A REVIEW STUDY OF OIL AND GAS PRODUCTION FACILITY FOR SEMI-SUBMERSIBLE PLATFORM

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A project report submitted in partial fulfilment of the requirements for the award of Bachelor of Engineering (Hons) Petrochemical Engineering

Faculty of Engineering and Green Technology

Universiti Tunku Abdul Rahman

September 2015

DECLARATION

I hereby declare that this project report is based on my original work except for citations and quotations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree award at UTAR or other institutions.

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APPROVAL FOR SUBMISSSON

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REVIEW STUDY OF OIL AND GAS PRODUCTION FOR SEMI-SUBMERSIBLE PLATFORMS

ABSTRACT

In the early phase of the selection process to exploit an offshore petroleum reservoir, it is truly important to be able to identify which type of production facility that is liable to deliver its utmost value. This study provides a general understanding of the semi-submersible platform and the comparison between the other types of offshore platforms. The study explains the water depth and well counts that are possible for the placement of the semi-submersible platform. As the oil and gas exploration has been expanding to deep water conditions, floating platforms such as the semi-submersible platform are proven to be a better option due to the exhibiting operating versatility. The semi-submersible platform was discovered to have a lot of advantages compared to the other floaters due to the operating cost, payload, water depth, loading, transportation and stability. A 2D sample drawing of the semi-submersible platform was drawn in AutoCAD and a 3D module was also built to represent the whole structure. In Malaysia, major oil and gas service companies like SapuraKencana, Aker Solutions, UMV Drilling, Murphy Oil Corporation, Technip, Noble Corporation and Malaysia Marine and Heavy Engineering Holdings Berhad are actively involved in the construction and commissioning process of the semi-submersible platforms. The study shows that semi-submersibles have many advantages compared to other type of offshore production platforms mainly due to the high productivity and stability eclipsing the high building cost. Furthermore, the semi-submersible platform is attracting many oil and gas companies due to the high flexibility and adaptability to the ocean conditions, increasing both the safety conditions and production rate.

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LIST OF SYMBOLS / ABBREVIATIONS

GOSP	Gas oil separation plant
%	Percentage
CH_4	Methane
C_2H_6	Ethane
C_3H_8	Propane
C_4H_{10}	Butane
CO_2	Carbon Dioxide
O_2	Oxygen
N_2	Nitrogen
H_2S	Hydrogen Sulphide
A	Argon
He	Helium
Ne	Neon
Xe	Xenon
NGL	Natural Gas Liquids
km^2	Kilometer square
3D	3-Dimensional
TLP	Tension Leg Platform
FPSO	Floating Production, Storage and Offloading
MODU	Mobile offshore drilling units
GPS	Global Positioning System
TV	Television

SSCV	Semi-Submersible Crane Vessels
OSV	Offshore Support Vessels
LNG	Liquefied Natural Gas
ktoe	kilotonne of oil equivalent
$USD	United States dollar currency
2D	2-Dimensional
NDT	Non-Destructive Testing
EFS	Electrochemical Fatigue Sensor
NIOSH	National Institute of Occupation Safety and Health
atm	Atmospheric pressure
^oC	Degree Celcius
HP	High pressure
TEG	Tri ethylene glycol
LP	Low pressure
GDP	Gross Domestic Products
EPU	Economic Planning Unit
ICU	Implementation and Coordination Unit
bbl/d	Barrels per day

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

The oil and natural gas industry is a major industry that consists of exploration, extraction, refining, transporting and marketing of petroleum products. The petroleum industry is among the biggest sector in the world where from a business perspective, it represents the global commerce on a massive scale. There are two different categories of extraction which is the onshore drilling on land and offshore drilling away from dry land. There are many different types of offshore drilling facilities that are used for oil and gas production and one of them is a semi-submersible platform.

A semi-submersible platform is an oil and gas platform that have a floating platform which are supported by a hull consisting of columns and pontoons. Pontoon is a floatation device with enough buoyancy to float itself together with a heavy load. When flooded with seawater, the pontoons will be submerged to a predetermine depth (CIMC Offshore Business, 2015). It is generally used in many offshore works, for example, drilling, heavy lift cranes, oil production platforms and safety vessels. Besides that, semi-submersible stably support payload and respond minimally to waves. These semi-submersible platform can also be called as semi-submersible rig or semi-submerged ship (Chakrabarti, 2005).

This platform will be stationed in position in all weather and has no fixed access to dry land. Semi-submersible platforms are used for deep water productions which is usually above 1000 metres where the platforms float over the drilling site held together by heavy anchors which are computer controlled (Speight, 2014). The platform buoyancy originates from the pontoons situated beneath the ocean surface. The operating deck is located high above sea level to provides good stability, keeping it far away from the waves. As the main structure are submerged at a deep draft, the platform will not be affected by the waves compared to a normal ship (Bowes, 1990).

Furthermore, the semi-submersible platform are designed as drilling units due to its high stability. Semi-submersibles have a good motion response due to high drilling capability and can be moved and towed from one location to another. Besides that, as they do not need to face and withstand oncoming waves like a ship, thus able to support a large number of flexible risers (Barltrop, 1985). Figure 1.1 shows an overview example of the semi-submersible platform design with the huge anchors holding its platform. Figure 1.2 shows an example of a semi-submersible platform that is currently operational offshore near Sabah.

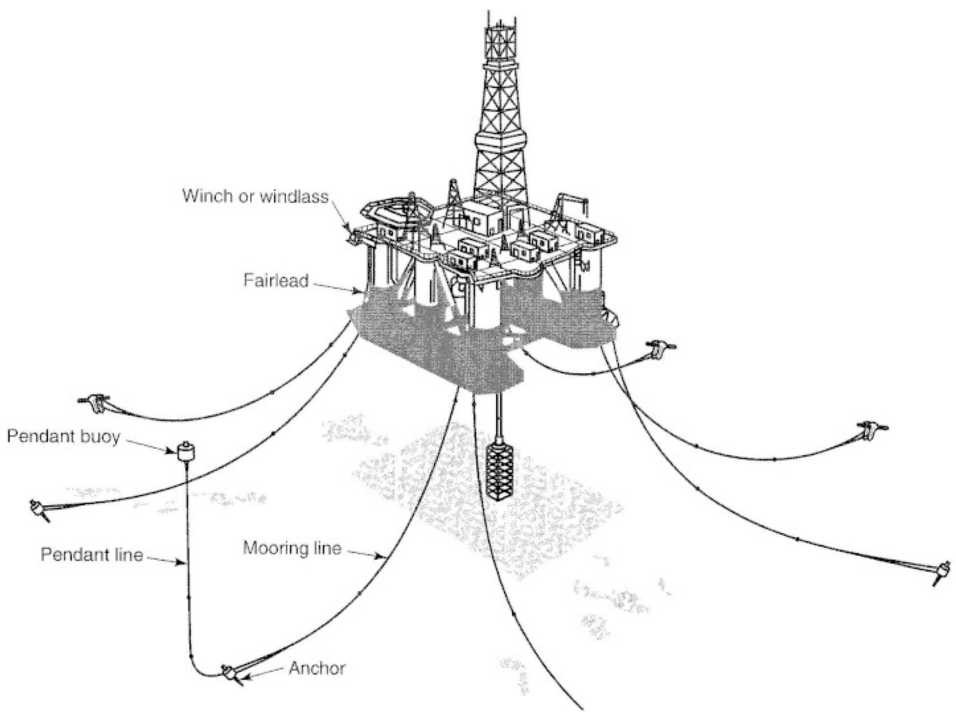


Figure 1.1: An overview example of the semi-submersible platform (Source: Knott, 1995)

Figure 1.2: Gumusut-Kakap semi-submersible platform near Sabah (Source: Krabbendam, 2013)

For the oil and gas production part, it can be classified into four important processes which are exploration, well development, production and site abandonment. Exploration consists of the hunt of rock formations that are connected with oil and natural gas deposits (Heminway, 2000).For the well development part, the main process involved is drilling. While the well is being drilled, anchors will hold still and make sure the rig does not move too much during the wind and sea currents. After the drilling is done, perforations or meshes are constructed to allow the oil and gas out of the rocks up the well to the surface (Hickman, 2008).

After the well development is completed, the production phase begins. Production recovers the hydrogen resources to the surface which will be transported (Cairn 2014). The hydrocarbons will be extracted and a blend of liquid hydrocarbons, gas, water and solids will be isolated. The liquid hydrocarbons and gas will be sold while the non-saleable part will be removed (Aliyeva, 2011). The figure 1.3shows the oil and gas production overview.

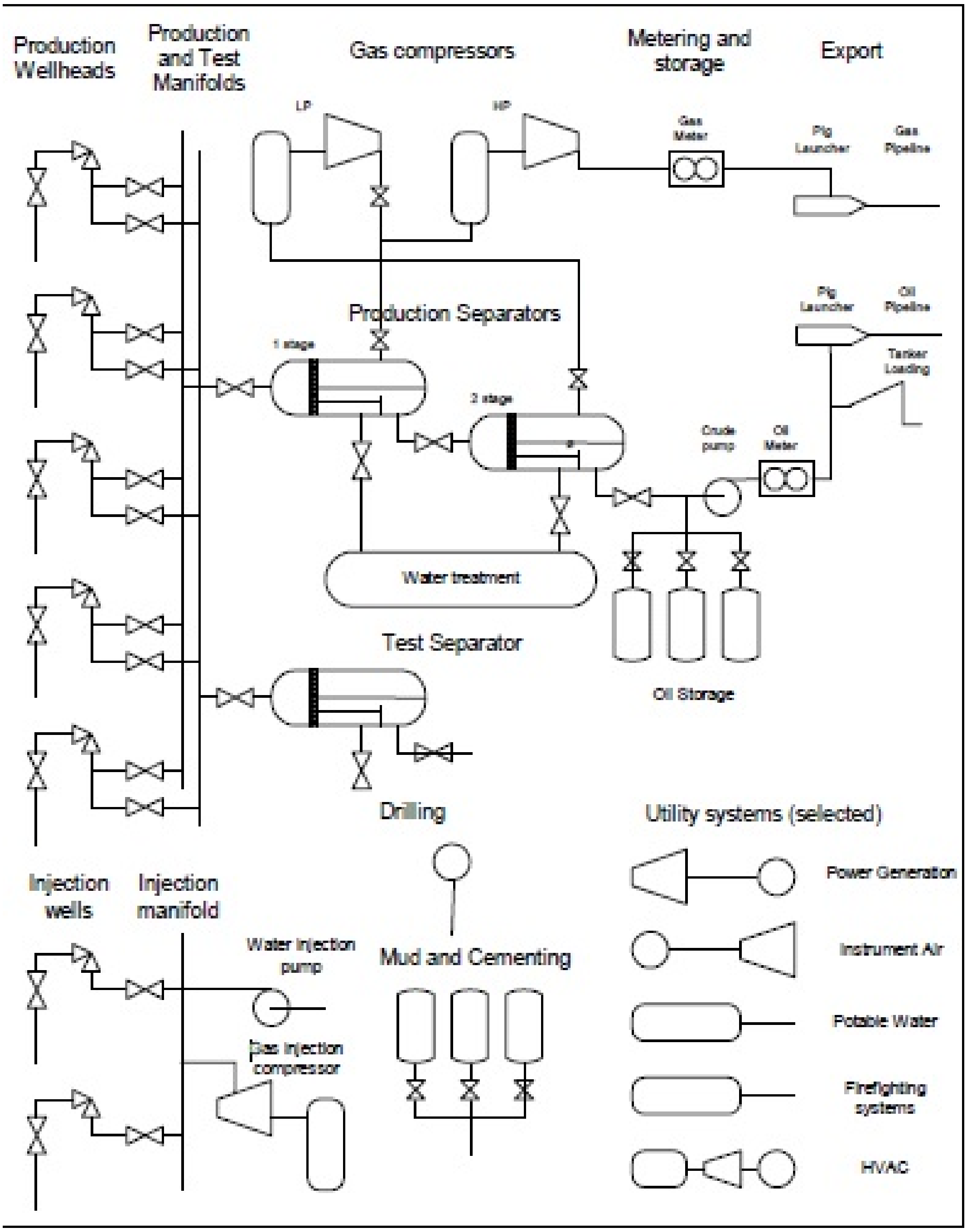


Figure 1.3: Overview of the oil and gas production (Source: Dewold, 2006)

Based on Figure 1.3, production wellheads feeds into the production and test manifolds in a process called the gathering system. The other part of the diagram is the gas oil separation plant (GOSP) which is the real process. The well flow will be processed into of a lot of hydrocarbons such as methane gas, butane gas and propane gas, condensates and crude oil. Other components such as water, carbon dioxide, sulphur and salts are released as by products which are unwanted (Dewold, 2006).

Finally, the last part which is the site abandonment where the wells will be decommissioned. This will only be done after confirmation that the recently drilled well could no longer sustain itself to produce the oil and natural gas economic quantities or no longer economically viable. The well is plugged to prevent the oil residue from contaminating the water (TEEIC, 2015).

In this research, the oil and gas production process that is being done using the semi-submersible platform will be simplified. The economic value and its importance will be reviewed and explained in further detail. The quantity of marketable products which will be in the form of crude oil and natural gas will be increased. The waste products will be tested and cleaned to produce new useful products that can be served as new raw materials for other products, increasing its cost effectiveness.

1.2 Problem Statement

The oil and gas production process involving offshore drilling has vastly increased in the past years to accommodate the increasing global demand of the products. Thus, the oil and gas exploration was increased and extended into the greater depths of water, increasing the use of semi-submersible platforms as they operate at depths higher than 1000 metres. The technology used in semi-submersibles have also increased throughout all these years.

The production facility of oil and natural gas for semi-submersible platforms has a lot of advantages compared to other oil rigs due to its high stability, large working areas and good mobility (NARCIKI, 2012). There are around 49 operational semi-submersible platforms around the world (Harris, 2014).

The technologies needed to improve the efficiency of the oil and gas production flow in the semi-submersible platform must be researched and used. Old methods are no longer applicable as new methods must be found to increase the productivity. Besides that, semi-submersibles have a high operating cost (Fang, 2014). A new method must be searched to reduce the cost while ensuring the profit is maintained or increased.

Furthermore, the quality of the production process will be affected by the low quantity and quality of workers with the poor management from the superiors (RIGZONE, 2014). A proper interview and recruitment system must be done to improve this situation. The structural fatigue and limited deck load must also be handled (Duan, 2014). Modifications must be made to ensure this problem is solved.

Thus, this study will focus on the best way to produce a maximized profit from the products sold while overcoming the problems faced to ensure a smooth and cost effective process. This study will also help to understand the benefits of a semi-submersible platform compared to the other methods of extracting and production process of oil and gas.

1.3 Objectives

This review study is carried out to obtain the following objectives:

i. To study the characteristics and benefits of a semi-submersible platform compared to other oil and gas platforms.
ii. To understand the oil and gas production process in a semi-submersible platform compared to other oil and gas platforms.
iii. To identify the disadvantages of the semi-submersibles and propose methods to overcome the problem.
iv. To analyse the impacts of the semi-submersible platform onto the oil and gas production in Malaysia now while exploring the economic benefits in the future.

1.4 Report Outline

There are five chapters that contains the information for this review study in this progress report.

Chapter 1 of this report provide a brief introduction which includes the background of study, problem statements faced and objectives that must be achieved during the project progress.

Chapter 2 provides knowledge and details about the oil and gas production process mostly on semi-submersible platforms.

Chapter 3comprises of methodology of this project where the techniques to complete this research is clarified orderly in subtle element.

Chapter 4 is the results and discussion part where the problem statement is addressed and the objective will be accomplished.

Chapter 5 comprises the recommendation part where improvements are made and the conclusion which deduces the entire report.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

The amount of oil and gas production industriesworldwidehave been increasing rapidly every year. Although there are calls to reduce the petroleum production industry due to the decreasing amount of fossil fuels left and the environmental pollution it causes, this industry continues to ignore the risks due to high profits it produce (Petroleum Industry, 2014). This industry plays a major role in the global economytoday as it is one of the highest demanding product in the current world.

This demand is driven by the growing population, economic prospect and the energy effectiveness for residential, industrial and transportation uses of oil and gas (HOOVERS, 2014). Hence, a considerable measure of organizations in this industrydevelop and operate fields to extract these unrefined oils and natural gas to increase their profitability. The whole history and process of the oil and gas industry from the exploration to the production process will be explained further in this study. There are a lot of machines and facilities that can be used for the production of the oil and gas but the semi-submersible platform is chosen and reviewed.

2.2 OIL AND NATURAL GAS OVERVIEW

Petroleum is the combination of natural gas and oil. These naturally occurring chemicals are made up of from mainly two elements which is carbon and hydrogen (Adventures in Energy, 2015). Petroleum are formed millions of years ago from the dead carcass of plants and animals. Over time, a lot of layers of sediments were formed over them and as the deeper they got buried, the high amount of heat and pressure will decompose the corpses with the help of bacteria. The soft part of these organisms over time were slowly converted to oil (San Joaquin Valley Geology, 2014).

Some oil and natural gas travel through the rocks and sediments and escaped while the other deposits lie under impermeable layers of rock trapped. Most of the oil reservoir is found in the ocean as the high pressure from the sea water prevents the petroleum from escaping (Marius, 2009). When petroleum is extracted from the ground, the liquid is called as crude oil if the characteristics are viscous. If the liquid is clear and volatile, it is called as condensates. Natural gas can be found together in the reservoir or alone (Welte, 2012). Figure 2.2.1 shows a cross section of the Earth's surface showing the location of the oil and gas reservoirs.

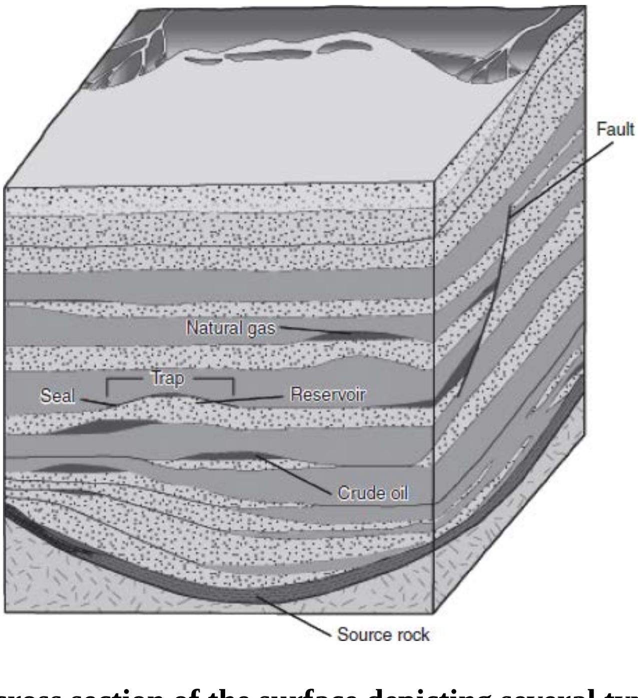


Figure 2.2.1: A cross section of the surface depicting several types of traps with crude oil and natural gas (Source: USGS, 2010)

Petroleum or in its raw form is called crude oil are distinguished by the percentages of the hydrocarbons found. There are four main hydrocarbons which are paraffin, napthene, aromatics and asphaltic. Raw crude oil is generally black or dark brown in spite of the fact that it can be greenish, yellowish or reddish (Petroleum.co.uk, 2012).Crude oil quality is determined by its light and heavy density together with the sulphur content.

A high sulphur content of crude oil greater than 0.5% is called as sour while a lower content of sulphur of less than 0.5% is called sweet. The nature of raw petroleum decides the processing level and necessary conversion expected to produce the ideals products (NESTE OIL, 2005). Crude oils are highly flammable and emits heat energy when ignited. Figure 2.2.2shows the example of the different types of crude oil.

Figure 2.2.2: The sample examples of different types of crude oil from very light to heavy sour (Source: Shamsi, 2013)

Natural gas is one of the cleanest and most environmental friendly energy resources. It is an odourless, colourless and highly flammable gas. Natural gas consists of mainly hydrocarbons mostly methane, non-toxic and lighter than air (International Energy Agency, 2015). The table 2.2.3 shows the normal composition that are present in the natural gas.

Table 2.2.3: The typical composition of natural gas (Source: Shamsi, 2013)

TYPICAL COMPOSITION OF NATURAL GAS

Methane	CH_4	70-90%
Ethane	C_2H_6	0-20%
Propane	C_3H_8	
Butane	C_4H_{10}	
Carbon Dioxide	CO_2	0-8%
Oxygen	O_2	0-0.2%
Nitrogen	N_2	0-5%
Hydrogen sulphide	H_2S	0-5%
Rare gases	A, He, Ne, Xe	trace

Natural gas can be classified into various types according to their specifications, characteristics and properties. Wet gas contains a high measure of hydrocarbon heavier than methane such as ethane, propane and butane due to its natural gas properties. These hydrocarbons will condense and are separated from methane when brought to surface. The separated hydrocarbons are called as natural gas liquids or known as NGL (Augustyn, 2010).

Dry gas is mostly methane and have very little heavy hydrocarbons. Thus, dry gas is considered as the cleanest of all naturally occurring fuels. Associated gas or flare gas is found together with crude oil deposits. These gases usually are burnt off at the production site but nowadays it is collected and purified to be sold off separately (Pietersz, 2005).

2.3MODERN HISTORY OF OIL AND GAS PRODUCTION

Today, oil and gas is very important to the current society where it has been known and used by civilizations long time ago. Oil usage and exploration begins 40,000 years ago until today. The first proof of oil usage is recorded when natural bitumen was found on stone tools in Syria 40,000 years ago (H. Giddens, 1938). The modern age of petroleum have been a story of technological advance where animal oils such as whale oil were used mostly before the discovery of petroleum. The first modern oil well was drilled in Asia by F.N. Semyenov, a Russian engineer north-east of

Baku, Azerbajian which was under the Russian ruling that time in 1848 (San Joaquin Valley Geology, 2010). As time moves on, this technology is used in a lot of places to drill and extract the oil from the ground.Figure 2.3.1shows the diagram of the oil well in Baku.

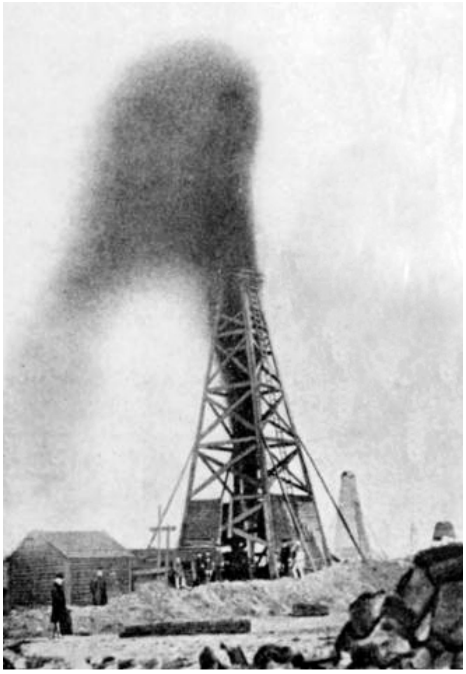


Figure 2.3.1: The Baku oil well (Source: Joaquin Valley Geology, 2010)

Due to this new technology of extracting oil from the ground through oil wells, half of the world's production and international market comes from the oil output from Russia around the 20th century. Next, modern oil refineries was established in Poland by Ignacy Lukasiewicz to provide high demand for kerosene lamps. There were other refined products such as naphtha, lubricants and asphalt (Skanseny, 2010).

After that, oil and gas industry exploded in the North America region as the community begins to realise the importance of petroleum and natural gas in the early 1900s.The demand for petroleum increased when the automobile industry start to emerge as it is a cheap and efficient fuel for transportation. James Miller Williams bored the first oil well in Oil Springs, Ontario, Canada. In the United States of America, the petroleum industry began in 1859 at Pennsylvania when E.L. Drake drilled the first true modern oil well, where a lot of modern oil wells were built near that region, creating a major boom in the economic industry of the country (Lagasse, 2012).

The automobile industry increased exponentially during World War I where the quantity of tanks, airplanes and trucks used for armies and equipment increased, therefore increasing the demand for oil. Since then, the United States became the world largest oil producer until World War II ended, where a lot of countries from the Middle East took control after that till today (Chakrabarti, 2005).

2.4 THE STAGES OF OIL AND GAS DEVELOPMENT

The oil and gas industry facilities are vastly defined according to their processes and uses in the production stream. There are four main stages involved which are the exploration, drilling, production and abandonment stage.

2.4.1 EXPLORATION

During the old days, hydrocarbon deposits were located using landmarks such as tar seeps or gas pockmarks (Devold, 2006). The structures containing the hydrocarbon deposits are usually porous rock with low-permeability rock on top, trapping the hydrocarbons from escaping (Anderson, 1992). However as technology have advanced and developed along the years, geological mapping is done using a series of surveys through the land and ocean using methods such as passive seismic, reflective seismic, magnetic and gravity study to provide data (Devold, 2006). Figure 2.4.1.1 shows the common trapped hydrocarbon deposits under sediments of rocks.

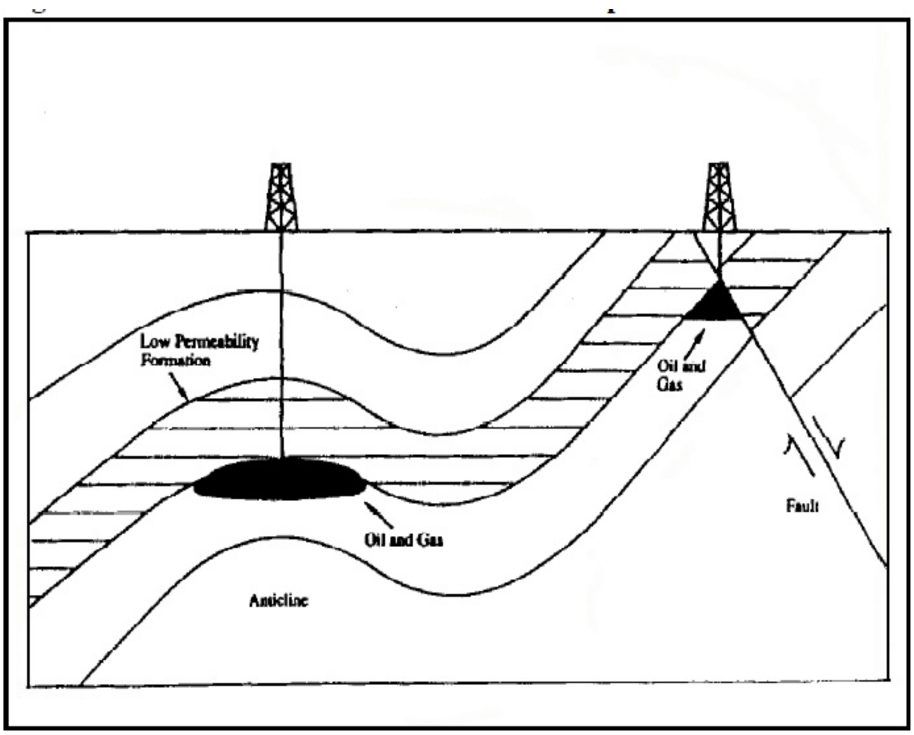


Figure 2.4.1.1: Hydrocarbon deposits trapped under rock sediments (Source: EPA. 1992)

Detailed seismic surveys are done to a suspected place to have a better understanding of the sub-surface structure. Seismic waves are generated by geophysicists that will travel through various layers of rock and gets reflected back, collecting data and the whereabouts of the positions of these hydrocarbon deposits. Seismic waves are created mostly utilizing unstable explosives detonated in holes drilled beneath the surface or land vibroseis and marine airguns (Berger, 1992). Land vibroiseis are used near populated zoneswhere trucks are utilized to drop substantial weights on hard surface to make seismic waves.

In offshore locations, explosives cannot be used due to environmental impacts and vibroiseis are impractical under the ocean. Thus, a machine airgun is used to create seismic energy where seismic waves are produced when water is permitted into the device at a quick rate. It is a large device that is emptied of air and water to make a vacuum. However, these surveys cannot perfectly locate the oil reserves as it only indicates the potential presence via certain suspected rock characteristics (Martin, 1998). The Figure 2.4.1.2 shows an example diagram of the machine airgun testing underwater.

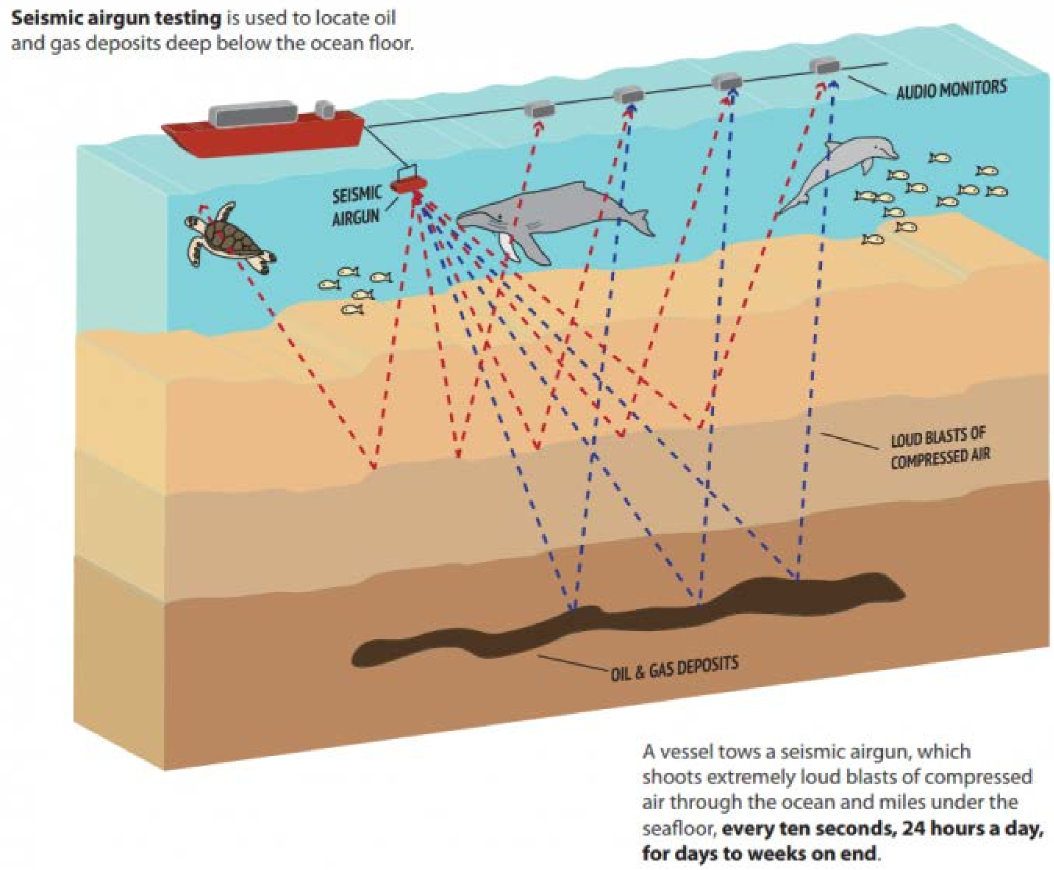


Figure 2.4.1.2: Seismic airgun testing locating oil and gas deposits (Source: Oceana, 2014)

After the potential reservoir is mapped based on the interpretation of the seismic data, exploration wells will be drilled and the data received will be assessed. The porosity and the permeability will be analysed to determine the water and hydrocarbon saturation. After that, the flow rates and maximum production potential are determined using production test data. Lastly, a computer model of the reservoir was built for further data analysis such as seismic reprocessing (Aliyeva, 2011).

The size of the amount of deposits is affected by the amount of earth movement, where a large motion will decrease the chances and size of traps accumulating oil and gas. For example, large homocline structures in Saudi Arabia contains a large oil reservoir. There have been very less geological movement there, so the oil deposits are preserved without disturbance (EPA, 1995). Figure 2.4.1.3 shows the pie chart of the world global oil reserve.

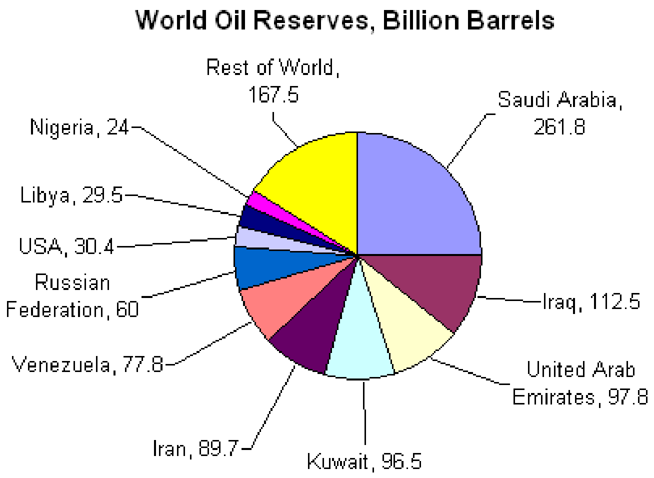


Figure 2.4.1.3: Pie chart of the global oil reserves (Source: World Oil & Gas Review, 2014)

In Southeast Asia, hydrocarbon deposits are located from north of Myanmar, extending through Eastern Sumatra into northern Java in an arc formation. Besides that, there are concentrations of hydrocarbon deposits in an arc shape too following the northern, eastern and southern coasts of Borneo. There is a rich source of hydrocarbon resource in this region and is the most active area of offshore exploration in the world. Petroleum exploration in this region begins in the 1870s largely thanks to the development of internal combustion engine and interest from European countries (Cleary, 1994).

Malaysia's oil reserve are the fourth largest in Asia Pacific after China, India and Vietnam where the majority of it originates from offshore fields (EIA, 2013). The exploration started at the 20th century in Sarawak after oil was first discovered in 1909 (Razmahwata, 2005). Today, Malaysia has the 25th biggest oil reserves and 14th largest oil reserves in the world. There is also 494,183 km^2 acreage accessible for oil and gas exploration. Figure 2.4.1.4 shows the location of oil and natural gas located around Southeast Asia.

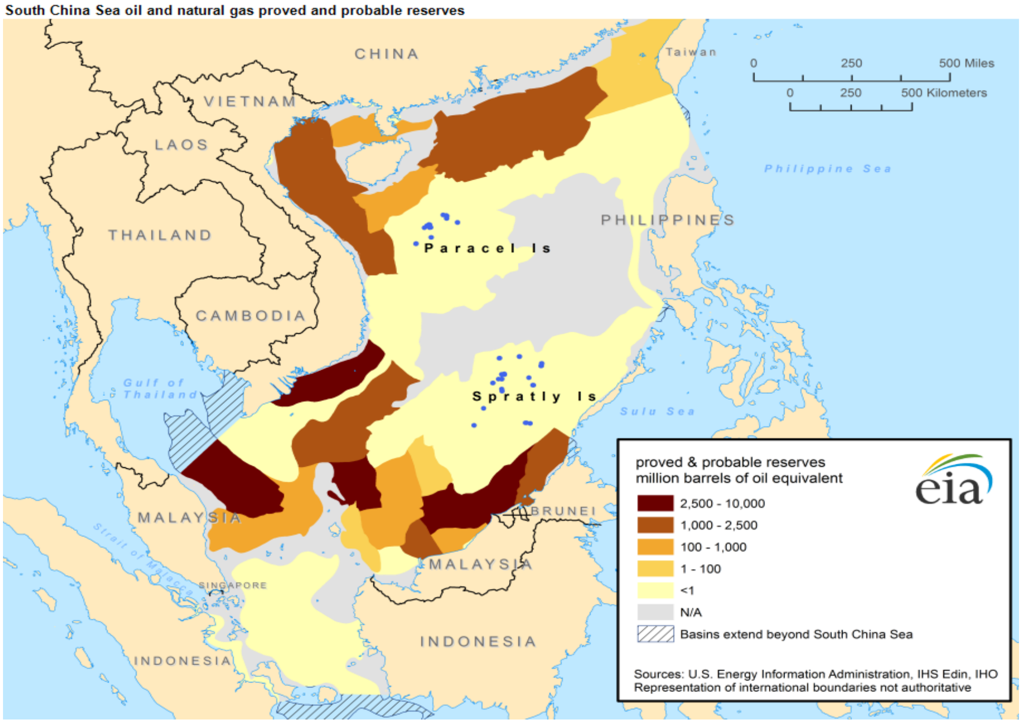


Figure 2.4.1.4: Location of probable and proved oil and gas reserves around Southeast Asia (Source: EIA, 2013)

Oil and gas exploration is a very risky operation where there is a high chance nothing will be discovered or the quantities of hydrocarbon is too small and not worth of extracting it. If a site is identified and the positively evaluated, an exploration well is drilled first to determine the presence of oil and gas.The exploration wells are sometimes untrustworthy because little are known about potential dancers like downhole pressures. Thus, lot of oil companies spend a lot of time on the analysis and result of exploration data before proceeding into the next stage.

2.4.2 DRILLING

After exploration is done, appraisal will be conducted to obtain details about the reservoir. A proper planning and implementation of the addition seismic data is done by reviewing the previous seismic data to provide an updated result. Once discovery is reaffirmed, a 3D numerical reservoir simulation model are built. This model can estimate the initial volume of oil and gas in the reservoir.

Besides that, the reservoir fluid flow pattern is stimulated and field development situations such as number, type and location of well and production quantity will be optimized (American Petroleum Institute, 1996).Based on the results and updated data from the computer simulation models, appraisal wells will be drilled to improve the field description.After that, initial field planning, economic assessment and environmental impact assessment is done on these sites before proceeding (Aliyeva, 2011). Figure 2.4.2.1 shows a 3D cross section model of a reservoir confirmed by the well.

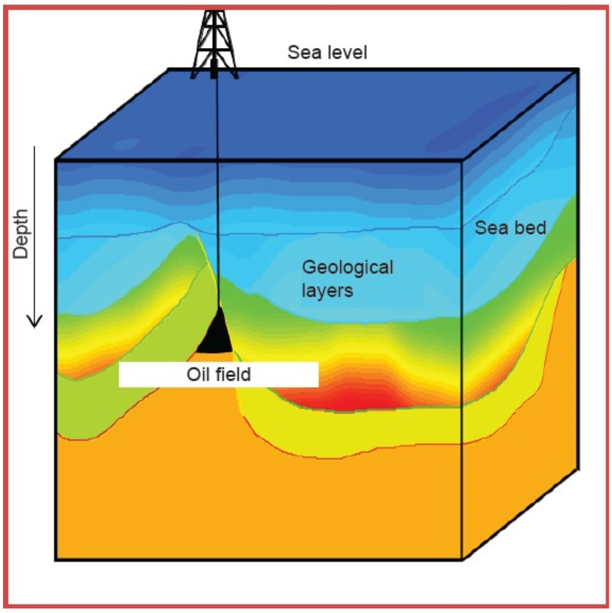


Figure 2.4.2.1: 3D cross section of geological layers showing a reservoir confirmed by a well (Source: IFP Energy, 2014)

Next, exploratory wells are drilled to make sure the presence of petroleum but sensitive instruments such as gravimeter, magnetometer and seismograph can also be used to find suspected rock formations that contains petroleum (Drake, 1960). As the perfect site is discovered, well development takes place where one or more wells are built in a process called spudding. Spudding means the beginning process of a new well drilling (American Petroleum Institute, 2015). This phase is called the development phase where various factors are taken into consideration such as the cost effectivity and longevity of the project.

After all the development is done to confirm the existence of petroleum in that area, the next process that will be done is the drilling phase. Drilling for oil and natural gas is an intricate process but technology have made it easier, effective and productive while the environmental impact have also reduced. There are two types of drilling which are onshore drilling and offshore drilling (Edwin, 2012).

Onshore rigs are portable and including tall derricks that handle tools and equipment that dip into the hole or well. The drilling equipment are transported using trucks and barges. There are two primary types of onshore drilling which is the percussion system or cable tool drilling. These procedure includes raising and dropping heavy metal bit into the ground that will blow a hole through the crust. This drilling is usually used on shallow and low pressure rock formations (Natgas, 2004).

The other method is commonly used which is the rotary drill. Rotary drill is the most universal drilling method and have been upgraded continuously.It is a sharp rotating metal drill bit suitable to bore through the Earth's surface for more profound wells that are under high pressure. This method would increase the well yield and cost effective (Devold, 2006).

A rotary drilling rig comprises of a power source, a derrick with lifting and lowering mechanism and a string where the tubular high tensile steel is attached to it. The drill string passes through a rotary table that turns which will provide the torque needed to turn the drill string and drilling bit. As the drill bit is lowered into the earth surface, additional drilling pipe is added on the top (Testa, 2014). Figure 2.4.2.2 shows an example of a common oil-drilling rig.

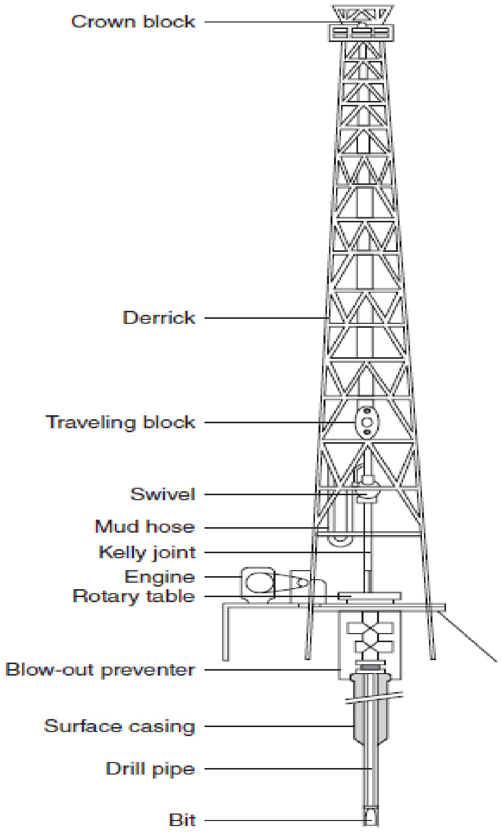


Figure 2.4.2.2: Schematic diragram of the various components of an oil-drilling rig (Source: Bea, 1993)

2.4.3 OFFSHORE DRILLING

Offshore drilling is a process where the metal drill bit will penetrate through the seabed to extract petroleum existing within rock formations underneath the seabed. Offshore drilling first started off the coast of California, United States of America in 1896 (Whitby, 2007).In Malaysia, offshore drilling began in 1957 and increased rapidly around 1966 around the coast off Sarawak (Valencia, 1983).

Offshore drilling and production was mostly done in stable shallow waters in the beginning but the economical productivity was low and the environmental impact was high as it is nearer to the coast where populated areas are present. Thus, greater exploration into deeper waters where the first discovery was from Shell Oil Company's Cognac field in 1975 (Augur, 1987). After the first discovery that shows a greater amount of hydrocarbon deposits available in deeper waters, technology was developed for these exploration, drilling and production purposes.

There are a lot different structures used for offshore drilling depending on the size and water depth. Offshore drilling can be done from bottom-based platforms, drill ships or submersible platforms that is self-contained with its own set of equipment. These include bottom founded drilling rigs like jackup barges and swamp barges or deepwater mobile offshore drilling units (MODU) such as semi-submersibles and drillships.

Figure 2.4.3.1shows the types of oil and gas offshore structures where from left to right include the conventional fixed platform for rig 1 and 2, compliant tower for rig 3, vertically moored tension leg platform for rig 4, mini-tension leg platform for rig 5, spar platform rig 6, semi-submersible platform for rig 7 and 8, floating production, storage and offloading facility for rig 9 and sub-sea completion and tie back to host facility.

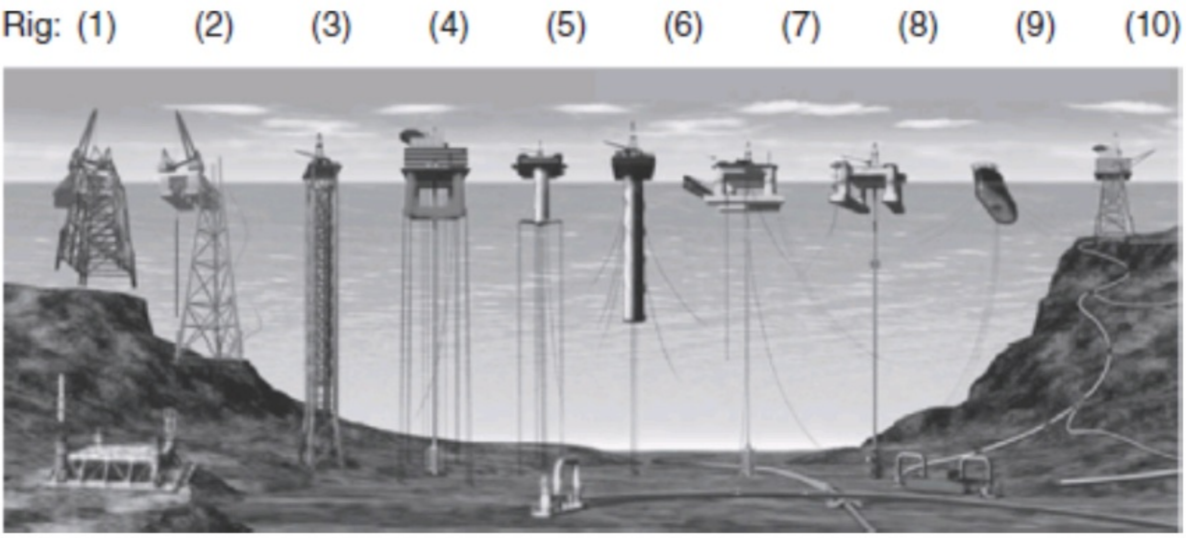


Figure 2.4.3.1: Types of oil and gas offshore structures (Source: NOAA, 2005)

Offshore drilling is extremely challenging compared to onshore due to the harsh and unpredictable climate in the open sea. However, the amount of reservoirs containing hydrocarbon deposits is high and although the risks are high as well, the profitability it produces will eclipse it. The next step after drilling is the well preparation part for production process.

2.4.4 PRODUCTION

The hydrocarbon deposits in the reservoir may need a time of between 15 to 30 years to be extracted normally but a giant field can sustain a reservoir for 50 years or more. The expectancy period of a reservoir are determined by the production size, stabilization phase, injection phase where water, gas or chemical products is used for the hydrocarbon recovery to maintain an optimum volume of production and the depletion period when the production process lessen rapidly (IFP, 2013).

Production process generally extracts the hydrocarbon deposits and separates the liquid hydrocarbon mixture, gas, water and solids. The major activities are conveying the liquid to the surface, separating the liquid and gas segments and removing impurities. In the past, only a few percentage of available oil that can be extracted from the surface due to lack of technology required to bring the rest up to the surface. However, advanced technology now allows to almost 60% of oil recovery from the reservoir (API, 2008).

Primary recovery is the first stage where underground pressure drives the fluids up to the surface. Artificial lift equipment is used if the underground pressure is not sufficient enough to force the oil up. This comprises of many types of pumps and gas lift valves. During pumping, motors can be utilized at the surface or inside the wellbore to help with lifting the liquid. This process mostly recovers 10% of the oil in the deposit (Smith, 1998).

Secondary recovery applies enhanced recovery techniques where the water produced from the initial oil separation process is injected back into the wellbore to bring more oil to the surface. This method is also known as waterflooding where external water sources can also be used (Craig Jr., 1971). This process dumps the wastewater in addition to enhance the oil recovery.An additional 20% of oil can be recovered here (API, 2008).Figure 2.4.4.1 shows the secondary recovery process overview.

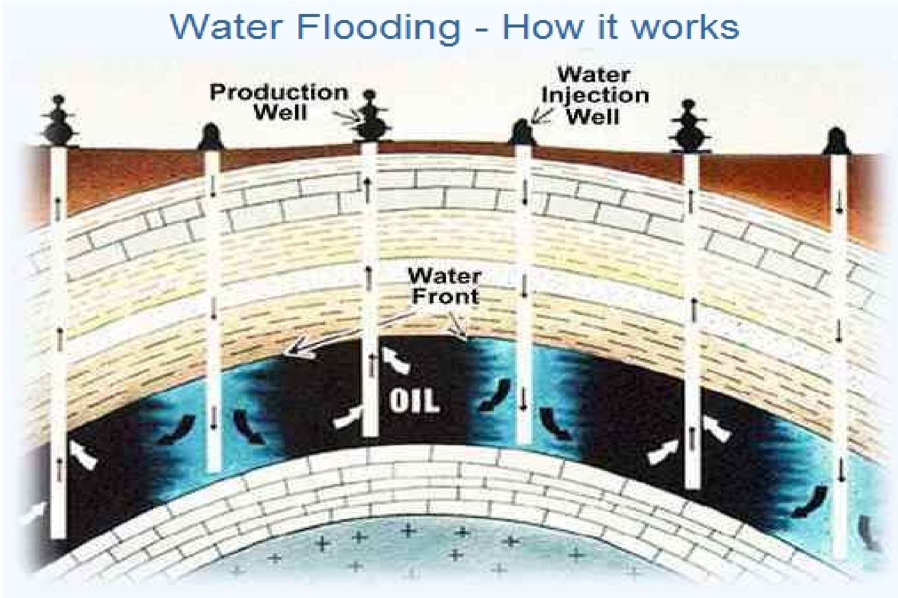


Figure 2.4.4.1: The overview of the water flooding process (Source: XINCA, 2013)

Enhanced or tertiary recovery techniques are then used lastly where generally additional materials are added to mobilize the remaining oil. These methods are usually expensive and the substance will be removed together with the product after being injected (Lake, 1989). The examples are thermal recovery where the reservoir fluid is heated up from steam injection, causing a pressure rise making the oil to flow up easily.

Besides that, the gas injection method which uses either miscible or immiscible gases to diminish the oil thickness and viscosity to increase the oil flow (Sittig, 1978). Lastly, chemical flooding can also be used where dense and water soluble polymers are mixed together and poured into the wellbore, pushing the existing lighter oil out. These recovery techniques recovers as much as 60% of oil reserve to the surface (EPA, 1992).

When the oil is brought the surface, it is mixed with natural gas, water, sand, slit and any additives that were used during exploration. These components will be then separated where the gaseous part will be removed followed by the removal of solids and water ending with the oil-water emulsion separation.The mixture will be first passed into pressure chambers, where gaseous components are removed from the liquidby differential pressure difference between the fluid and chamber (Landes, 1970).

Next, the heater will treat the remaining mixture to break up water from oil, increasing its density. The lighter natural gas are removed for processing or burning while the water will be stored for future treatment (Schackne, 1960). After that, the remaining liquids are mostly a mixture of oil and water in an emulsion form. Chemicals are used to separate the emulsion where hydrocyclones spin the mixture and oil will be separated from water via acceleration, producing an oil content that is about 98% pure that is sufficient for storage or transportation to the refinery (Sittig, 1978).

The wastewater that are removed are mostly salty, thus it cannot be used as a water resource. It will be usually injected back into the subsurface mostly into the wellbore to help force more oil out from the reservoir. Before releasing back the wastewater especially in offshore, the salty water is tested to prevent any accumulation of oil and impurities that could damage the ecosystem. This method have been studied and closely monitored to ensure the environment is not impacted due to rich marine life staying close to the offshore platforms (Mosley, 1973).

Natural gas is removed in a conditioning process where impurities will be removed from the gas stream. Dehydration will be done to remove water from the gas stream with the use of liquid or solid desiccant that will absorb the water (Smith, 1999). Next, sweetening where commonly amine treatment is used to remove hydrogen sulphide and carbon dioxide from the gas stream. Finally, the remaining gas will be cooled down below the condensation point of water for easy transportation.

Lastly, all production and maintenance activities must be carried out according to the safety regulations and environmental policies and procedures. The main safety activities are the production must be regulated to meet approved plans for quantity and quality for the product and all information to manage the reservoir, wells and facilities are monitored and regulated. Besides that, maintenance must be carried out regularly whereas all the production and maintenance activities should be planned and scheduled to minimize production deferment and operating costs (Aliyeva, 2011).

2.4.5 ABADONMENT

After all the hydrocarbon deposits are extracted to a point where the production rate becomes non-economical where the operating costs exceed the revenue from production sales, the reservoir will be abandoned. This is the last phase where all installations and subsea structures will be decommissioned (Hook, 2009). This procedure is common where offshore facilities are dismantled and removed and the site will be returned to its original state.

First, the wells will be filled with concrete at various depths while the well-head and casing will also be removed about 2 meters below the surface or seabed. Next, all the facilities and equipment are dismantled and removed while no environment contamination occurs during this procedure. Lastly, the site will be restored where the well will be placed in a safe state and a final environmental impact study is conducted (Dan, 2015). Some offshore platform after undergoing site abandonment can be used for different purposes. Figure 2.4.6.1 shows an example of an old offshore platform that is being currently used for a different purpose.

Figure 2.4.5.1: An example of an offshore platform transformed into a floating luxury hotel (Source: IFP, 2013)

2.5 OFFSHORE PRODUCTION FACILITIES

There are two type of oil and gas drilling which is the onshore drilling and offshore drilling. Onshore drilling is done on dry land while offshore drilling will be done on seabed away from land. Offshore drilling are more challenging due to the additional constraints such as water depth, climate conditions and remote locations.

The main difference between these two drilling is the way in which the rig is supported where offshore drilling is conducted on platforms which either float or are fixed to the sea bed (Dake, 2004).Offshore drilling platform are usually big and tall in height, due to the length of wellbore required to reach the depths of the sea. Figure 2.5.1 shows the comparison between offshore platforms and normal landmark buildings.

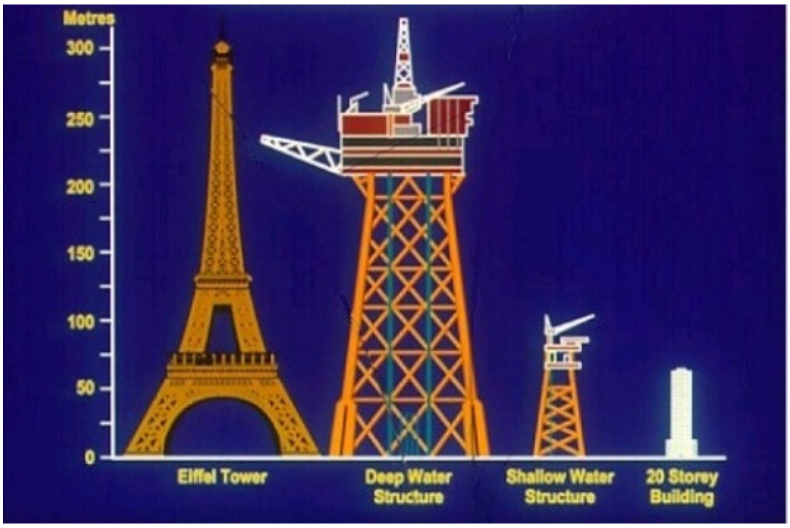


Figure 2.5.1: The comparison of height and size between offshore oil platforms and normal buildings (Source: World Oil Reserves Chart, 2009)

Production platforms are usually placed on a drilling site for 20 to 30 years with the exemption if a giant field is discovered that will take up to 50 years or more (RIGZONE, 2014). The most common oil platform that are in operation nowadays is the fixed platform structure or also known as jackets. However, if the exploration and drilling takes place in deeper water depths, a floating platform and sub-sea structures are used (Sadeghi, 2007). Figure 2.5.2 shows all the examples of the offshore production platforms.

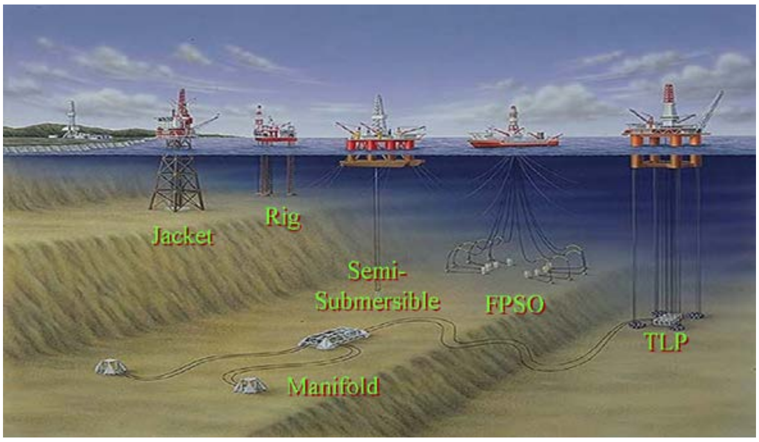


Figure 2.5.2: Examples of common offshore production platform (Source: Dutta, 2009)

Fixed platforms as the name shows, is located on a fixed structure on where the reservoir is located and well is installed. It comprises of a jacket which is a tall vertical segment made of tubular steel structure helped by piles attached into seabed. There is a deck placed on top which will provide space for the workers together with a drilling rig and production facilities (Devold, 2006).

The tubular structure provides support to the platform and protects the structure from strong waves, wind and sea current. However, the fixed platform is only economically feasible for installation in water depths until 500 meters (API, 2015). Thus, it is impractical for deep water exploration and drilling. Examples of fixed structure platforms are steel jackets, concrete gravity based structures, jack-ups, Tension Leg Structures (TLP) and compliant towers (Howe, 1966).

Sub-sea structures are drilling production units that are located on the seabed. These units are economical for minor fields near existing installation and are suitable for great water depths more than 500 meters (Devold, 2006). Although there is no direct vertical access to oil and no storage facility plus the high maintenance, the production time is early as it is attached to the seabed directly, extracting petroleum as fast as possible (McCrae, 2003).

Floating platforms does not have a fixed vertical access to oil wells but it provides a big storage facility and are used for depth greater than 500 meters. This structure depends on the merging of water plane area and stiffness to achieve stability as there is no embedded steel structure to support it. Some are equipped with hulls for buoyancy and stability purposes (API, 2015).

Examples of floating platform are Floating Production, Storage and Offloading (FPSO) drillship, semi-submersibles and spar platforms. Floating platforms are generally known as mobile offshore drilling units (MODU) which are mobile and can be transported anywhere (Kaiser, 2013). Table 2.5.3 shows the difference between fixed and floating production platform.

Table 2.5.3: Comparison between Fixed and Floating Production Platform (Chakrabarti, 2005)

Function	Fixed Platform	Floating Platform
Water Depth	Shallow regions below 500 meters	Deep regions above 500 meters
Support Structure	Tubular structure beneath the seabed	Buoyancy and stability provided by the hull
Mobility	Barge transport or built on site	Towed to the site
Installation	Piled foundation attached to seabed	Attached to the pre-installed moorings
Decommissioning	Heavy lift equipment needed to remove the structure	Can be done readily and might be able to function in a different site

2.6 SEMI-SUBMERSIBLE PLATFORMS

Mobile offshore drilling rigs or units (MODU) are marine vessels that are utilized to investigate, create and workover wellbores. Since 1950, over 120,000 wells have been drilled offshore and over the previous decade, about 3500 offshore wells are bored every year where the majority are drilled using MODUs (BOEM, 2007). MODU rigs are classified into bottom supported and floating rigs (BOEM, 2007). This project will focus more on the semi-submersible platforms and their production facilities.

A semi-submersible is a MODU outlined with a platform-type deck that incorporates drilling equipment and other machinery that is upheld by immense pontoon-type column submerged into water. Pontoon is a floatation device with enough buoyancy to float itself together with a heavy load. This floating platform consists of vertical hollow legs that are connected to horizontal pontoons utilized for seawater ballasting for stability purposes. Besides that, there are large heavy anchors that keeps it secured to the seabed (Howe, 1986).

Semi-submersibles originate from submersible drilling vessels where it is operated on shallow water and a platform deck above the wave action (Ronalds, 2000). These early structures float on pontoons and need stability columns for it to submerge in a safe level. Stability columns are primary columns providing floating stability. Marine riser and spread moorings was developed in order to allow deeper water drilling (Burleson, 1999). Although by time, semi-submersibles have improved in configuration and size, the basic foundation is nearly the same with a deck supported with submerged pontoons and large columns providing stability.

There are five different generations of semi-submersibles that was built from the early 1960s that varies according to the development of design and technology (Chakrabarti, 2005). The first three generation design was lacking technology and design development, thus the structures are mostly faulty and does not produce the required production level. Most of these semi-submersibles have been converted into drillships or FPSOs. The first semi-submersible platform is built accidently in 1961 by the Blue Water Drilling Company as the pontoons are not able to support the weight of the platform, thus allowing it to operate in a floating method (Industry Pioneers, 1998). Figure 2.6.1 shows the diagram of the first semi-submersible drilling rig that was built.

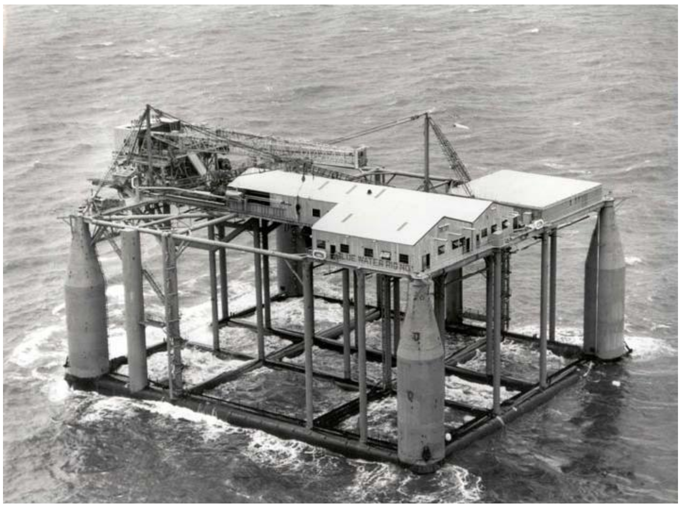


Figure 2.6.1: Blue Water Rig No. 1 that was built in 1961 by the Blue Drilling Company in the Gulf of Mexico (Source: Industry Pioneers, 1998)

Semi-submersible platforms can work in either shallow or deep water depths. However, in shallow water there is a concern that the lower hulls might clash with the surface blowout preventer stack is if it moves off to another location. Thus, a semi-submersible oil platform is preferable to be used at depths greater than 500 meters (Lim, 2000).

The first three generation semi-submersibles were operating in water depths below 500 meters. Starting from the 4th generation semi-submersibles, operation to water depths above 500 meters began where the current generation semi-submersibles are operating at water depths above 3000 meters. Table 2.6.2 shows the comparison between all the semi-submersibles generations.

Table 2.6.2: The comparison between all the generations of semi-submersible platforms (Glendasmith, 2012)

Generation	Water Depth	Year Built	Comments
1	Less than 200 meters	Early 1960s	Mostly built to be submersibles but accidently converted to semi-submersibles.
2	200 – 300 meters	Mid to late 1970s	The foundation for all the semi-submersibles where

			moderateupgrades are done.
3	200 - 500 meters	Mid to late 1980s	Major water depth upgrades and are mostly new built.
4	500 - 1000 meters	Late 1990s to early 2000s	Improved mooring ability, riser tension, mud volume, hook load and other new features.
5	Above 1000 meters	Early 2000s to now	Mostly designed for harsh environments and for ultra-deep water depths.

2.6.1 SEMI-SUBMERSIBLES DESIGN

Semi-submersibles consists of a hull supporting the deck, multiple columns and pontoons. The centre of gravity is above the buoyancy centre, thus the columns placement determines the stability, making semi-submersibles column stabilized. The main components in the semi-submersibles are the hull, pontoons, deck and the multiple columns.

Hull

The main structure that holds the platform floats on horizontal pontoons and vertical columns known as legs. The pontoons and columns are joined in a circular cross pattern, giving the hull its structural strength. The bottom pontoons and legs are void to allow seawater to provide ballast to submerge the structure and to hold large quantities of diesel oil, drilling mud and fresh drinking water (Lim, 2000). There are four hull arrangements which is shown below in Figure 2.6.1.1.

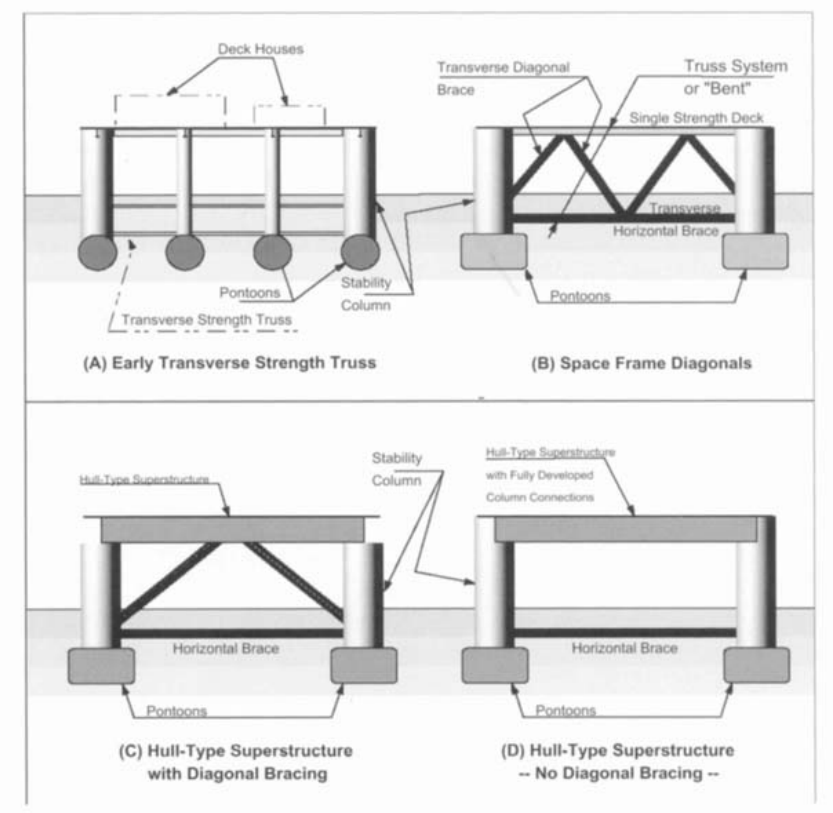


Figure 2.6.1.1: Semi-submersible sectional arrangements (Chakrabarti, 2005)

Columns and Pontoons

Pontoons provide stability and buoyancy from its ballasted and watertight properties. The pontoons are located below the water surface and wave action. Columns provide stability where when the semi-submersible is submerging, the floatation properties change from the pontoons to the columns (Ronalds, 2000). The columns connect the pontoons and deck. There are multiple arrangements of pontoons and columns that provide stability and determines the size of the operating deck and production facilities, which can be seen in Figure 2.6.1.2 and Figure 2.6.1.3.

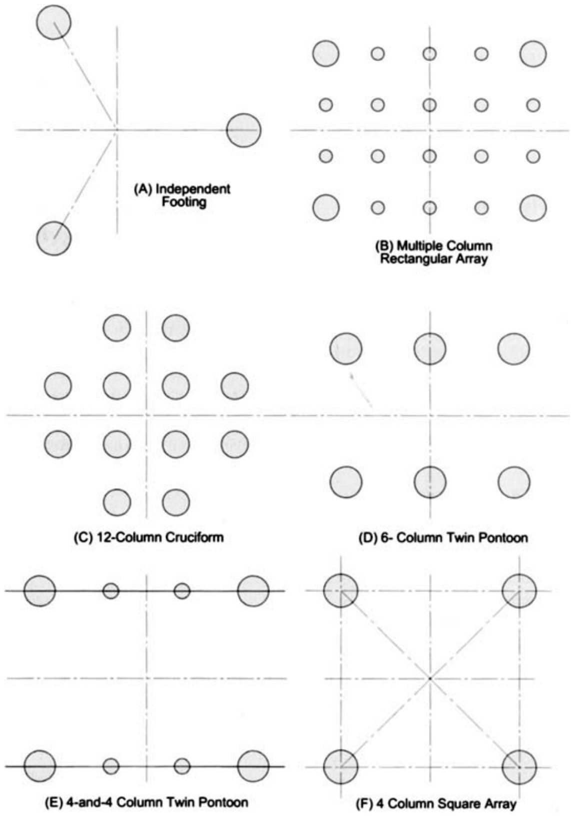


Figure 2.6.1.2: Types of semi-submersible column arrangements (Source: Chakrabarti, 2005)

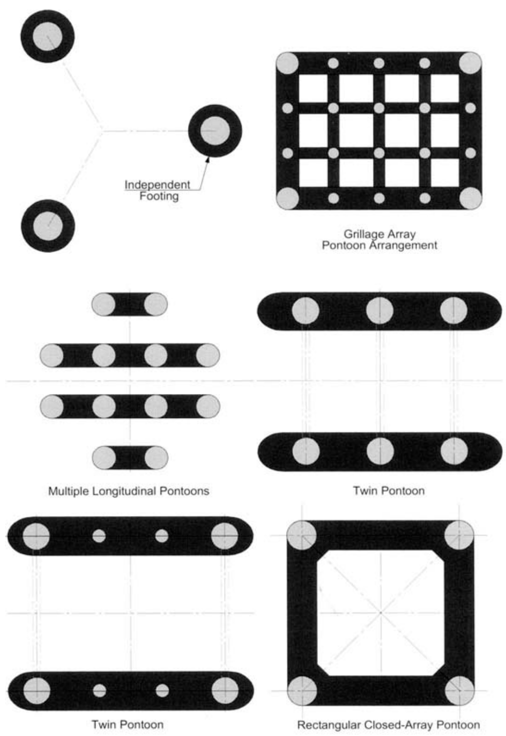


Figure 2.6.1.3: Types of semi-submersible pontoon arrangements (Source: Chakrabarti, 2005)

Anchors

The anchors are attached to the cables and wires in a set of 6 to 12 (Sharda, 2011). It a mooring device used to secure it to the bottom of the seabed where the vessel is stationary. The anchors plays an important role in drilling as the anchors must be strong and withstand the ocean currents to maintain the platforms position. The anchor is made of metal and works according to the anchor chain, resisting the platform movements. The anchor is released and controlled automatically using dynamic positioning such as the global positioning system (GPS) until it reaches the seabed. When not in used, the anchors are stored on the deck (Narciki, 2012).

Deck

Single decks were favoured in earlier semi-submersible designs due to the limited erection resources then. There are two type of deck which is the hull-type deck which is stronger, more spacious, less costly and lighter as it is attached together with the hull and the truss-decks which is built separately and joined together to the hull (Petrobas, 2010). Deck are welded to the hull and consist of the accommodation, control room, power generation unit, helideck and pad, mud system and pumps, drill platform, rotating table, cranes, lifeboats, flare tower and derrick (Scott, 2012).

The control room is the rig hub where the operation manager surveys all the different instrumentation and printouts that will provide all the data and information such as drilling rate, core sample reports and analysis, sea and wind conditions and many relevant technical details that are important (Bowes, 1991). Accommodation is usually comfortable with satellite TV, gyms and even saunas. The cabins sleep two men in bunks, who are normally on the same shift pattern. The workers will be working in a twelve-hour shift with twelve hours rest and the food provided is satisfactory. The workers will have leave for every two weeks departing and returning to the rig via helicopter (RIGZONE, 2015).

The oil rig is mostly powered by diesel or self-containing power generation units from gas turbines. The gas turbines will run on gas or on a mixture of gas and oil. There is an emergency diesel generator in a fire-proof room that can provide power to emergency crisis and crucial services for 24 hours (HOOVERS, 2015).

Modern lifeboats are hung over the side of the deck in a near vertical steep angled ramps and are free-fall launch. Previous lifeboats are placed on the deck but during the 1988 Piper Alpha disaster, the crew could not lower the lifeboats as it was covered with burning oil (Duff, 2008). When launched, the boats will hit the water at an edge going under the surface for a distance before surfacing back, extinguishing fire around the lifeboat surface in case if there is a fire explosion (Scott, 2012)

Normally there are two or three cranes with long jibs to cover the whole deck area. It is operated by a hydraulic system driven by diesel engines. The cranes function to unload supply boats and help in bunkering, hoisting hoses to and from bunker barges and lift equipment to workspace for maintenance (Lim, 2000). The drill platform have a rotating table which comprises bushings in the centre and is normally chain using heavy duty chains. This bushings allow drill string to move down under its own weight, the table rotation will be transferred to the drill string turning it and the drill bit in a clockwise rotation as it descends into the subsea rock (Devold, 2006).

The drill derrick contains the lifting gear for drilling pipes and drill pipe strings. At the top of the derrick is the crown block consisting the pulley system, sheaves and wire ropes that must be capable of holding the weight of the drill pipe (RIGZONE, 2015). The flare tower extends clear of the rig and holds the pipe and flare tips containing sour gas that will be fared off. There is a heat shield around this tower to protect the flare heat from the workers (Scott, 2012). Figure 2.6.1.4 shows the diagram of the semi-submersible drilling mechanism and Figure 2.6.1.5 shows the overall sketch of a semi-submersible platform

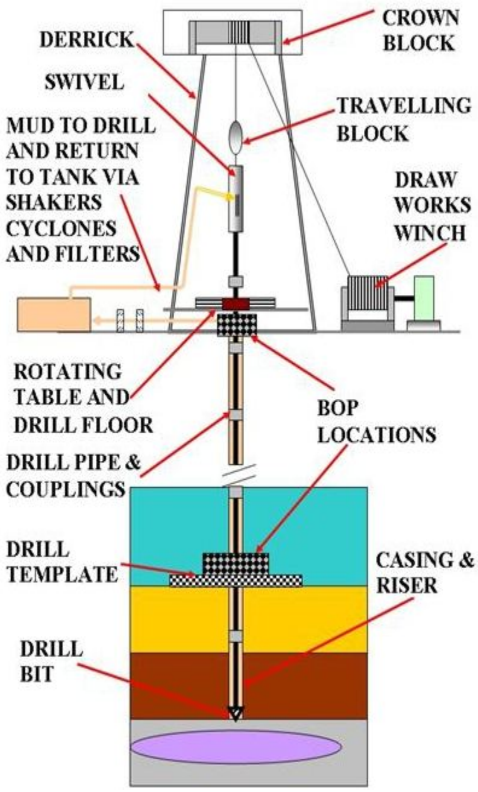


Figure 2.6.1.4: The drilling mechanism present in the semi-submersible platform (Source: Scott, 2012)

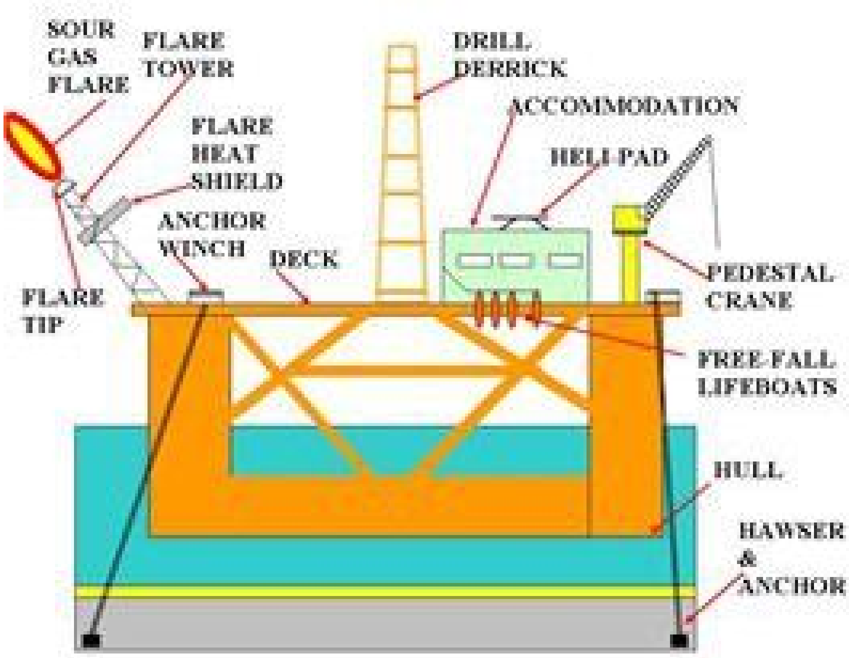


Figure 2.6.1.5: Sketch overview of a semi-submersible platform (Source: Scott, 2012)

2.6.2 TYPES OF SEMI-SUBMERSIBLE PLATFORMS

Bottle-type

These structure consists of bottle shaped hulls below the drilling deck that is submerged when water flows into the hull. The bottle shaped hulls were completely submerged under the sea when it was a submersible rig. However as time moves on, the oil rig was discovered to be stable only if it is partially stable and able to drill in deeper waters. Mooring lines are utilized to keep the structure set up with the assistance of anchors tied to the seabed (RIGZONE, 2015). Figure 2.6.2.1 shows an example of a bottle-type semi-submersible platform.

Figure 2.6.2.1: The Noble Clyde Boudreaux bottle-type semi-submersible (Source: RIGZONE, 2015)

Column-stabilized

This is a more popular design and is currently used mostly compared to the bottle-type. Two horizontal hulls are connected in a cylindrical or rectangular columns to the drilling deck placed above the water. The structure are supported by smaller diagonal columns. This semi-submersible is submerged when the horizontal hulls are partially loaded with water until the platform is submerged to the obliged depth. Mooring lines will anchor the oil rig above the well with the help of dynamic positioning to maintain its position (Keppel Corporation, 2010). Figure 2.6.2.2 below shows an example of a column-stabilized semi-submersible platform.

Figure 2.6.2.2: The DSS 38 column-stabilized semi-submersible platform (Source: Keppel Corporation, 2010)

2.6.3 APPLICATIONS

Mobile offshore drilling units (MODU)

Semi-submersible rigs create stable platforms for offshore oil and gas drilling. These rigs will be towed to a position by a tugboat and anchored. Besides that, some semi-submersibles can be moved into position by own azimuth thrusters with dynamic positioning. An azimuth thruster is an arrangement of huge marine propellers placed in pods that can be rotated to any horizontal angle, hindering the use of the rudder and providing a better manoeuvrability (Maasmond Maritime, 2015). Figure 2.6.3.1 shows an example of a MODU application.

Figure 2.6.3.1: A semi-submersible drilling rig being towed to its place by the MS3 semi-submersible Heavy-lift Ship (Source: Maasmond Maritime, 2015)

Semi-submersible crane vessels (SSCV)

Semi-submersible vessel have high stability as it was discovered in 1978 when the Balder and Hermod crane vessels were built (Heerema Marine Contractors, 2014). It consist of two lower hulls attached together with pontoons, three columns on each pontoon and an upper hull. These cranes have the ability to carry enormous weights up to above 14,000 tons (MARIN, 2015).

During movement, the lower part of the hull will be submerged and during lifting, the vessel will be ballasted down. This will cause the wave and swelling effect to reduce. As the columns are placed far apart, high stability is formed that enables lifting of extreme high loads (Heerema Marine Contractors, 2014). Figure 2.6.3.2 shows an example of a semi-submersible crane vessel.

Figure 2.6.3.2: The Saipem Scarabeo 7 semi-submersible drilling rig with the two crane vessels (Source: Saipem S.p.A, 2013)

Offshore support vessels (OSV)

Some semi-submersibles are used for offshore support vessels due to the high stability, broad and wide deck areas and variable deck load. Some of these support vessels are used as construction or diving support vessel, offshore operation vessel, accommodation platform, multiservice vessel or as a converted spacecraft launch pad (SeaLaunch, 2011). Figure 2.6.3.3 shows an example of an offshore support vessel.

Figure 2.6.3.3: The Ocean Odyssey semi-submersible platform that have been converted into a rocket launch pad (Source: SeaLaunch, 2011)

Offshore production platforms

After inconceivable oil fields and repository was discovered and developed in offshore areas, semi-submersibles were changed from their drilling purposes to both drilling and production platforms. These structures are very stable and financially savvy. By time, the oil and gas industry begin exploring into deeper water and harsher environments which would create more purpose-built semi-submersible production platform as all the previous platform were multi-purpose (Chakrabathi, 2005). Figure 2.6.3.4 shows an example of an offshore semi-submersible production platform.

Figure 2.6.3.4: The Aker Spitsbergen semi-submersible production platform (Source: AkerSolutions, 2015)

2.6.4 ADVANTAGES AND DISADVANTAGES OF SEMI-SUBMERSIBLES

Advantages

a) High mobility
b) Good motion response
c) Easily positioned over well template for well drilling
d) Large number of flexible risers due to no weathervaning system, keeping the platform fixed in place
e) Stable in high sea conditions
f) Low initial cost
g) Fast tow speeds
h) Large working areas from the broad platform deck size
i) High working platform away from the wave actions

Disadvantages

a) High operating and building cost
b) The stability depends on the limit capacities, where the it will fail if the weight limit is breached
c) Expensive to tow beyond the distance limit
d) Well operations and moorage are difficult to handle during rough climate
e) Need a large drydock facility for maintenance and repairs

2.7 SOUTHEAST ASIA OFFSHORE PRODUCTION FACILITIES

2.7.1 SOUTHEAST ASIA OIL AND GAS PRODUCTION

Southeast Asia have a rich source of hydrocarbon deposits of petroleum and natural gas. The offshore exploration and drilling are largely there active and have been productive currently. Three important factors where improvement in offshore drilling technology, political developments and emergence of Japan as a major petroleum trade operation country have caused Southeast Asia to become one of the major exploration and drilling locations for many companies (Virtual Information Center, 2005).

Southeast Asia roughly produces 2 million barrels per day and 500 million cubic feet of natural gas currently (Global Security, 2008). Four countries control 88% of the oil and gas reserves in this region which is Malaysia, Indonesia, Myanmar and Vietnam while the rest controls the other 12% (Infield System Offshore Asia Oil & Gas, 2013). The figure 2.7.1.1shows the total percentage of Southeast Asia oil reserves in a pie chart form.

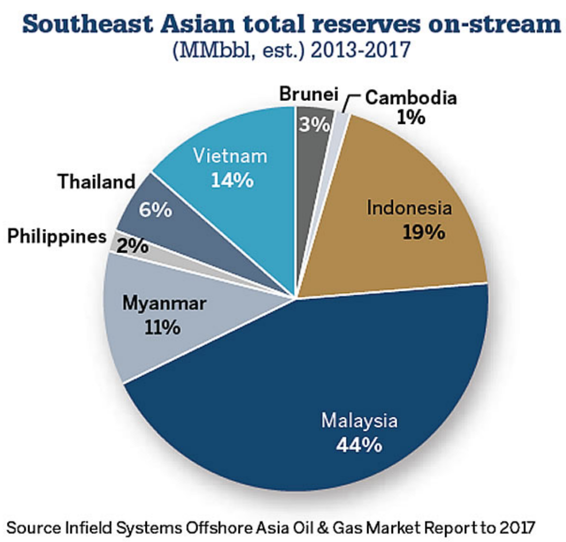
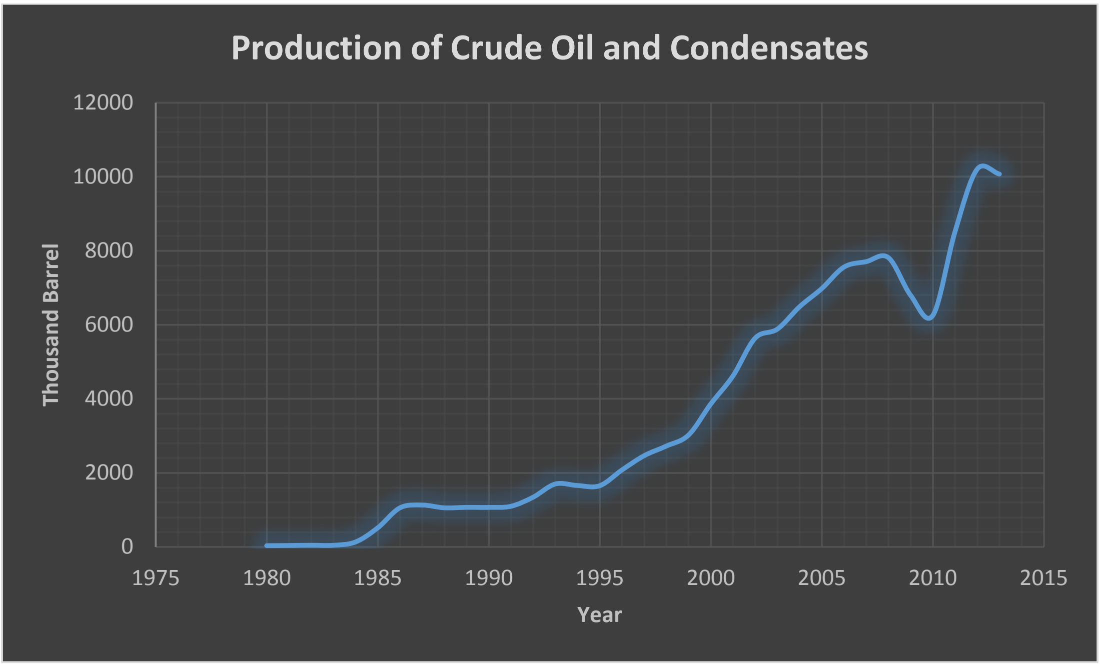
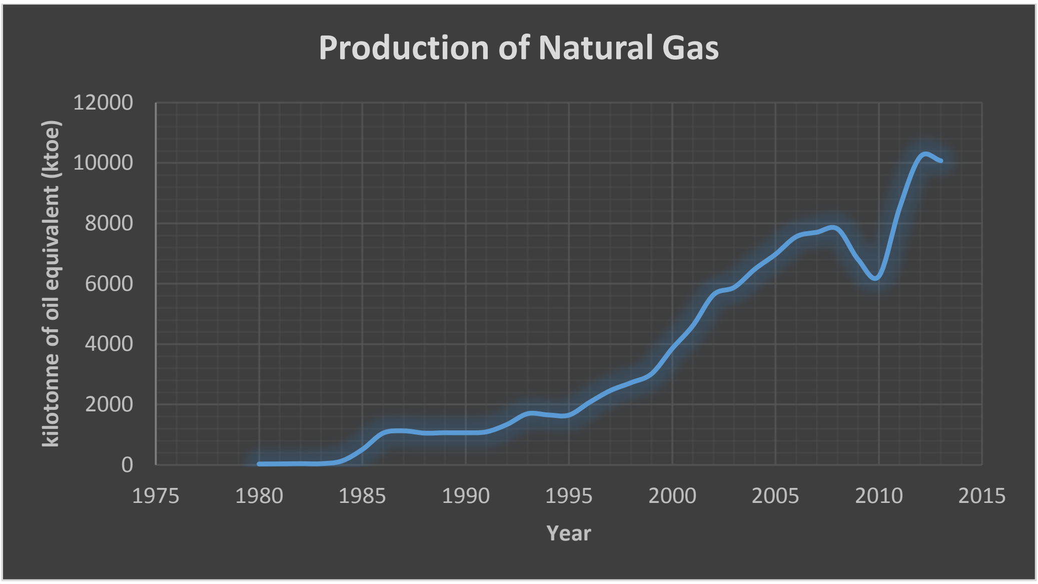


Figure 2.7.1.1: The percentage of oil reserves in the Southeast Asia (Source: Offshore Engineer, 2014)

Malaysia have the largest oil reserve compared to all the other countries in Southeast Asia. Thus, Malaysia is one of the main oil and gas producers globally, significantly exporting oil and is the second largest liquefied natural gas (LNG) exporter in the world (EIA, 2009). Malaysia have around 4 billion barrels and 83 trillion cubic feet of natural gas reserves as of January 2009 (EIA, 2009). Most of Malaysia's oil and gas are produced in offshore regions. Graph 2.7.1.2 shows the Malaysian crude oil and condensate production rate from the year 1980 to 2013. Graph 2.7.1.3 shows the Malaysian natural gas production rate from the year 1980 to 2013.



Graph 2.7.1.2: Malaysian crude oil and condensates production rate (Source: Energy Commission, 2015)



Graph 2.7.1.3: Malaysian natural gas production rate (Source: Energy Commission, 2015)

The major reserves in Malaysia are located in the sedimentary basins with potential hydrocarbon deposits underneath the rock layers. There are seven major sedimentary basins located offshore of Malaysian waters where the major ongoing oil and gas industry takes place in 3 basins which are the Malay Basin, Sarawak and Sabah Basin (Madon, 1999). Malaysia produces sweet crude oil known as Tapis Blend, where it has low sulphur content and lesser impurities compared to other crude oil. Figure 2.7.1.4 shows the location of all the sedimentary basins of Malaysia.

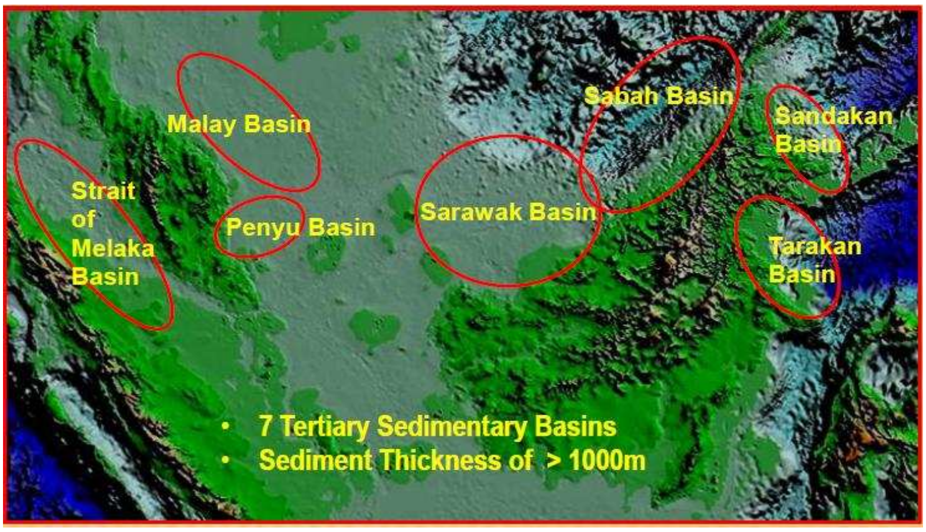


Figure 2.7.1.4: Sedimentary basins located offshore Malaysia (Source: Madon, 1999)

Petroleum and natural gas are the fundamental energy sources consumed in Malaysia. Because of the overwhelming reliance on oil and natural gas to support the monetary development, the Malaysian government is emphasizing fuel diversification through coal imports and advance interest in renewable energy (IHS Energy, 2015). Figure 2.7.1.5 shows the pie chart of Malaysia's primary energy consumption based on 2012 survey.

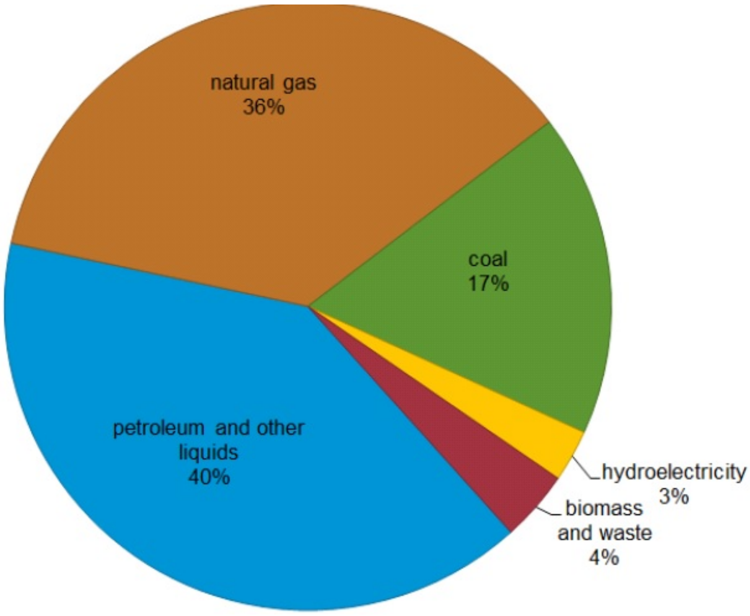
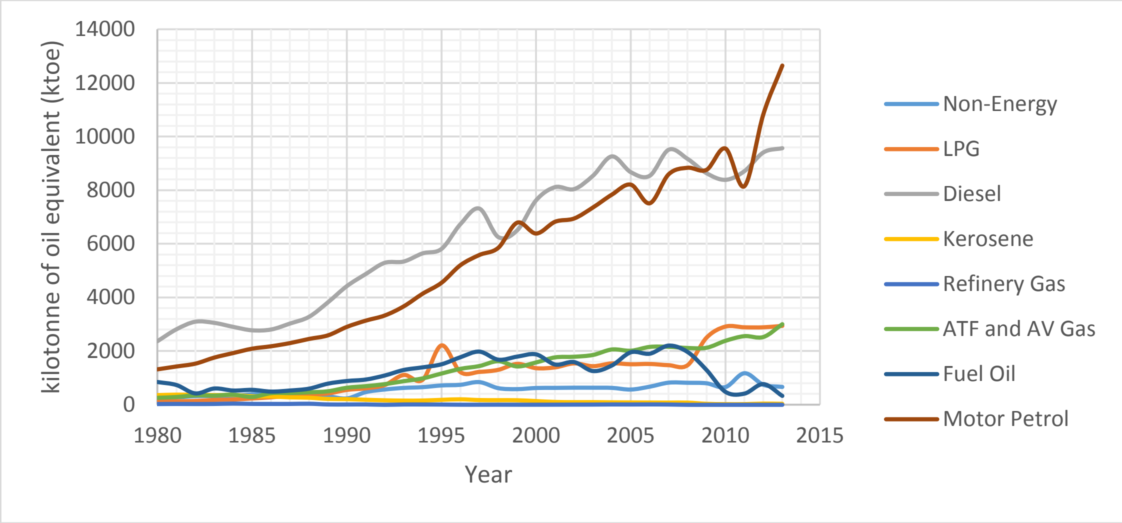
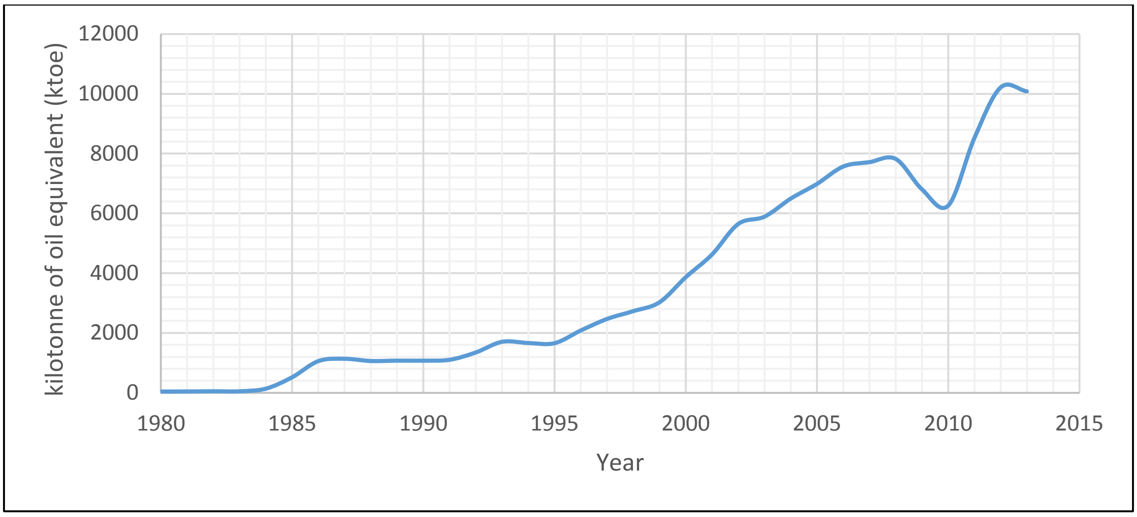


Figure 2.7.1.5: Pie chart of Malaysia's primary energy consumption (Source: U.S. Energy Information Administration, 2012)

Crude oil will be processed in oil refineries to derive materials known as petroleum products. Examples of useful and profitable products are mostly fuel oil and gasoline which come from the highly volatile parts. The less volatile fractions produce asphalt, paraffin wax, lubricating oils, heavy oils and tar (Irion, 2012). Natural gas are mostly used for power generation uses, transportation, fertilizers and also domestic use (NaturalGas.org, 2011). Graph 2.7.1.6 shows the consumption of crude oil products from the year 1980 to 2013. Graph 2.7.1.7 shows the consumption of natural gas products from the year 1980 to 2013.



Graph 2.7.1.6: Malaysian crude oil products consumption rate (Source: Energy Commission, 2015)



Graph 2.7.1.7: Malaysian natural gas products consumption rate (Source: Energy Commission, 2015)

2.7.2 SOUTHEAST ASIA SEMI-SUBMERSIBLE PLATFORMS

Southeast Asia is rich with hydrocarbon resources with Malaysia is one of the main oil and producers worldwide. In 2013, Malaysia had produced an average of 673,000 barrels per day in average and are ranked 28th in the world for total oil production (EIA, 2014). Thus to sustain the enormous oil and gas production in a daily basis level, there are few major oil and gas companies that constructs the offshore platforms required to achieve this target.

There are 24 companies that are active with 46 oil rigs consisting of jackups, semi-submersibles and drillship currently operational in the Southeast Asia region. Due to the high demand in oil and natural gas production industry, the spending on offshore rigs in Southeast Asia have increased over the last several years where by 2009, $USD 785 million was spent for semi-submersibles construction. There are currently 17 semi-submersible platform currently under construction in this region for future production purposes (RIGZONE, 2015). Figure 2.7.2.1 shows the total oil and gas platform that is in operation and demand in Southeast Asia. Figure 2.7.2.2 shows the graph of offshore rig expenditure in the Southeast Asia region.

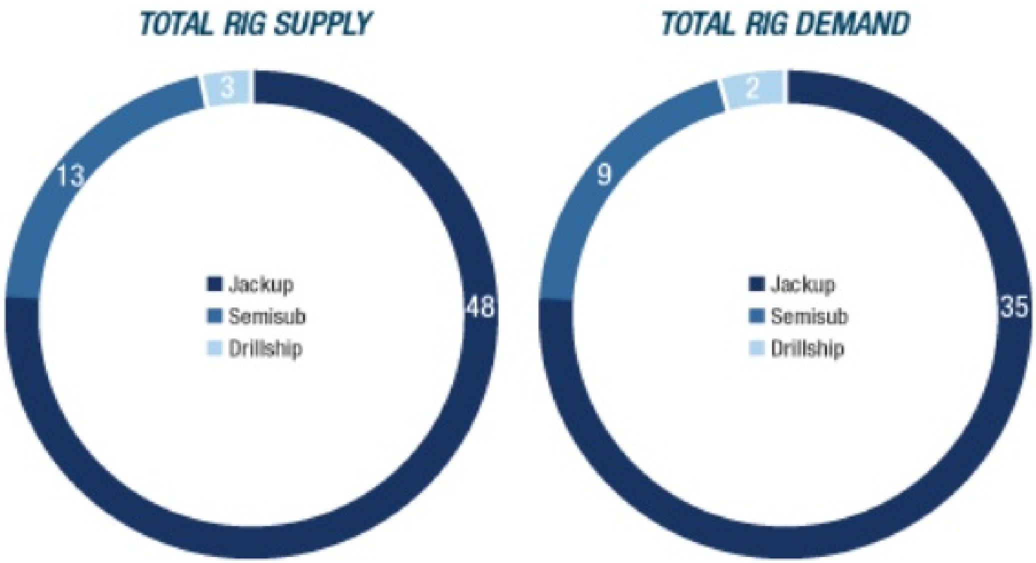


Figure 2.7.2.1: The total offshore platform supply and demand in the Southeast Asia region (Source: RIGZONE, 2015)

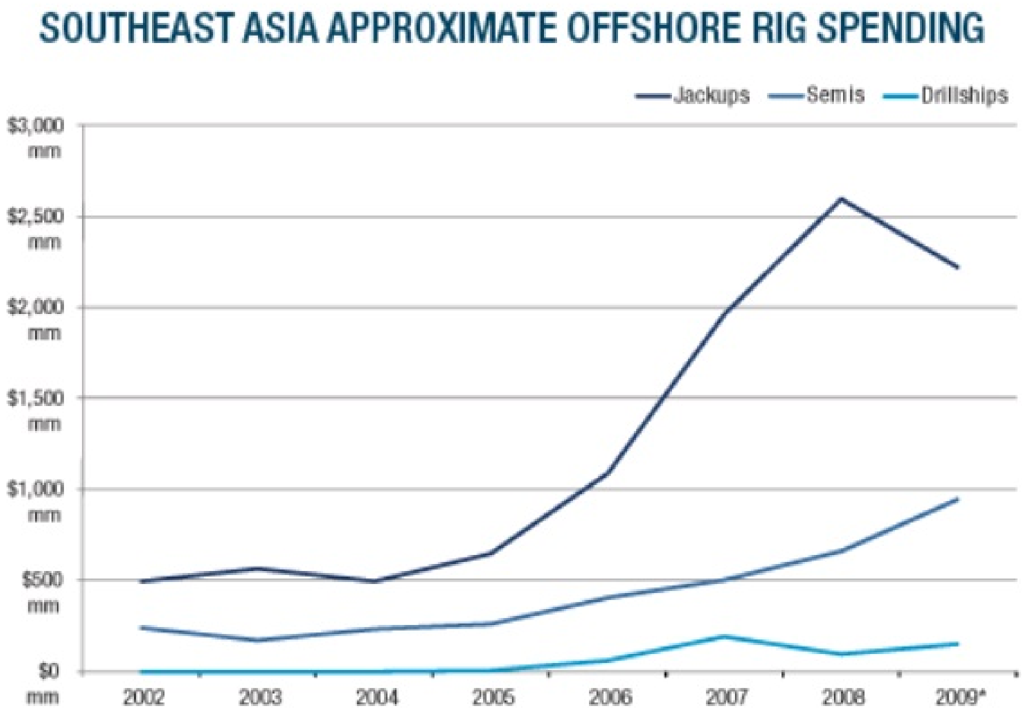


Figure 2.7.2.2: Graph chart of the Southeast Asia approximate offshore oil rig spending (RIGZONE, 2015)

2.7.3 MALAYSIA SEMI-SUBMERSIBLE PLATFORMS

Southeast Asia have twenty-one semi-submersible platforms currently in active or stackedand from those, four arelocated off the Malaysian offshore region.

Gumusut-Kakap

Malaysia's second deepwater development project which is the currently located offshore Sabah, East Malaysia. This semi-submersible platform is one of the largest in the world and is placed in water depths up to 1200 meters (PETRONAS, 2013). These 23,000 tons structures consists of four decks that includes accommodation up to 140 workers and eleven technical buildings (PETRONAS, 2013).

This platform was manufactured with regional standards by Malaysian Marine and Heavy Engineering Sdn Bhd (MMHE) and consist of four decks with a

40,000 square meters area, involving the world’s heaviest onshore lift when the topside of 23,000 tons was lifted onto the hull (Shell International Media Relations, 2014). The annual peak oil production is expected to be nearing 135,000 barrels per day (PETRONAS, 2013). The key contractors involves MISC Berhad, FMC Technologies, Malaysia Marine and Heavy Engineering, Atwood Oceanics, JP Kenny, Sapura Acergy and Technip Geoproduction (Shell International Media Relations, 2014).

Around 5000 local employees were directly involved in building this structure (PETRONAS, 2013). The Gumusut-Kakap project involves mainly Shell and ConocoPhillips Sabah, each with 33% interest while Petronas Carigali holds 20% and Murphy Sabah Oil holds 14% respectively (RIGZONE, 2015) Figure 2.7.3.1 shows the Gumusut-Kakap semi-submersible production platform.

Figure 2.7.3.1: The Gumusut-Kakap semi-submersible platform floating off Sabah’s coast (Source: The Star Online, 2014)

Naga 1

This is a Mitsubhishi MD25-SP propulsion-assisted semi-submersible drilling rig that was constructed in 1974 in Hiroshama, Japan by Hiroshima Shipyard & Engine Works and Mitsubishi Heavy Industries, Ltd and are currently owned by Japan Drilling Company Panama and UMV Drilling (RIGZONE, 2015). This platform is currently operational at a water depth of 300 meters and a drilling depth until 10 kilometres (RIGZONE, 2015). Petronas Carigali is currently operating this platform off the Sarawak coast currently (Infield Systems, 2015). The figure 2.7.3.2 shows the Naga 1 semi-submersible drilling rig.

Figure 2.7.3.2: The Naga 1 semi-submersible drilling rig floating off the Sarawak coast (RIGZONE, 2015)

Harkuryu-5

This Mitsubishi MD-501 platform was built in 1977 by Mitsubishi Heavy Industries Ltd in Hiroshima, Japan (Infield Systems, 2015). This semi-submersible can be deployed up to water depth of 500 meters and drilling depth to 10 kilometres (Infield Systems, 2015). This semi-submersible is currently being operated by Petronas Carigali off the Labuan coast (RIGZONE, 2015). Figure 2.7.3.3 shows the Harkuryu-5 semi-submersible platform.

Figure 2.7.3.3: The Harkuryu-5 semi-submersible platform currently operational near Labuan (Source: JDC, 2014)

Ocean Rover

This is the Ocean Victory model and was designed and built by Odeco Ocean Victory Enhanced in 1972 at New Orleans, Los Angeles, U.S.A (Infield Systems, 2015). This semi-submersible have the capability to operate at water depths up to 2500 meters and a maximum drilling depth of 11 kilometers (RIGZONE, 2015). This semi-submersible platform is being managed by Murphy Oil Corporation northwest of Labuan near offshore Sabah (Murphy Oil Corporation, 2013). Figure 2.7.3.4 shows the Ocean Rover semi-submersible oil rig.

Figure 2.7.3.4: The Ocean Rover semi-submersible oil platform located in the Kikeh field northwest of Labuan near offshore Sabah (Source: Murphy Oil Corporation, 2013)

2.8 OILAND NATURAL GAS RELATED COMPANIES IN MALAYSIA

Major Oil and Gas Companies

a) Petroliam Nasional Berhad
b) Shell Malaysia
c) Conoco Asia Pacific Sdn. Bhd
d) ExxonMobil Exploration and Production Malaysia Inc
e) Murphy Oil Corporation

Major Engineering and Construction Companies

a) Aker Solutions
b) Dialog Group Berhad
c) MMC Oil and Gas Engineering Sdn Bhd
d) Saipem (Malaysia) Sdn Bhd
e) Noble Corporation
f) Technip
g) SapuraKencana Petroleum Berhad

Major Shipyards and Fabricators

a) Brooke Dockyard and Engineering Works Corporation
b) Malaysia Marine and Heavy Engineering Holdings Bhd
c) TH Heavy Engineering Berhad

CHAPTER 3

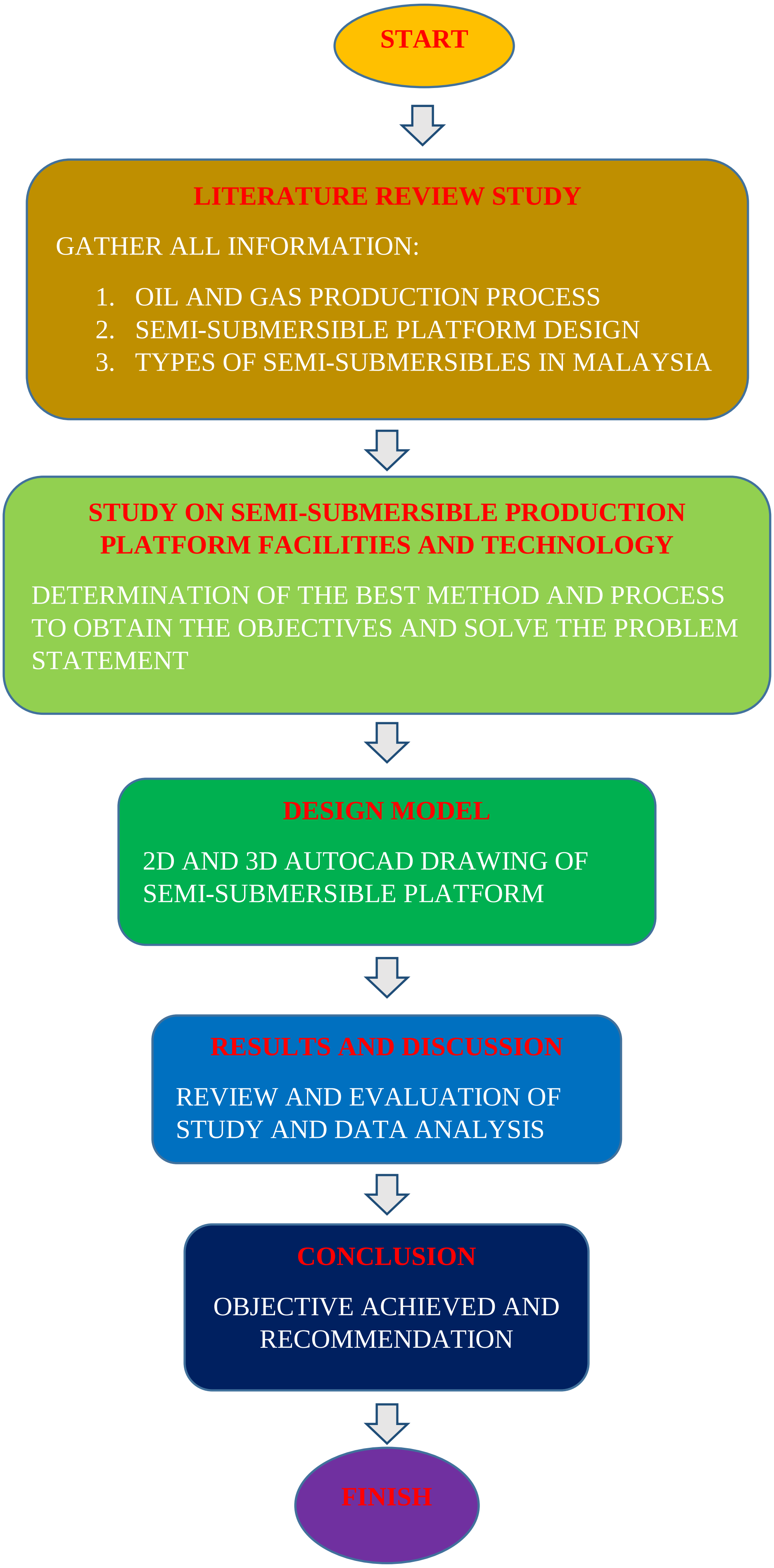
METHODOLOGY

3.1 INTRODUCTION

In this chapter, the methodology of this project will be covered. This project have covered several topics in chapter one such as introduction consisting of the background of study, problem statements and objectives. Next, chapter two which is the literature review consisting of introduction, oil and natural gas overview, modern history of oil and gas production, stages of oil and gas development, offshore production facilities, semi-submersible platforms, Southeast Asia offshore production facilities and Malaysian semi-submersibles were also discussed.

Chapter 3 will further discuss the details off the method on simplifying the oil and natural gas production on semi-submersible platforms. This project will focus on the best design and development of the technology needed to improve the production flow and capacity while solving all the problem statement. This chapter also concentrates on the loading, operating and survival condition of semi-submersible platforms.

3.1 FLOW CHART



3.3 PROJECT SCOPE

This project will focus on the semi-submersible platform functions while obtaining the objectives and solving the problem statement. A model will be drawn based on the strong hull section consisting the pontoons and multiple columns. The semi-submersible platform will be tested on its operating condition, stability and buoyancy to determine the best general arrangement and design that should be chosen.

After the best criteria is chosen, the main parameter of the semi-submersible is edited and a model design will be drawn. The oil and gas production process which includes the exploration and drilling phase will be reviewed, simplified and taken into account for the best design. Lastly, a 2D and 3D model will be drawn based on all the information produced.

Table 3.3.1: Semi-Submersible Platform Parameters (Stone, 1986)

Functions		**Units**
Supported Water Depth		200 – 3500 meters
Total Height		43.2 meters
Hull	**Area**	75 $meter^2$
	length	80 meters
Column	**Number of Columns**	4
	Diameter	13 meters
	Area	100 meters
Pontoons	**Number of Pontoons**	2
	Length	81 meter
	Width	16 meter
	Height	8 meter
Deck	**Length**	90 meters
	width	80 meters
Tonnage	**Lightweight**	8400
	Deadweight	42200

3.4 AUTOCAD DRAWING MODEL

The semi-submersible platform design will be drawn using AutoCAD Version 2015 where both the 2D and 3D model will created. Figure 3.4.1 shows an example of a 2D diagram and Figure 3.4.2 shows an example of a 3D AutoCAD drawing of a semi-submersible model.

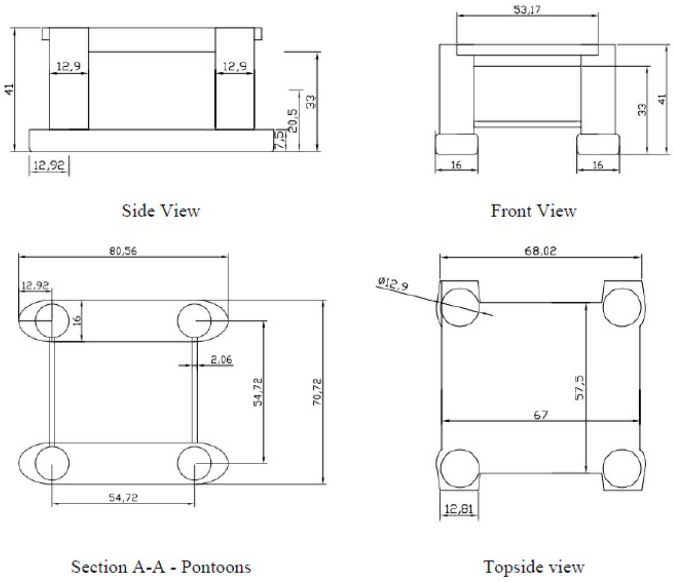


Figure 3.4.1: General Arrangement of Semi-submersible (Source: Stone, 1986)

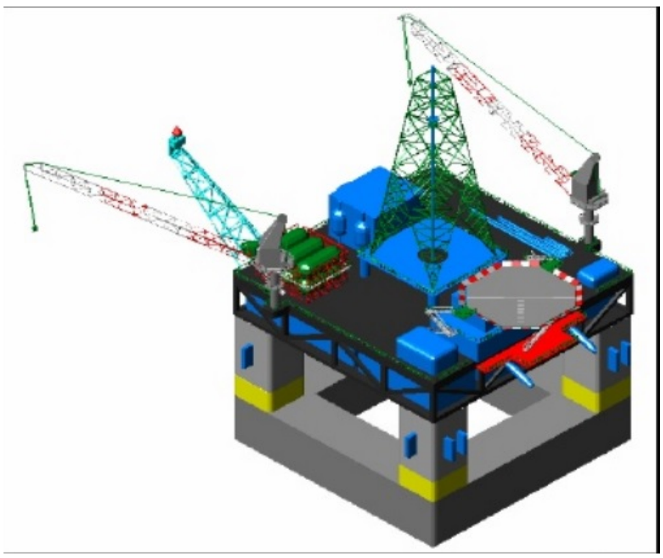


Figure 3.4.2: The original basic hull design of a semi-submersible platform (ABS, 2000

CHAPTER 4

RESULTS AND DISCUSSION

4.1 RESULTS

The review study about the semi-submersible production platform was done. The objective of this result was achieved and it is found out that semi submersibles have been attracting the current energy market's attention. A 3D design of the Semi-submersible platform was drawn in AutoCAD. The drawing is attached on Appendix A. Besides that, a replica 3D model was built to represent the overall semi-submersible platform. The image is attached on Appendix B.

4.1.1 REVIEW STUDY RESULTS

This review study was done based on many semi-submersible platforms mostly in Malaysia. Currently, major oil and gas companies are exploring the locations of dormant oil and gas reservoirs in deeper water due to the decreasing amount of oil and gas deposits in shallow water. However, deep water explorations poses serious threat due to their hostile weather conditions. Complex designs and lavish physical dimensions must be added to these offshore platforms in order to acquire the suitable stability.

Fixed offshore structures can only be placed in shallow waters, thus making it unrealistic in deeper regions. Thus, floating platforms are more flexible and practical to be used for exploration and drilling purposes. Semi-submersible production platforms are one of the most conventional used floating offshore platform. This is due to its multiple capability usage as a crane vessel, drilling vessel, production platform and accommodation facilities (Omanjene, 2013). Semi-submersibles are not attached to the seabed, thus having a mobile movement across the ocean in the search of oil reservoirs in deeper water regions (Pedersen, 2012).

Semi-submersible platforms are well known for its drilling capability. The drilling performance and production process within the platform is much better compared to the other types of production platform. Broadly, it is the most reliable structure making it a feasible option in deeper regions (Society of Petroleum Engineers, 2013).

4.2 CHARACTERISTICS AND BENEFITS OF SEMI-SUBMERSIBLE PLATFORM

4.2.1 CHARACTERISTICS

A semi-submersible platform are usually placed in water depths greater than 500 meters. The structure’s buoyancy comes from the pontoons below the ocean surface and wave action. These pontoons are stabilized and watertight. The operating deck are located high above the pontoon, supported by the hull. Structural columns connect the pontoons and operating deck together. Compared to all the other type of oil and gas platforms, the semi-submersible platform is considered to be one the highly stable structure, thus the operating deck can be placed high above the waves.

A semi-submersible production platform consists of mainly four parts which are the hull, pontoons, deck and structural columns. The hull is the main structure of the platform which floats on the pontoons and columns. These horizontal pontoons and vertical columns are joined together in a circular cross pattern to provide the structural power. Thus, the centre of gravity is above the buoyancy centre due to the high stability it provides.

The massive columns supporting the hull are known as legs and the bottom pontoons are null and empty. This will allow seawater to enter and provide ballast. The semi-submersible will then submerge among the waterline area (Lim, 2000). The legs provide stability as the floatation properties are changed from the pontoons to the columns while the semi-submersible is submerging (Ronalds, 2000).

The semi-submersible are placed at a fixed location using anchors attached to the seabed. The anchors are a type of mooring device and plays a key role in drilling process. The anchors must be strong and able to withstand the ocean currents to keep the semi-submersible stationary in order the drilling process to run smoothly. The anchors are made of metal and works in accordance to the anchor chains, resisting the ocean currents and platform movement. The anchor is computer controlled where the global positioning system (GPS) will control and release the anchor automatically using dynamic position until it reaches the proper position on the sea bed. The anchors are placed on the deck when not in used (Narciki, 2012).

Next, the deck is a hull-type deck that is attached together with the hull and the truss-decks. The deck are built separately and will then be joined together to the hull (Petrobas, 2010). The deck consists of the accommodation building, control room, power generation unit, helideck and pad, mud system and pumps, drill platform, drill tower, cranes, forklifts, lifeboats, flare tower and derrick (Scott, 2012).

The operation manager will view all the important instrumentation and printouts that provides many relevant technical details such as drilling rate, core sample reports and analysis, sea and wind conditions and many more from the control room. The control room is also known as the rig hub, as it controls all the action and machinery on the platform (Bowes, 1991). The accommodation building consists of many cabins and a public rest area with satellite TV. There also gyms and even saunas for the workers to exercise and relax. The cabins usually can occupy two men who are normally on the same shift pattern. The crews will work physically hard in a twelve-hour shift with twelve hours rest. Every two weeks, the workers can depart to the main land for a regular outing and return to the rig via the helicopter (RIGZONE, 2015).

The power generation unit will power the semi-submersible using gas turbines. The gas turbines will run on a mixture of gas and oil. These is also a diesel power generator in a fire-proof room to provide power during emergency for 24 hours (HOOVERS, 2015). The lifeboats will be hung over the side of the deck in a near vertical steep angled ramps and are free-fall launch (Scott, 2012).

There are two cranes with long jibs the cover the whole deck area which are driven by a hydraulic system powered by diesel engines. The cranes will unload supply boats, help in bunkering, hoisting hoses to and from bunker barges, heaving equipment to workspace for maintenance and many more lifting works (Lim, 2000).

The drill platform consists of the drilling tower covered with derrick. It is placed usually in the middle of the platform for extra stability. The drilling platform have a rotating table containing bushing in the centre chained using heavy duty chains. Next, the drill string will then move down under its own weight where it will be rotated in a clockwise rotation together with the drill bit from the rotating table. The drill bit will then drill into the seafloor downwards (Devold, 2006).

The drill derrick contains the lifting gear for drilling pipes and drill pipe strings. At the top of the derrick is the crown block consisting the pulley system, sheaves and wire ropes that must be capable of holding the weight of the drill pipe (RIGZONE, 2015). The flare tower extends clear of the rig and holds the pipe and flare tips containing sour gas that will be fared off. There is a heat shield around this tower to protect the flare heat from the workers (Scott, 2012).

4.2.2 BENEFITS

Semi-submersible platforms are one of the most used and favoured structure due to its drilling and production process from its floating position. Next, semi-submersible platform are well known for its platform drilling capability. Universally, they are more dependable compared to all the other type of platforms. Thus, it is the most viable option for oil and gas exploration and drilling process (Society of Petroleum Engineers, 2013).

Jackups were the most commonly used platform in this industry. However, it is only restricted to shallow water regions. It is not economical nor practical to build a jackup in those deep water depths. Jackups also have a smaller deck space that is vulnerable to facilities damage. This is due to the long period of progressive flooding usually in severe storm conditions. In semi-submersibles nevertheless, the platforms will not remain in station at one particular place as it is mobile to move to a much safer area if an impending storm nears the area. Thus, the deck would remain safe from the high ocean waves caused by the storm (BMT Fluid Mechanics Limited, 2006).

Drillships are well known for its rapid mobilization but are very prone to severe environmental loadings and not as steady compared to a semi-submersible (Pedersen, 2012). Semi-submersible is more stable as a ship can only be stable when its bow is heading to the weather loadings. Drillships are not stable if it is placed at the sideways of the weather loadings. Thus, it cannot withstand extreme conditions. In this case, the semi-submersible is more prominent to wind and wave loadings due to its high stability. The stability remains the same regardless of the platform’s position as there is no need for reorientation due to the waterline area and overall hull area as the weather loadings are essentially the same in any direction of the platform. Conclusively, the drillships motion performance are limited, favouring the semi-submersible (Pedersen, 2012).

Spar platforms have a low centre of gravity with respect to the centre of buoyancy. Ballast will help to lower the gravity centre that will increase its overall stability. However, it is not suitable as the risers could not accommodate the platform’s considerable motion. These structure is also too large which will complicate the fabrication and installation process at the production site. Spar platforms are more similar to semi-submersible platforms due to their identical advantages and disadvantages. However, semi-submersible is more mobile and cost effective compared to a spar platform.

Tension Leg Platform (TLP) is a floating platform structure that is attached to the seabed by many high tension mooring lines. This will provide the required restoring force to maintain the overall stability. However, it is very expensive due to extensive increase of tensioned lines according to its water depth. The tensioned lines must be specifically and carefully designed due to the high tension required. Semi-submersible will not encounter this problem as there is no high tension lines holding it in place. Semi-submersible is held stationary by anchors that are computer controlled, making the process much cheaper (Lefebvre, 2012).

Floating Production, Storage and Offloading (FPSO) platform is a floater type used for processing hydrocarbons and storage of oil and natural gas (Xue, 2014). It are designed with a mooring system which places the vessel within its given boundary (Fontaine, 2013). FPSO's are advantageous due to the easy mobility and flexibility in wide range of water depths. Despite that, the hydrodynamic performance is low due to deficiencies in handling severe storm conditions and heavy environmental loads. The load on the mooring system will then increase, endangering the vessel and shuttle tanker during offloading (Ma et al, 2013). There are also lack of drilling facilities, high cost of well worker and maintenance and the limitation of FPSO's only to oil field application use (Archipelago Offshore Engineering, 2011). Semi-submersible however have a lot of facilities on its platform deck. Besides that, semi-submersible can be used for other purposes such as crane vessels, mobile drilling units and offshore support vessels.

4.3 OIL AND GAS PRODUCTION PROCESS IN A SEMI-SUBMERSIBLE PLATFORM

4.3.1 EXPLORATION

Seismic airgun testing is used to locate oil and gas deposits deep below the ocean floor. A machine airgun attached to a large boat will create seismic energy, generating seismic waves. It is a large device emptied of air and water to create a vacuum (Martin, 1998). A vessel that is towing this seismic airgun shoots huge loud blasts through the ocean. These compressed air will travel until it reaches the seabed and bouncing back off to be received by computer data located on the vessel (Oceana, 2014).

After a potential reservoir is determined based on the interpretation of the seismic data received from seismic airgun testing, exploration wells will be drilled providing data. The hydrocarbon and water saturation will be determined using the porosity and permeability analysis. A computer model will be created of the reservoir for further data analysis.

4.3.2 DRILLING AND PRODUCTION

A 3D model is built to estimate the volume of oil and gas in the reservoir. Based on these multiple data’s, appraisal wells will be drilled to improve the field description. A final confirmation is done on these sites to access the planning, economic assessment and environmental impact assessment. These appraisal wells are built usually using FPSO’s or drillships (Aliyeva, 2011).

The semi-submersible production platform will be then towed to the reservoir location. Water will be ballasted out from the rig to reduce the hull drag. Heavy transport ships are used to either pick up the platform or tow it to its position. The safest method is to carry the platform and place it on top of a ship. This is because the one large ship method is both faster and safer compared to tugboats towing the platform due to the irregularly shaped structure making it hard to move (Carlyle, 2014). The transport ship is sink moderately, the platform towed over it and the transport ship is lifted underneath the platform (Dockwise Vanguard, 2014). Figure 4.3.2.1 shows the semi-submersible Nautilus being towed into its position by a transport ship.

Figuer 4.3.2.1: The transport ship Black Marlin towing the semi-submersible Nautilus (Source: Marine Modelling International, 2015)

After the semi-submersible platform is placed on top of the reservoir, the tall derricks placed will contain a rotary drill with a sharp rotating metal drill bit to drill through the seabed. This method is cost effective and will increase the well yield for high pressurized deep wells (Devold, 2006). Figure 4.3.2.2 shows an example of the drill derrick containing the rotary drill.

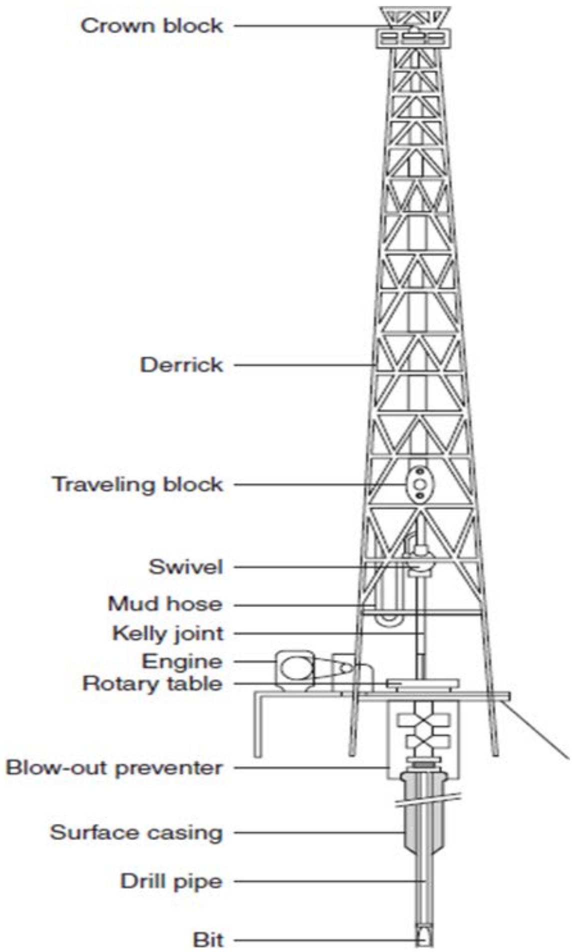


Figure 4.3.2.2: Schematic diagram of the various components of an oil-drilling rig (Source: Bea, 1993).

After the metal drill bit reaches the oil deposit, the production process begins. The hydrocarbon deposits will be generally extracted where next the liquid hydrocarbon mixture, gas, water and solids will be distinguished. There are several process and recovery methods due to the advanced technology that allows almost to 60% oil recovery from the reservoir (API, 2008).

The first stage is the primary recovery where underground pressure inside the reservoir will push up the fluids through the drill pipe to the surface. If the underground pressure is not ample enough to force the oil up, artificial equipment such as many types of pumps and gas lift valves to lift the oil up. During the pumping process, motors on the surface and inside the wellbore will be used as well to assist the lifting process that will recover almost 10% of the oil in the deposit (Smith, 1998).

Next, the secondary recovery process where the water residue from the initial oil separation process will be injected back into the wellbore to bring more oil to the surface. This advance recovery technique is also known as water flooding as external water sources from the pipe can also be used (Craig Jr., 1971). The wastewater will be then dump to enhance the oil recovery around an additional 20% of oil (API, 2008). Figure 4.3.2.3 shows the water flooding process overview process.

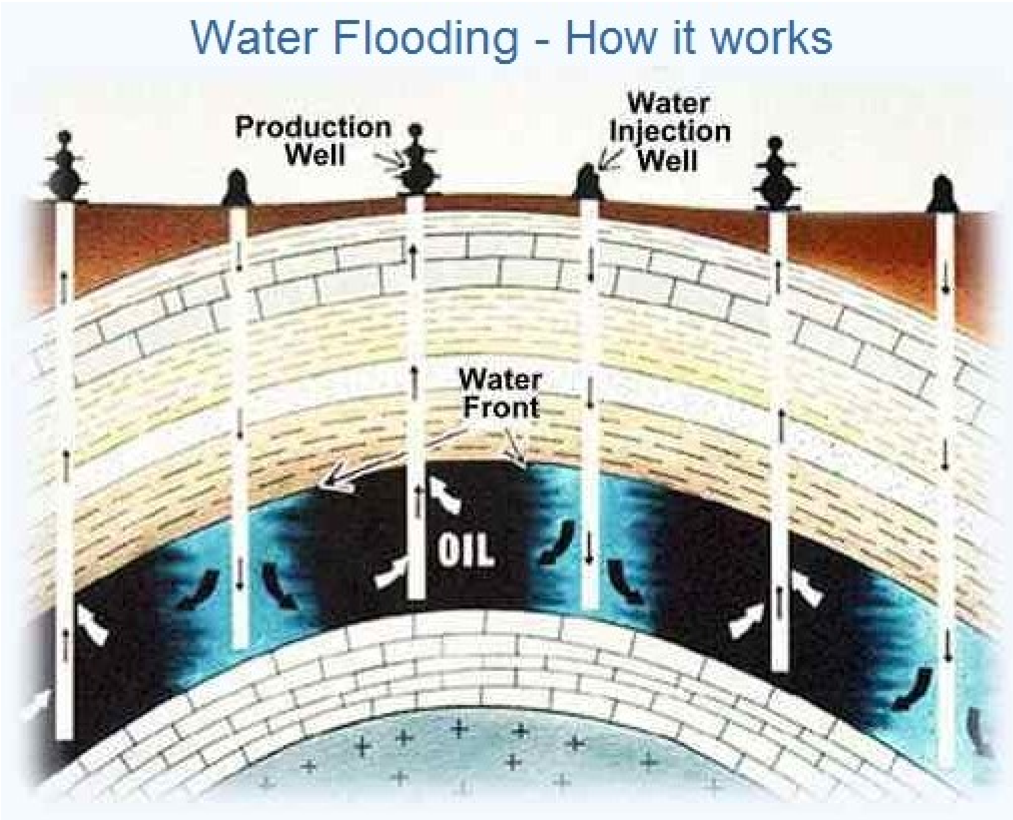


Figure 4.3.2.3: The overview of the secondary process overview (Source; XINCA, 2013)

The third stage is the tertiary recovery process which is usually used lastly where additional materials will used to extract the remaining oil. These methods are mostly expensive and the additives will be removed after being injected (Lake, 1989). There are three methods for this process where the common usage is the steam injection method. This thermal recovery process will heat up the reservoir fluid, increasing its pressure to make the oil to flow up easily.

The other method is the gas injection method which uses miscible or immiscible gases to reduce the oil density and viscosity to increase the oil flow up

(Sittig, 1978). Chemical flooding can also be used where dense and water soluble polymers are mixed together and poured into the wellbore to push the lighter density oil out. The combination of all these process will recover at least 60% of oil reserve to the surface (EPA, 1992).

The oil that is being brought to the surface is mixed with a lot of components such as natural gas, water, sand, slit and additives during the chemical flooding process. There will be a separation process where the gaseous part will be removed first followed by solids and water removal finishing with the oil-water emulsion separation. There will be pressure reactors placed on the semi-submersible production platforms that have pressure chambers to remove the gaseous components from the liquid oil using differential pressure difference (Landes, 1970).

After that, the heater will treat the remaining mixture to break up water from oil to increase the density. The lighter natural gas will be removed for processing or burning while the water will be stored for future treatment (Schackne, 1960). The remaining liquid are mostly in the emulsion form of oil and water mixture. This emulsion mixture will be separated using chemicals as hydrocyclones spin this mixture. The acceleration of this spinning mixture will eject the oil out, separating it from the water. The oil content is about 98% pure that will stored and transported later to the refining process plant on dry land (Sittig, 1978).

The wastewater that are produced from this process are mostly salty and cannot be used as a water resource. It will be usually injected back into the wellbore during the water flooding process to extract more oil out. Some of the remaining wastewater will be released back to the sea after being tested to prevent any accumulation of oil and impurities that could damage the ecosystem (Mosley, 1973).

The process of producing natural gas will be done in a conditioning process where impurities are removed from the gas stream. A dehydration process will remove the excess water from the gas stream where a liquid or solid desiccant will absorb the water (Smith, 1999). Next, a sweetening process where amine treatment is done to remove hydrogen sulphide and carbon dioxide from the gas stream. Finally, the remaining gas will be cooled down below the condensation point of water for easy transportation. All this production and maintenance work must be done according to safety regulations and environmental policies to prevent any occupational hazard (Aliyeva, 2011).

4.4 DISADVANTAGES AND METHODS TO OVERCOME THE PROBLEM

4.4.1 HIGH INITIAL AND OPERATING COST

Semi-submersibles usually have a high operating cost due to the large size and many buildings built on top it (Fang, 2014). Semi-submersible are also expensive to build compared to the other platform mainly due to its large size. The platform construction is done in three phases where in the design phase, engineers will provide specifications that are distinctive for each platform and the planned location. The land stage is when all the prefabrication process occurs. The last phase is the marine phase where the platform will be towed to its location (IRS, 2013).

The marine phase is separated into two parts where the derrick containing the drill bit will built separately then the rest of the platform. The phase demands specialized construction equipment to be built. Due to two parts being built at the same time and must be attached together to function, the initial cost is higher.

Moreover, the operating cost is also high due to the three expenses used in acquisition of the mineral property, exploration and development together with the drilling phase. Most of the time, the operating costs will increase due to expensive secondary and tertiary stage during the production phase. Thus is due to the added pump, compressors and other energy consuming equipment operations that require high cost including its maintenance cost. The cost includes operating labor, maintaining the equipment on the lease, repairs and supplies, utilities, automobile and truck expenses, taxes, insurance and overhead expenses billing cost (Exxon Corp, 1976)

However, the money used to build, operate and maintain the semi-submersible platform can be claimed back via depreciation. The income that comes from the sale of oil and gas will facilitate the production cost as the amount of profit generated will diminish the cost size. It is not impossible to reduce some of the labor and construction work as all the components in a semi-submersible is important for it to run. All these operating expenses are deductible due to high profit that will be produced during production and sales. Some of the operating cost are lower due to the decreasing price of the components needed to build the production platform. The drop in fuel price worldwide will reduce the market price of other items as well (Kahn, 2015).

To reduce cost, the semi-submersible structure can be built at the nearest shipyard, making it easier and cheaper to tow to the required reservoir location (Kaiser, 2012). There is also a way to reduce maintenance costs by using an oil filtration system on generators placed on the platform by decreasing the oil maintenance needs and costs. The engine oil will be kept clean and in good working order continuously. This oil filtration system will also provide a proper oil drain extension, reducing operation costs and waste oil production. The environmental impact is lessen as the amount of harmful gases released will be released. Figure 4.4.1.1 shows an example of an oil filtration system.

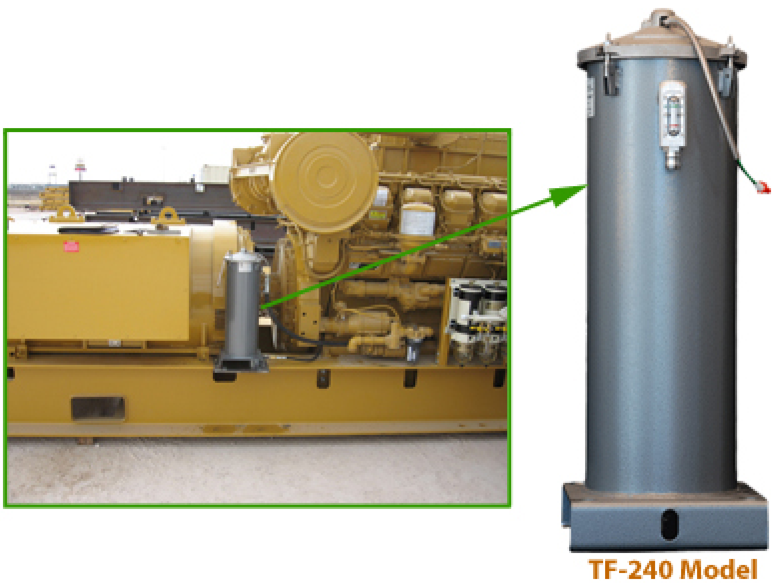


Figure 4.4.1.1: The TF-240 which is one largest oil filtration system (Source: Puradyn, 2015)

Steel is very expensive and by reducing the amount of steel, cost can be lowered exponentially. A semi-submersible platform is in a box shape body structure due to its flat plate. Thus, the amount of steel needed is low, improving the structure besides decreasing the cost. By reducing more components such as column, the weight and power on per unit shrinks as well. The drilling time reduces by 30%, decreasing the construction cost by 30% which saves steel and reduces cost (Fang, 2014).

Conclusively, the semi-submersible production platform cost might increase time by time, but the profit it produces will always dwarf the initial and operating cost due to huge amount of crude oil and natural gas it produces.

4.4.2 STRUCTURAL FATIGUE AND DECK LOAD

The semi-submersible platform is usually placed in deeper water regions with harsh conditions. These constant extreme conditions will gradually weaken the oil platform structure. Like most platforms, these oil rig will also experience structural fatigue by time due to heavy load it carries. Although semi-submersible platform is one of the biggest and widest oil platform, the deck load is limited to small free spaces due to congestion of structures on the deck (Duan, 2014).

In order to prevent the structural fatigue problem, the rigs specification must be modified mostly around its structural weight. The larger the platform, the more powerful drilling equipment that it can support besides withstanding harsh ocean conditions. The semi-submersible capabilities are related to its weight as it is an important factor. To overcome this severe weather conditions, the columns is built longer and thicker. This will also increase the height of the operating deck, keeping it far away from the ocean waves (Snyder, 2012).

The semi-submersible main components such as the hull, pontoons, deck and multiple columns can be built in a proper arrangement to increase its stability. If the semi-submersible platform is stable, the high deck load and structural fatigue can be reduced. The hull should be built in the hull-type superstructure with diagonal bracing arrangement. The horizontal bracing will provide extra support to the deck together with the strong legs and pontoons. The column will be in a 6-column twin pontoon arrangement with a twin pontoon arrangement. This column and pontoon arrangement will make it easier for it to be carried onto the heavy transport ship. Figure 4.4.2.1 shows all the best hull, column and pontoon arrangement.

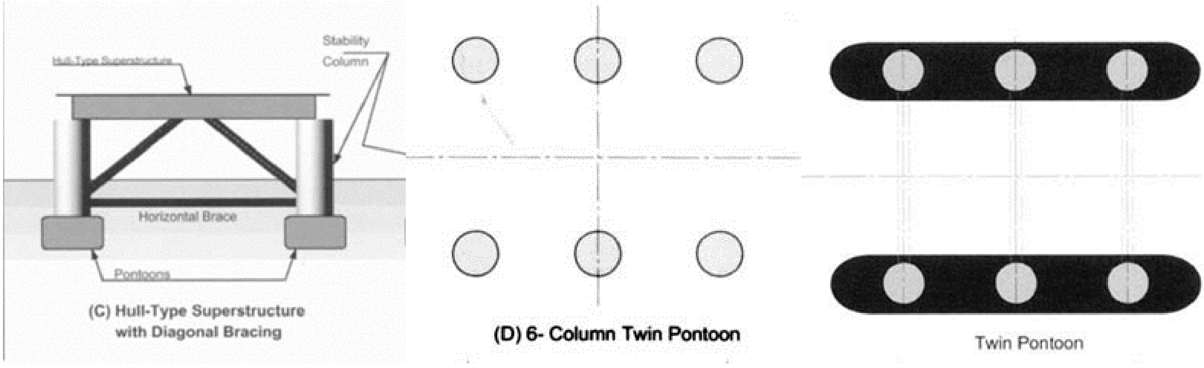


Figure 4.4.2.1: The best and safest hull, column and pontoon arrangement (Source: Chakrabarti, 2005)

Structural fatigue is usually caused due to the corrosive surroundings and repetitive action of ocean waves. Structural fatigue cannot be prevented permanently but can be detected early so that repairs can be done to maintain the structure. Inspection must be done to locate the fatigue cracks and weak points using several fatigue sensor equipment. Ordinary techniques such as Non-Destructive Testing (NDT) are not as reliable compared the newer Electrochemical Fatigue Sensor (EFS) System such as eddy current can detect crack growth rates faster. This fast sensor is very important in managing the stability and safety of the semi-submersible platform (Metal Fatigue Solutions, 2015). The deck load limited size is not a major problem as the drilling mechanism must be bigger to accommodate the large productivity rate to increase the profit.

4.4.3 LOW QUALITY AND QUANTITY OF WORKERS

The production platform are usually managed by the top engineers and supervisors. They guarantee all the equipment is running smoothly and safely, and all the other operating procedures run smoothly. Next below the hierarchy, the roustabouts who clean and maintains the equipment which is the second largest employee group. After that, the pumpers who operates and maintains the large wellhead pumps which extract the oil from the seabed. There are also many other skilled workers such as service unit operators that maintain wells and pumps, drillers and derrick operators and general workers (Strauss, 2015). In conclusion, an oil and gas platform consists of managers which are the offshore installation manager, process manager, maintenance manager, well platform manager and health and safety manager who control teams such as the process control room operators, wellhead teams, pipeline teams, mechanical and electrical teams, skilled and unskilled technicians.

Most workers are not trained enough to handle the daily operations on the semi-submersible platform. Besides that, the amount of qualified workers to their appropriate work are not enough, usually resulting in delay of production work or even worse, jeopardizing the platform along with the workers safety. There is also a lack of man power due to the decreasing amount of workers on these platforms. This is caused by the lack of faith of workers on the safety of the platforms due to the high risk it possess and the improper shift and sleeping time (Costa, 2003)

The solution for this problem is to provide all these certified training programmes to the workers before entering the offshore work. Training programmes usually conducted by the National Institute of Occupation Safety and Health (NIOSH) will produce a certificate or safety passport after the workers undergo classes and pass the test. Companies will be relieved from training their staff of the basic safety procedure as this adequate training programme will also reduce accidents, downtime and increase the productivity based on the efficiency of the workers (NIOSH, 2015).

The decreasing amount of workers can be curb by improving the infrastructure on the semi-submersible platform. As the structure of these rigs are becoming more safer and stable, the hazard and risk involved is diminishing, providing confidence in more employees to join in. The accommodation will also be maintained properly to provide a good sleeping period for the workers and strict shift periods will be implemented so that the workers will have a good proper sleep and be ready to perform the work required, thus increasing the semi-submersible productivity rate (Industrial Health, 2013).

4.4.4 EFFICIENCY OF SEMI-SUBMERSIBLE PRODUCTION PLATFORM

Many equipment on a semi-submersible platform are mostly outdated and old. Besides that, the production process efficiency is one of the most talked about issue in the current world. This is due to the downward swing of the production efficiency in these past years. Some of the cause of this drop is due to old age of the production platform, decreasing the production process as it gets older (Ferguson, 2013). Besides that, the primary recovery process is always given more important compared to the other two recovery process, reducing the amount of oil that can be extracted out.

Currently, semi-submersible production platform are equipped with high power advanced drilling equipment. A super computer will control a hydrostatic transmission rig with a main winch maximum power of 2940 kilowatts, a rotary table of 1.257 meters, drilling depth up to 900 meters, drilling power up to 1684 kilowatts and working pressure up to 5000 psi (Duan, 2014). Besides that, there is an automatic drill piper discharge system with a new pumping system mechanism. In this system, the drilling fluid mechanism and cementing operation will be joined together, creating a favourable and efficient working condition.

As for the age problem, it is not relevant to build a new production platform to replace it as its very expensive and time consuming to finish building it. It is better to maintain the structure and continuously repairing and restoring it. However, a semi-submersible platform has a long lifespan usually an average expectancy of 20 to 30 years. Thus, the platform can be used for many oil reservoirs during their lifespan, making it unnecessary to constantly build a new one to replace the older version (Schilling, 2014). Furthermore, there is a more advance dynamic position system replacing the conventional anchor system in deeper water regions, optimizing the operation energy. These position system have four strong 7 megawatts motors to maintain the position (Fang, 2014).

There are four major processes which are the separation and oil dispatch, gas compression and dehydration system, produced water conditioning and sea water processing and injection system. In order to perform this processes, a production platform requires a lot of structures and systems to maintain the flow. There is usually a fire detection and suppression system, power generation, well services and drilling modules, water and sewage treatment (Tzimas, 2005).

The separation process also known as the primary recovery process usually separates the mixture of oil, gas and water in an inlet separator. The separation process is usually done in around 5 minutes using the force of gravity where the heavier water will sink, oil will be floating on top of water and gas will be flowing on top. The longer the residence time in the separator, the better the separation process. Chemical reaction and heat can also aid the separation process to be more efficient (Freudenrich, 2015).

The production separator will contain fluid pressure up to 50 atm (atmospheric pressure) and temperature of above 100^{o}C. This process will be repeated usually two times to ensure maximum separation. To enhance this process, a second separator is used to break down the products even more. This second separator will remove the gas from the fluid at 10 atm and below 100^{o}C temperature. There is a third separator also known as flash drum that will remove the oil from water at 1 atm (Strickland, 2015).

The separated gas will be sent to a gas compression system and dehydration module. The gas centrifugal compressors are usually powered by gas turbine. These gas will be compressed to about 90-100 kg/cm^2 due to the field gas lift requirement. The gas released from the first separator will be transferred to a scrubber to ensure more fluid is removed before entering the high pressure compressor. The fluid that are removed will be channelled back to the second separator (Devold, 2006).

There will be lesser gas released in the second separator that is directed to the low pressure compressor due to its low pressure. This gas must also pass through the scrubber to remove the fluids before entering the compressor. This gas released from the low pressure compressor will join the high pressure while entering the high pressure (HP) compressor (Kraus, 2011).

Next, the compressed gas will undergo a dehydration process in a glycol contactor. The glycol contactor is bubble cap tray column with many bubble cap trays where tri ethylene glycol (TEG) acts as an absorbent for moisture from compressed gas. The TEG flows in a counter current flow with compressed gas from the top of the column and will absorb all the moisture from the gas, dehydrating it.

TEG that have already absorb all the moisture is sent for re-concentration, converted to lean glycol and recycled back to contactor for dehydration (Richard, 2011).

The dehydrated gas also known as fuel gas is sent to the knockout drum where liquid condensates are removed. Knock out drums is a vertical vapour-liquid separator to separate vapour-liquid mixture (Allied Flare Inc, 2013). The fuel gas is used as energy for the power generation gas turbines, export pumps and compressor turbines. The remaining gas will be transported as natural gas via transport ships to the shore.

The oil recovery process can be improved if it passes through a coalescer in its final processing stage. A coalesce is a machine used to separate immiscible liquids or liquids from gas stream. This liquid/liquid separator will isolate the water from the hydrocarbon steam (Pall Corporation, 2015). An electric coalesce will reduce the water content in crude oil to a percentage of 0.5% volume.

The water that are removed from this process are known as produced water which must be treated before being released back into the sea. It is pumped through sand cyclones before entering the oily water separator. Sand cyclones will reduce the clay, slit and slime content of the water (Terex Corporation, 2015). The oily water separator will separate the solids and oil. Next, a degasser drum will allow water passage for gas and oil removal where the gas will be flared off and oily water being sent back to the low pressure (LP) separator. The remaining water is mostly used for the water flooding process to increase production (Scott, 2013).

Lastly, the storage process where crude oils and natural gas will be kept inside tanks. Fiscal metering is the last and important stage of the production process as this is the point of sale. A full product data on the specification of the crude oil such as viscosity and water content is catered to the clients to ensure it reaches the planned benchmark (Scott, 2013). Figure 4.4.4.1 shows the overall production process view. Figure 4.4.4.2 shows the locations of all the major components on the semi-submersible platform.

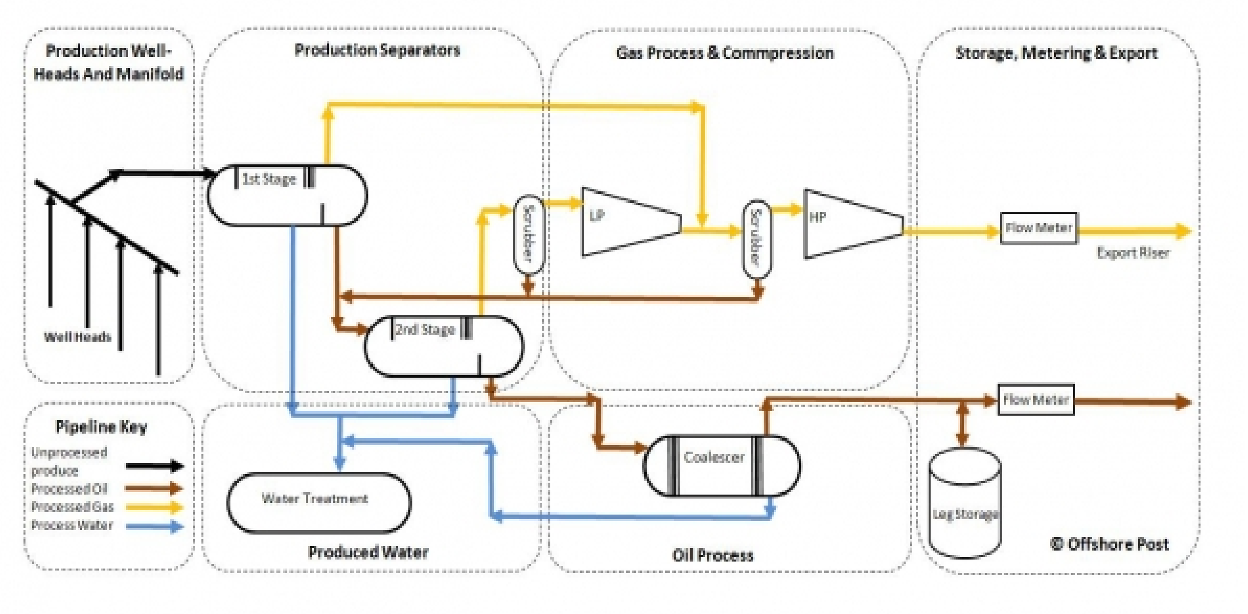


Figure 4.4.4.1: Basic diagram of offshore oil and gas process (Source: Offshore Post, 2013)

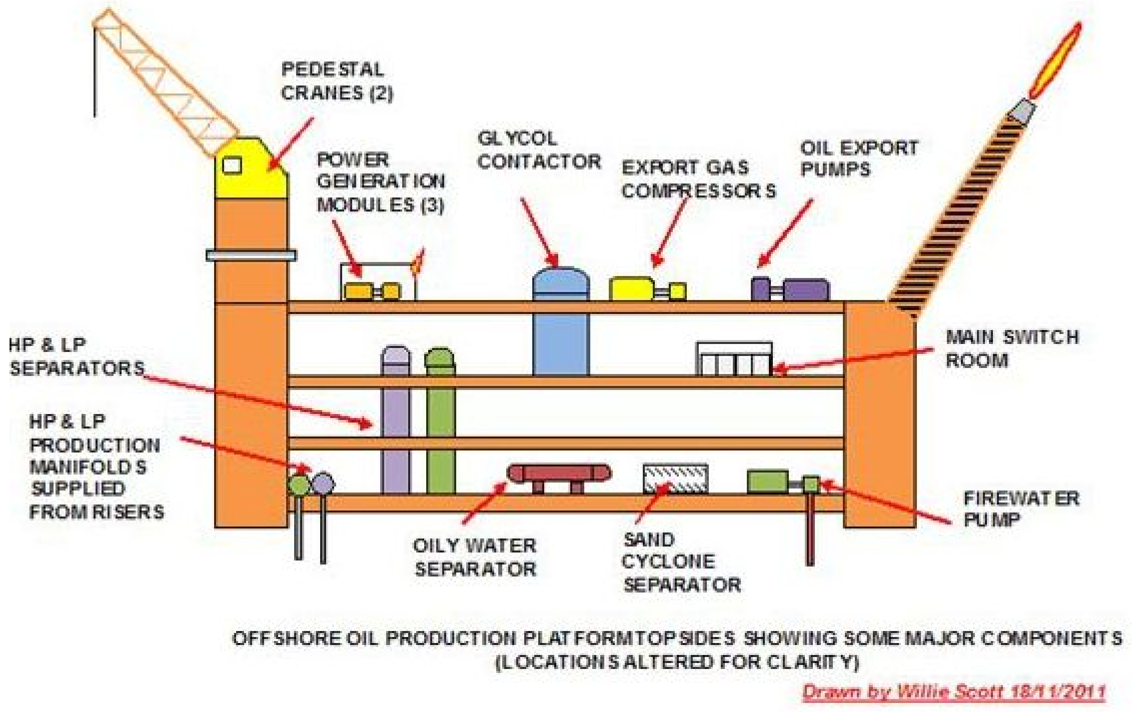


Figure 4.4.4.2: Location of all major components and machines in a semi-submersible production platform (Source: Scott, 2011)

4.5 ECONOMIC BENEFITS IM MALAYSIA

Malaysia is the second largest producer of oil and natural gas producer in Southeast Asia and second largest liquefied natural gas exporter in the world. This is further enhanced due to the high amount of reservoirs and strategic location of seaborne energy trade routes. There are an estimated amount of 4 billion oil reserves and 83 trillion cubic feet of natural gas reserves surrounding Malaysia's seas (Oil & Gas Journal, 2015).

In Malaysia, the Prime Minister will receive a report set by the Economic Planning Unit (EPU) and the Implementation and Coordination Unit (ICU) about the energy policy. All the licensing policy and ownership rights of oil and gas exploration projects in Malaysia belongs to Petroliam Nasional Berhad (Petronas). Petronas contributes to 45% of the government revenues from taxes and dividends (RIGZONE, 2015). Due to this percentage, the government income will increase further, providing an abundant money to build more non-profitable infrastructure that will benefit the people.

Exxon Mobil Corporation controls most of the production platform in Malaysia, about 40 offshore platforms with a working interest in four production sharing contracts with Petronas. A production sharing contract is an ordinary contract signed between the government with a group of oil extraction companies regarding on how much raw material extracted from the country each will garner (Stauffer, 2005). Another active company is Shell which have more than 10 production sharing contracts near Sabah and Sarawak. ConocoPhillips have three near Sabah and Murphy Oil Corporation operates six production sharing contracts around Malaysia (RIGZONE, 2015). There are also major oil and gas contractors and service companies that are involved in the upstream system such as Technip, Petrofac, Halliburton Baker Hughes, Schlumberger and Aker Solutions. Furthermore, associations such as the Malaysian Oil & Gas Service Counsel (MOGSC), Malaysian Oil & Gas Engineering (MOGEC), Malaysian Offhsore Contractors Association (MOCA) and Malaysian Gas Association (MGA) will provide a discussion forum among each other (Haq, 2015).

Semi-submersible production platforms plays a prominent role in the Malaysian economy, due to its high production rate of crude oil and natural gas. The oil and gas industry contributes to one-fifth of the national Gross Domestic Products (GDP) over the past years (Haq, 2014). Malaysia has nearly 539,000 barrels per day (bbl/d) of refining capacity (Oil & Gas Journal. 2015).

There are four semi-submersible production platforms currently operating off the Malaysian offshore. The biggest semi-submersible is the Gumusut-Kakap platform with an expected oil production of 135,000 barrels per day (PETRONAS, 2013). The other three platforms are the Naga 1 semi-submersible drilling rig, Harkuryu-5 semi-submersible platform and the Ocean Rover oil rig. Although there are only four semi-submersible production platforms compared to the abundance of offshore jacket platforms, the production rate on a semi-submersible can easily dwarf any fixed platforms rate besides many other benefits.

The oil and gas products generated from the semi-submersible platform is currently bestowing the Malaysian GDP for about 20% and is predicted to increase further in the future. In order to provide economic benefits to the country, semi-submersible platforms is currently sustaining the production process as more deep water exploration and better enhanced oil recovery (EOR) methods are being developed. These will allocate many investors interested in capitalising the country's policies with many opportunities (MIDA, 2013).

Besides that, semi-submersible is making Malaysia a regional storage and trading hub as the downstream activities are increasing. The high production rate will encourage the demand of crude oil and natural gas, improving our economy profit. Furthermore, it also supports upstream and downstream industries by helping the oil and gas industry to grow (MIDA, 2013).

Semi-submersible can provide opportunities both in upstream and downstream projects. The enhanced oil recovery methods besides increasing production rate, will provide job opportunities due to the amount of specialists required. Besides that, many companies will become more competitive among each other to gain advantage by taking over the oil reserve in a certain location using a semi-submersible. This healthy competition will further increase the production rate of oil and natural gas which will heighten the profit value. Although a lot of money will be invested into the building and maintenance of semi-submersible in Malaysia, it is expected the daily oil production capacity will increase to around 166, 000 barrels per day by 2020 (MIDA, 2013).

The Malaysian government is planning to bring many foreign companies to strategically do a partnership with Malaysian companies to combine both their capabilities and mastery to improve the growth of oil and gas industry here. From this, the already existing semi-submersibles will undergo improved changes that can aid the extraction and production process better. This dynamic business environment will provide many benefits to the companies related to this industry (Offshore Energy Today, 2015).

Tentatively, the oil and gas industry have been fuelling Malaysia's development programmes as it is the government's main source of revenue. This industry is currently moving rapidly due to the new discovery in innovation and technology that reduces cost and improves production as well with the profit. Semi-submersible production platforms are the most highly advanced oil rig due as there are many advantages and boon, making it to be sought out mostly. It is hopeful that by 2017, Malaysia will become the number one oil and gas centre in the Asia Pacific region (Haq, 2014). Thus, the semi-submersible platforms provides many economic benefits in the oil and gas sector.

CHAPTER 5

RECOMMENDATIONS AND CONCLUSION

5.1 RECOMMENDATIONS

The structural safety of the overall design of the semi-submersible platform must be highly emphasized as well as the strength of the structure when it is exposed to unfavourable dynamic loads. Mainly, a semi-submersible platform must be designed in a versatile way towards the persistently evolving ocean environment (Zhang, 2011). The semi-submersible design and production process should promote flexibility to keep this structure to feasibly work in this industry. Adoptable features such as drilling mechanism and interventions promotes flexibility. Furthermore, the semi-submersible platform should be greatly assessed for a given time into the future to maintain a relatively stable return on investment. Implication of robust, flexible and adaptable designs helps in avoiding cost escalation (Patricksson, 2012).

5.2 CONCLUSION

From this study, the semi-submersible production platform was studied based on all the types of offshore platforms in the world. Fixed platforms have many disadvantages mostly due to their limitations in deeper water regions. The high cost and impracticability to build in those regions makes it an unfavourable oil rig for most companies. Fixed platforms such as jacket platform, compliant towers and gravity based platforms are the earliest and most abundant platform in the world. It is only suitable for shallow water depths up to 300 meters where the modular steel structures are spiked with piles on the seabed designed for long-term operations.

Floating platforms such as semi-submersibles, spar platforms, tension leg platform, drill ships and floating production storage and offloading units (FPSO's) are primarily preferred by many oil and gas companies. However, semi-submersible platforms have a lot of advantages and benefits compared to the other types of floating platforms. This study have proven that semi-submersible production platform is the most promising and favourable offshore platform compared to other platforms.

Semi-submersibles have many advantages in terms of cost, water depth, payload, stability, drilling rate, production rate, loading and transportation. This advantages have increase the demand of semi-submersibles in the offshore oil and gas industry. The high stability makes it a viable option to be used in harsh ocean environments. These platforms do experience moderate movements under constant wave actions, it is still stable due to the large size of the platform. As this structure possesses appreciable motions, it has attracted the attention of many oil and gas companies.

This review study also shows that the best semi-submersible design is with the hull-type superstructure with diagonal bracing, 6 twin column arrangement and twin pontoon. A mooring device using anchors or dynamic positioning such as global positioning system (GPS) will be used for the semi-submersible to stay in position. The operating deck consists of the many buildings and structures that are useful to maintain the oil rig's performance.

The column-stabilized semi-submersible production platform is deduced to be the better option due to high stability. The production process of a semi-submersible happens in three phases which are the exploration, drilling and production stages. The exploration is done usually using the machine airgun system and exploratory wells. After confirming the presence of oil reservoir there, the semi-submersible will be stationed there for drilling process.

The rotary drill in the drill derrick on the oil platform will drill through the seabed and rocks to reach the oil source. Next, the production process will happen where there is three major recovery process is used to extract the maximum amount of crude oil. All production activities must be done according to the safety and regulations to ensure no harmful or dangerous incidents will take place. After all the natural resource in that reservoir has finished, the semi-submersible will be towed to a new location and the same process will be repeated again. After a long period of time when the oil platform can no longer operate functionally, it will be decommissioned or be used for different purposes.

There are four semi-submersible production platform currently operational in Malaysia which are the Gumusut-Kakap, Naga 1, Ocean Rover and Harkuryu-5. The major oil and gas companies in Malaysia are Petroliam Nasional Berhad, Shell Malaysia, Conoco Asia Pacific Sdn. Bhd, Exxon Mobil and Murphy Oil Corporation. The major engineering and construction companies is Aker Solutions, Dialog Group, MMC Oil and Gas Engineering Sdn Bhd, Saipem (Malaysia) Sdn Bhd, Technip and SapuraKencana Petroleum Berhad.

Generally, semi-submersible platforms are preferred because of the capability to cost-effectively produce and export oil and gas (Reddy, 2013). The industry analysis and study research were done where it proves that semi-submersible production platforms are the most commonly chosen design and viable option in any kind of offshore environments. This platform gives flexibility and adaptability in any kind of ocean conditions and parameters ranging from shallow to deep water depths and low to high well counts.

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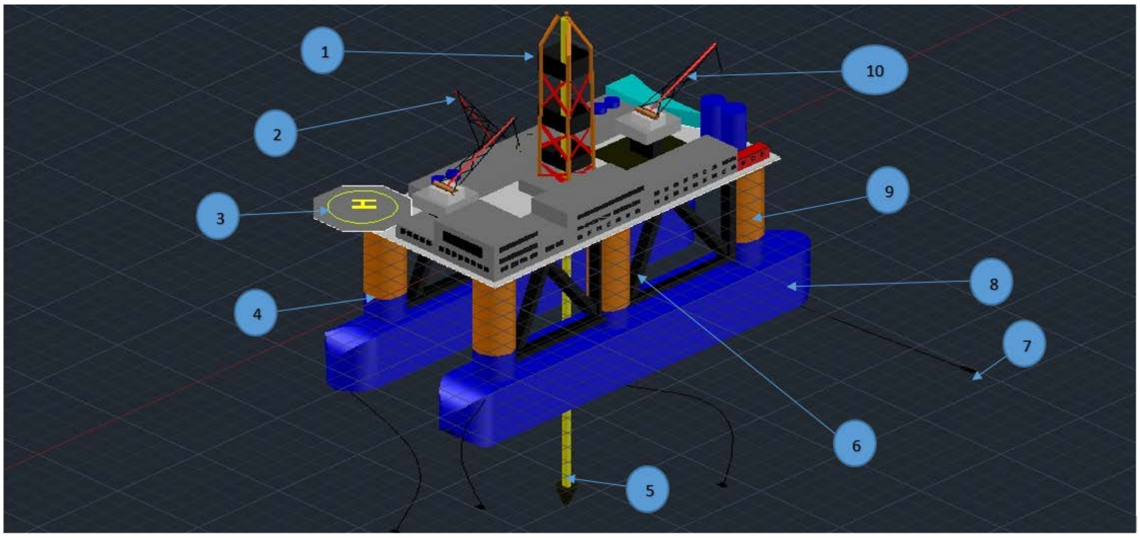
APPENDIX A



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DESCRIPTION

1. DRILLING TOWER
2. FLARE GAS
3. HELIPAD
4. WATERLINE LEVEL
5. DRILL BIT
6. BRACING STRUCTURE
7. ANCHOR
8. PONTOON
9. COLUMN
10. CRANE

FINAL YEAR PROJECT			
SEMI-SUBMERSIBLE PLATFORM			
DRAWN	YUBENRAJ	APPROVED	IR. DR. LOW
DATE	28/08/2015	DATE	28/08/2015
REV	1	SIGNATURE	

APPENDIX B