of oil platform on our globe performs a specific purpose and boasts a unique set of qualities. The owner of an offshore platform must know several things before beginning construction: where the platform will be located, how deep the water will be, how the wave pattern will be at that point, what kind of seabed will be there, and what kind of work the platform will be expected to perform. Some oceanographic variables that had already been set were used in this experiment. Wave frequency, wave amplitude, wave length, water depth, and the number of mooring lines were some of these variables. This experiment also used a wave tank at KKTM Kemaman that was 10 m long, 4 m wide, and 1.3 m high.

It is clear from looking at the results that the experiment parameters led to large variations across runs. To facilitate easier and more precise data analysis, it is common practice to first tabulate the data and then compare the data in the form of graphs.

The experiment reveals that the jacket platform is the most stable option since it makes the best use of the oceanographic variables that were used in the experiment. The behavior of the jacket platform is found to be much more stable when the wave hits the structure.

By contrasting the plots, we were able to determine that the wave frequency and wave amplitude are the two variables primarily responsible for the observed differences in output. When either the wave frequency or the wave amplitude is high, the oil platform is more likely to become unstable.

This experiment was effective in determining the optimal design and operation of an oil platform. The equipment used in this experiment was carefully selected to keep costs to a minimum.

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