Offshore structure subsea production system engineering essay

The offshore industry nowadays, becomes the primary in progress of civilization. Oil and gas are essential assets in world trade. Impact of that, there are many offshore structure worldwide. An offshore structure, referred to an oil and gas platform where it is a large structure with facilities to drill wells and extract and process oil and natural gas and export the products to shore.

There are several type of platform depends on the circumstances, likes fixed to the ocean floor, compliant structure and floating structure.
Remote subsea wells may also be connected to a platform by flow lines and umbilical connections. Subsea production systems can range into complexity; from a single well with a flow line linked to a fixed platform, FPSO or an onshore installation. Otherwise it can be from several wells on a template or clustered around a manifold and transferring to a fixed or floating facility, or directly to an onshore installation

Figure 1: Deepwater Systema Types (Chakrabarti, 2005)

Subsea production systems can be used to develop reservoirs, or parts of reservoirs, which require drilling of the wells from more than one location. Deep water conditions, or even ultra deep water conditions, can used a subsea production system, since traditional surface facilities such as on a steel-piled jacket, might be either technically unfeasible or uneconomical due to the water depth.

LITERATURE REVIEW

The increase of natural gas in the energy matrix all over the world has posed a strong demand on offshore exploration and production. British Petroleum

Company’s outlook for the future shows ultimate offshore reserves to be 571 billion barrels with onshore reserves to reach 1038 billion barrel (Bleakley, 1998).

HISTORICAL

Under water oil field facilities are generally referred to using a subsea prefix, such as subsea well, subsea field, subsea project, and subsea development. Subsea oil field developments are usually split into Shallow-water and Deepwater categories to distinguish between the different facilities and approaches that are needed.

The term shallow water is used for shallow water depths where bottom founded facilities like jack up drilling rigs and fixed offshore structure can be used, and where saturation diving is feasible. While deepwater is a term often used to refer to offshore projects located in water depths greater than around 600 feet, where floating drilling vessel and floating oil platform are used, and unmanned underwater vehicles are required as manned diving is not practical.

The first subsea well was in one of the Great Lakes in the USA and was in only a few feet of water and Shell was completed its first subsea well in the Gulf of Mexico in 1961 (Bleakley, 1998)

In the Gulf of Mexico, Marathon began producing at Droshky in 3, 000 ft (914 m) of water in Green Canyon block 244, 160 miles (257 km) southeast of New Orleans. Droshky, too, is tied back to an existing platform; Bullwinkle takes the dual 18-mi-long (29-km-long) flow lines from Droshky. Marathon says the initial development stage is expected to produce 50, 000 boe/d at its peak. (Kliewer, et al., 2010)

Meanwhile Petrobras is not left out. The FPSO Cidade de Santos in Uruguay is expected to reach 25, 000 b/d of oil from three wells, with a fourth scheduled for tieback before year end to bring production to 35, 000 b/d. Petrobras says the development plan for Uruguay field will consist of four horizontal oil wells and five gas wells directly connected to the FPSO. (Kliewer, et al., 2010)

SUBSEA EQUIPMENT

The development of subsea oil and gas fields requires special equipment. The equipment must be reliable enough to safe guard the environment, and make the exploitation of the subsea hydrocarbons economically feasible. The deployment of such equipment requires specialized and expensive vessels, which need to be equipped with diving equipment for relatively water depth environment work.

Pipes

Pipes are the employed mechanical components to convey fluids. Subsea pipes are varies in sizes, typically 2 to 10 inches diameter, depend on the number of well and the pressure (Kliewer, et al., 2010). The pipes can be classified as rigid and flexible. Flexible pipes comprise several layers with polymeric and metal components and bending rigidity much smaller than that for rigid steel pipes.

Figure 2: Rigid and Flexible Pipes

In subsea system, pipes are function as for flow-lines. Those it subjected to the static load since rested on seabed (Bai, et al., 2005).

Wet Xmas Trees

The first Petrobras wet X-mas Tree was installed during April 1979 over well 1-RJS-38 in the Compos Basin Bonito Field (Trotman, et al., 1987). In general, the functions of subsea tree vary on the nature of system. It is the equipment that installed at the wellhead to guarantee security barriers in case flow interruption is necessary, which assures reservoir natural pressure blockage. It comprises basically a set of valves, hydraulically operated through spring return to assure closing in case of hydraulic system depressurization (Estefen, et al., 2005). Trees can be fitted with subsea chokes to actively regulate flow and valve system control and injection of wax chemical either downhole or into flow-lines (Trotman, et al., 1987).

http://www. gepower. com/businesses/ge_oilandgas/en/prod_serv/systems/images/main_deepwater_con. jpg

Figure 3: Wet X-mas Tree

Subsea Manifolds

Subsea manifold is a set of tubes, valves and monitoring instruments assembled on a metal structure, interconnecting the drainage/flow of several wells to the production unit, thus reducing the number of lines that would be necessary (Estefen, et al., 2005). The idea behind of using subsea manifold is to reduce the number of riser from the seafloor up (Trotman, et al., 1987).

http://www. gepower. com/businesses/ge_oilandgas/en/prod_serv/systems/images/main_subsea_manifold. jpg

Figure 4: Subsea Manifolds

Manifolds is the unit that as the heart of the entire system. It is made up of all necessary piping to carry out the submerged production system. It is a rectangular shaped with well rounded corners to allow use of pump-down tools.

The manifold is fail-safe. If hydraulic power is lost, or if any abnormal conditions exist, all valves close and the system are left in a safe condition.

Jumper

Typically subsea pipelines consist of pipes and riser. In order to connect each other, riser has been use. The jumper is tied with the riser and pipeline with connector and Pipeline End Termination (PLET). PLET function as support to pipeline connector and valve. At the subsea end, pipeline is connected to manifolds or a well through a jumper which is installed between PLET and manifold / trees by connectors (Gou, et al., 2005).

Figure 5: Schematic of typical subsea pipeline system

Figure 6: jumper diagram

Umbilical Cable

Umbilical cables are employed to control the subsea equipments remotely. They are able to transfer hydraulic pressure and electrical power to operate submerged equipments and valves as well as to retrieve data through electrical and/or optical fiber cables. Umbilical can also be used associated with additional hoses for well chemical injection. An example of umbilical is shown in Figure 6.

Figure 7: Umbilical Cable

Pipe Line end Manifold – PLEM

Figure 8: Pipe Line End Manifold

The PLEM is a collector / distributor equipment, which is characterized by the incoming or outgoing of more than two pipes. When used in the arrangement, it allows pipe sharing without operational flexibility.

Pipe Line End Termination – PLET

The PLET makes it possible to connect, without divers, a rigid pipe and equipment to another pipe. It features a flange connection to be interconnected to the extremity of the rigid pipe, a blockage valve operated by Remotely Operate Vehicle (ROV) to allow pipe hydrostatic test, a HUB/MCV for future connection to flexible riser or jumper.

http://www. oceaneering. com/wp-content/uploads/2009/08/subfdh-flowline3. jpg

Figure 8: Pipe Line End Termination

SUBSEA PROCESSING TECHNOLOGIES

Subsea developments are suitable for widespread reservoir structures. They provide a degree of vessel and field expansion flexibility with simplified riser interfaces, but at the expense of high drilling and workover costs.

There are three common scenarios in oil and gas industries that used subsea system in for drilling system. This systems were attached either to semi-submersible structure, jacket structure or direct to subsea. However for simple understanding, subsea production normally will link to floating structure, such TLP, Guyed Tower, and semisubmersible.

Example of Semi-Submersible Platform Arrangement in Brazil

(wells water depth of 500 meters)

Model of Jacket Platform Arrangement

(water depths decreased from 500 to 180 meters and 20km away from the wells)

Ormen Lange layout

Subsea processing consists of range technologies to allow production from offshore wells without needing surface production facilities. It consists of treating produced fluids upstream of surface facilities on or below the seabed, including seabed and downhole oil/gas/water separation, downhole and seabed multi-phase pumping, gas compression, and flow assurance. The most important benefits from using these technologies include production boosting, improved oil and gas recovery, increased Net Present Value (NPV), reduced surface production facility costs, and the lower likelihood of gas hydrate formation in flowlines.

However there are numbers of issue that have kept subsea boosting and processing from being used more widely. The most important issue is the reliability of subsea units. They must be able to operate for long periods of time without any disturbance. In addition, the consequences from a subsea processing system failure are more badly than those from a topside unit because when a unit of equipment fails, an interfere vessel or a drilling rig have to be deployed to repair or service the unit (Chakrabarti, 2005). This downtime will lead the rate of quantity production and increased costs from securing an intervention vessel or drilling rig.

The two technologies in subsea processing are seabed separation and seabed boosting. The latter technology includes seabed multi-phase booster pumps and seabed gas compression. In this topic subsea production system, technologies of seabed separation will be discussed further on their process, and application around the world.

SEABED SEPARATION

One of the technologies in subsea processing is seabed separation. Apparently with the name, seabed separation is operation that involves of separate the oil, gas, and water directly at the seabed instead on topside facility. This development of subsea separation technologies allow companies to process offshore production without the sea level production facilities.

This technology is used in mature fields where water production increasingly exceeds oil production and where it becomes economically unviable for operators to continue with the recovery of the field’s reserves. The technology can be used also in green fields that have high gas to oil ratios and which face the risk of blocked pipelines because of hydrate formation.

For oil and water separation in mature fields, key factors include the level of the field’s water production and the existence of heavy oil. Meanwhile for liquids and gas separation in green fields, high gas volume fraction, increased distance from the host, and low reservoir pressure and temperature are considered as important parameters because the transport of wet gas over 10 of kilometers can lead to hydrate formation and, hence, pipe blockage.

As mentioned at above, subsea separation systems are designed to separate bulk water from production stream close to subsea trees on the seafloor. Basic components of that system include separator, pump to re-inject water, and water injection well. Others additional components include instrumentation, equipment associated with controlling the pump and separator, power transmission and chemical injection.

Figure 9: Subsea processing schematic (http://www. bp. com/liveassets/bp_internet/globalbp/STAGING)

The separation of oil is essentially a passive process based on reducing the pressure of the liquid. In separator components, oil will leaves the wellhead at a pressure typically between 14 and 20 MPa. First stage in a separation unit will reduce the pressure of oil to 1 MPa. At this pressure, most of gas will be trapped in the oil released. Time taken depend on thick of the oil is; those heating the oil will often speed the release of the gas.

Oil is sent by pipeline to the surface for the pilot plant, however small amount volumes of gas are recombined to subsea with oil for transportation to the host platform.

As water flows from the base of separator, the sand which has settled in the vessel is added to the flow. Sand will remove by continuous water-driven ‘ swirling’ flow pattern. The water and sand together entered cyclonic desander for separation. The bulk of the produced water from desander is deoiled in a cyclonic deoiler to produce relatively clean water for reinjection into the reservoir using a variable speed drive pump. The oily water is taken from the deoiler through an eductor to join the main flowline to the surface.

Normally, the export oil will contain between 2% and 10% water, while the reinjection water will be cleaned to 50-100 parts per million (ppm) of oil and might contained 2-10ppm sand.

APPLICATIONS SEABED SEPARATION AROUND WORLD

The first seabed separation unit was installed in Statoil’s Troll Olje field in 2000, while Tordis and Statoil field, being the second field in the world operating a subsea separation unit since October 2007. The driver behind these installations is Statoil Hydro’s improved oil recovery (IOR) strategy.

Unlike the Troll subsea separation project, the new Tordis station is absolutely central to the commercial viability of the whole field. This is because its increasing water out flow was restricting production because pipelines and surface facilities do not have the capacity to transport and handle the extra water being produced in increasing amounts by the well stream.

Meanwhile, Shell recently installed seabed separation units in two of its green field projects, BC-10 in Brazil and Great White in the US Gulf of Mexico. FMC supplied six subsea separation modules for these projects. At the Perdido Host Regional Development production from the first three fields (Great White, Tobago, and Silvertip) will tieback to a central separation and boosting cluster directly beneath the Perdido Host spar. The fields' key characteristics are their low reservoir pressure, temperature, and great water depth, each of which adds to hydrate potential.

Other upcoming seabed processing projects include gas and liquids separation at Total's Pazflor field off Angola, and oil and water separation at Petrobras' Marlim field in Brazil, Statoil's Fram East project in Norway, and BP's Foinaven field in the UK. The Pazflor project includes three seabed separation units by FMC to be installed in 2011 and expected to reduce significantly the risk of hydrate formation. FMC also will supply Petrobras with a seabed separation unit in 2011 for its Marlim field.

Figure 10: History Subsea Processing (Bleakley, 1998)

Meanwhile, Infield Systems views the mature NWECS region as a good opportunity for subsea processing technology. Statoil's extensive exposure to Norwegian waters is an important factor for the implementation and future proof of the viability of this technology. That operator has made a strategic decision to increase oil recovery rates from its fields, and subsea processing will be the primary tool to achieve this goal.

ADVANTAGE OF SUBSEA SEPARATION

In an ideal world, the separation process would take place at the bottom of well or in the reservoir itself. This concept of subsea separation, aims to do on seabed work which separate oil from the gas and remove contaminants. Therefore it will remove the need of carry out the processing on platforms. Subsea separation could be ultimate unmanned process operation. Subsea production has become an economic way of recovering hydrocarbons from offshore reservoir, especially those located at deepwater.

A most attractive benefit by this technology, which significantly more oil, could be shipped through the platform. Hydrocarbon production could not only increase but would reach its plateau level faster and remain there for longer.

If enough water removal, hydrate formation could not be occurring. Subsea separation system can reduce water flow in subsea flowline. The advantage for applying subsea separation systems is not only hydrate control, but also increasing recovery of reserves and accelerating recovery by making the produced fluid stream lighter and easier to lift (Sasanow, 1989).

Subsea separation is particularly attractive at very great depths, where it can be part of an anti-hydrate policy. If separation performances is sufficient and residual water content in oil is limited to a low water cut, anti hydrate treatment is no longer required or is limited to an injection of low dosage of additives (Falcimaigne, et al., 2008).

CONCLUSIONS

A subsea oil and gas production system (SPS) includes most of the main elements found in a conventional platform production system, but is unique when it comes to remoteness in installation, service and operation. The number of existing and proposed subsea boosting and processing projects has increased over the last few years. The majority of these units were awarded prior to the recent decline in offshore activity caused by the global economic downturn, pressures on the supply chain, and oil price volatility. Therefore, as a result of the timing of the contracts, several projects have gone ahead despite these conditions. Most operators involved in these technologies are either partly nationalized companies such as Petrobras and Statoil, or oil majors such as Shell and Total.

Subsea systems are less expensive to install and can be brought on stream faster. They offer flexibility in the location and size of the host facility and can reach into water depths where conventional development of all but the largest fields would be prohibitively expensive. The drawback is that if something goes wrong with a subsea well, intervention can be costly. Although several of these oil companies aim for additional cost savings in the short term, we believe there will be a continued effort to push these techniques to improve oil and gas recovery, boost production, reduce the platform’s operating cost, and reduce the likelihood of gas hydrate formation in the pipelines.

Another key concern in deepwater, long step-out applications is communication speed and response time. As requirements for downhole data increase in complexity, the modest communication speeds of current multiplex electro-hydraulic MUX/EH systems are challenged. Use of the all-electric control system virtually eliminates this problem as communication and power transmission are accomplished via high-speed coaxial cables.

Subsea processing and boosting technologies are a long-term objective for oil companies that face short-term fluctuations in R&D investment. If these technologies become proven winners that increase NPV they may become the preferred development solution.

The success of upcoming projects is vital to the longevity of the deepwater oil and gas industry. The competition between manufacturers for different technologies, such as the helico-axial and the seabed ESP, is expected to increase. The subsea boosting and processing market is experiencing its first “ experimental” stage after which ISL anticipate that these technologies will be used more widely.