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CONCEPTUAL STUDY OF SUBMARINE PIPELINE USING SUBMERGED FLOATING TUNNEL

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ABSTRACT

Standard practice of submarine pipeline installation is by laid on the seabed. The risk in pipeline construction and operation caused by the challenging seabed and environmental load has led to the invention of new technologies of pipeline installation. The greatest risk of conventional pipeline is leakage and the oil will come out and pollute the sea. Innovative concept is offered to overcome that problem where the oil and gas pipeline placed in the Submerged Floating Tunnel (SFT) structure. This paper presents various advantages and points out some obvious disadvantages with this SFT usage for submarine pipeline. Furthermore, the expansion usage of SFT structure in order to house the submarine pipeline will also be presented.

Keywords: submarine pipeline, Submerged Floating Tunnel, pipeline placement, expansion usage of SFT

INTRODUCTION

The first submarine pipeline was installed in the Summerland, southeast of Santa Barbara USA. Recently, it is used wider in the world because it is trusted as a more efficient means of transporting large quantities of crude oil and natural gas than other transportation mode. It is estimated that approximately 10-12% of the total pipeline in the world is submarine pipeline. Although the pipeline was considered as efficient means of transporting oil and gas but in the fact, the conventional pipeline was built laying on seabed exposed to surrounding environment. It cause various problems associated with the environmental loads such as waves and currents, the harsh environment-related threats such as corrosion, marine growth, extreme contour, soil liquefaction, scouring, landslides and also associated with functional load such as buoyancy, external hydrostatic, installation pressure [1]. In addition, across the globe, the average age of pipelines is 30 years, while some pipelines are as old as 100 years. Those facts will lead submarine pipeline potentially experience structural failure and then leak.

The oil leakage in submarine pipelines causes sea pollution. The oil spill would impact to ocean water and the shoreline and then damage to marine ecosystem as depicted in Figure-1. Some cases of offshore pipeline leakage have been reported like Europe's North Sea [2], the 'Mumbai High' fields in India [3, 4] etc. Pipeline leaks resulting in huge losses, some losses due to the leakage of submarine pipelines include loss of production, the cost of the pipeline repair, the cost of the oil spill clean up and recovery costs of environmental damage. The estimation cost of oil spills clean up involves some complicated and interrelated factors. Cost associated with cleaning up oil spills greatly influenced by the circumstances surrounding spill including: type of product spilled; location and a spill; sensitive are as affected or threatened; liability limits in place; local and national laws; and clean up strategy. Franken (1991), an economist showed that the cost of eliminating the off shore oil averaged$7, 350/tonne, whereas shoreline clean up ran as high as$147, 000-$294,000/tonne [5]. With the passage of time, the estimation cost of oil cleanup should be adjusted to the latest condition.

Because of those, a serious attention must be paid where at the design stage; it needs some firm analysis such as analysis of wall thickness, analysis of on-bottom stability of pipeline, analysis of the pipeline free span length, and stress analysis [6]. In addition, at operational stage it needs better monitoring and detection system. Furthermore, it needs some innovation to find better submarine pipeline development where they must be able to mitigate environmental challenges and even able to overcome the problem if pipeline leakage occurs.

Figure-1. Images of oil spill off the Mumbai coastcaused pipeline leak.Source : http://www.thehindu.com

CONVENTIONAL PIPELINE

Almost all conventional offshore pipelines is used in oil and gas industry which can be classified as follow [7]:

a) Flowlines transporting oil and/or gas from satellite subsea wells to subsea manifolds;
b) Flowlines transporting oil and/or gas from subsea manifolds to production facility platforms;
c) Infield flowlines transporting oil and/or gas between production facility platforms;

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d) Export pipelines transporting oil and/or gas from production facility platforms to shore land
e) Flowlines transporting water or chemicals from production facility platforms, through subsea injection manifolds, to injection wellheads.

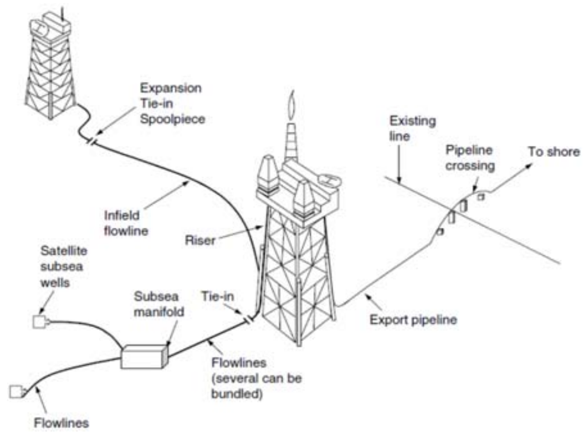

Figure-2. Uses of offshore pipelines

Beside of the aforementioned uses of offshore pipeline as seen in Figure-2, submarine pipeline can be also used to transport the oil or gas between onshore to onshore which crosses water expanses (seas or straits) such as the Langeled pipeline, i.e. at North Sea (Norway - England), Nord Stream pipeline at Baltic Sea (Russia-Germany), FranPipe pipeline at North Sea (Norway-France) [8]. Therefore, according to place of origin and destination delivery, submarine pipeline could be divided into the following:

a) Submarine pipeline which transporting oil and natural gas from onshore/Island/continent terminal to other onshore/Island/ continent terminal.
b) Submarine pipeline which transporting oil and natural gas from floating production system (FPS) to onshore terminal.
c) Submarine pipeline which transporting oil and natural gas from offshore platform to offshore platform.

CONCEPTUAL PIPELINE USING SFT

Some weaknesses in pipeline which laid on the seabed can be solved with the proposed solution in this research proposal where the pipeline is placed in the structure of Submerged Floating Tunnel (SFT) as seen in illustration in Figure-4. In general, SFT is a tubular structure that is floating at a certain depth below the surface of the water, exploiting bearing capacity derived from Archimedes force, has a fixed position through a system of anchors made of cables connected to the seabed.

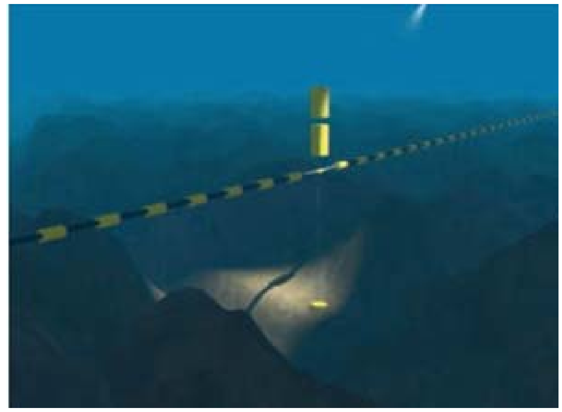

Figure-3. DNV Float Pipe concept proposal.

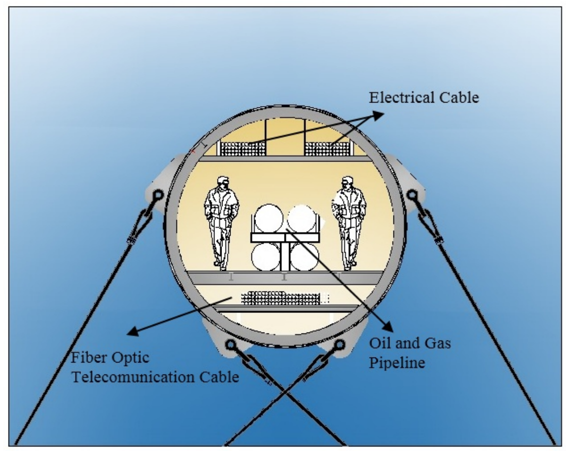

Figure-4. SFT structure concept proposal.

Beside of SFT proposal, another efforts to find alternative solution of submarine pipeline construction have been proposed. Det Norske Veritas (DNV) has proposed a concept to modify the basic premise that pipelines must be placed on the seabed [9]. The DNV Float Pipe is proposed to place it in the water column, removing the pipeline from the seabed to mitigate challenges of seabed area and struggle with deep water condition as seen in Figure-3.

SFT tunnel tube has dimension of 3-5 m diameter according to needs, 12 mm steel wall plate thickness attached with steel frame that consist of longitudinal and transversal frame section. The cross section of all the frames are I-shape with various dimension which has to fullfill the standar [10] as depicted in Figure-5. Because of its unique, the circle frame of the tunnel tube should be made through fabrication process. The steel wall plate is welded on the circle frame and coated to prevent corrosion. The tunnel is equipped with some rack of oil and gas pipeline, rack of electrical cable, rack of fiber optic telecommunication cable and steel floor [11].

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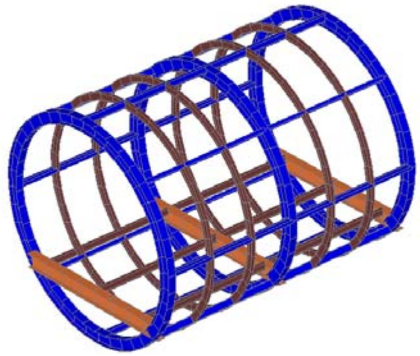

Figure-5. Steel frame of tunnelsegment.

EXPANSION USAGEOF SFT STRUCTURE

According to explanation previously mentioned where submarine pipeline could be divided into three kinds. Based on those, pipeline concept using SFT could be used to accommodate those needs especially in oil and gas industry such as the following description:

Case-1: Submarine pipeline which transporting oil and natural gas from onshore/Island/continent terminal to other onshore/Island/ continent terminal.

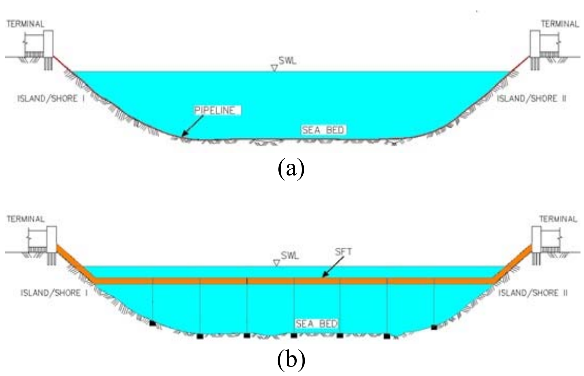

Figure-6. (a) Conventional pipeline case-1 (b) Proposed pipeline using SFT case-1.

The case-1 developed in this paper is submarine pipeline which is defined as pipeline section that extends from the inlet point generally onshore compressor terminal to the outlet point generally onshore receiver terminalas depicted in Figure-6(a). This case usually occurs when the oil and gas resources located on the mainland or when the hydrocarbon derived from offshore should be refined in onshore first before it is delivered to another place through the sea by submarine pipeline. In this case, the alternative solution is offered where the pipelines are placed in submerged floating tunnel (SFT) structure as depicted in Figure-6(b).

Case-2: Submarine pipeline which transporting oil and natural gas from floating production system (FPS) to onshore terminal.

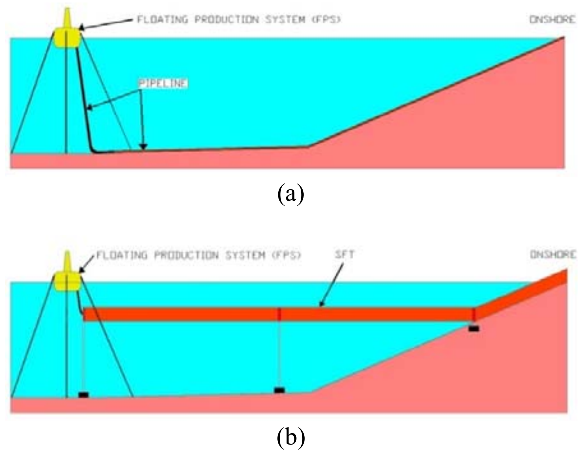

Figure-7. (a) Conventional pipeline case-2 (b) Proposed pipeline using SFT case-2.

In case-2, Floating Production Systems (FPS) is usually applied to water depths and many marginal fieldsas depicted in Figure-7(a). Production from submarine wells is transported to the surface deck of FPS platform through production risers. From Floating production system (FPS), crude oil and gas liquidswill be transportedto onshore entry points by submarine pipeline. In this case, the alternative solution is offered where the pipelines are placed in submerged floating tunnel (SFT) structure as depicted in Figure-7(b).

Case-3: Submarine pipeline which transporting oil and natural gas from offshore platform to offshore platform [12].

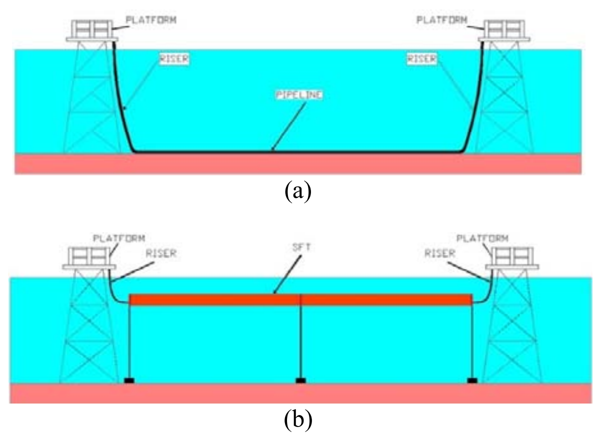

Figure-8. (a) Conventional pipeline case-3 (b) Proposed pipeline using SFT case-3.

In this case submarine pipeline treated as tranportation mode of hydrocarbon material between two or more offshore platforms as depicted in Figure-8(a). It is because not all platform has processing facilities to segregate hydrocarbon material derived from the well. There is a case, crude oil and gas has to be transferred to other platform just to tie-in crude oil and gas production from several others platform to optimize one pipeline to processing facilities before sent to onshore. In this case, the alternative solution is offered where the pipelines are placed in submerged floating tunnel (SFT) structure as depicted in Figure-8(b).

THE ADVANTAGES OF PIPELINE USING SFT

The state of the art is: for many years, conventional pipelines are installed on the sea bed. In pipeline installation process, it often faces many seabed areas which have complex contour thus forcing it to look for others alternative route. It makes the cost of pipeline installation to be high. In addition, because the pipeline is exposed to the environment, the harmful interaction could be experienced between pipeline and the environment. To overcome this problem, there must be something to cover the pipeline so that it could be well protected. In this regard, the SFT present to answer these challenges. Some advantages of placement of oil and gas pipelines in the structure of SFT are concluded by the following:

Environment-friendly

It is regarded as the greatest advantage of the use of SFT structure. Why ? Could you imagine what happen if the pipelines leak?By using the SFT, the oil will be spilled into the SFT so that it will not pollute the sea water. Futhermore, by the better detection system, the leakage will be easily detected and repaired as soon as possible only by sending the technician to leakage position by motorcycle/by foot.

No Significant influence of the environmental loads

By placing in SFT structure, pipelines will be sheltered from the negative influences of environmental loads such as the hydrostatic and hydrodynamic loads so that it is no longer needed the analysis of over stress, buckling, fracture and fatigue caused by potential vortex induced vibration (VIV). Obviously, it is more economical because it is no longer needed ballast material that typically uses concrete material to keep stability movement. Based on those facts, it can be ensured that the pipeline has high safety factor.

No Influence of the seabed contour and seabed soil stability

By placing in SFT structure, pipeline is no longer influenced by the challenging sea bed where the pipeline route becomes more definite and clearer. In addition, it is also no longer influenced by the stability of seabed soil such as scouring, settlement, landslide, liquefaction etc.

No chemical and physical interactions between pipeline and sea water

By placing in SFT structure, the rate of corrosion can be reduced significantly because it is protected from the interaction of the pipeline and water. In addition, the phenomena of marine growth can be also abolished so that service life could be significantly prolonged.

Easier on installation, operation, maintenance and repair of pipeline

By placing in SFT structure, the installation process could be easier and faster, the operational processed could be monitored well, leakage detection and repair of the pipeline would be much easier, faster and economical than if the pipeline is installed on the seabed.

Easy removal and reuse of SFT

Part of the SFT especially tunnel tube could be removed easily. It could be towed away, parked and stored temporarily in certain onshore area and can be reused for the same purpose to some place. This is a tremendous added value from the viewpoint of economic and environmental reasons.

Enable to join in building and operating of SFT

This is the most important aspect in order to press construction and operation costs. SFT structure can also be used simultaneously to transport of oil and gas pipelines, cross over the submarine telecommunication cables and electrical cable. Some companies (oil, telecommunication and electric company) could be joined to build the SFT with a portion of the financing that has been agreed and then join in operation.

THE DIFFICULTY IN SFT ACTUALIZATION

Actually, the real problem is not in the pipeline but in the SFT structure itself. Some difficulties to actualize this structure of SFT are concluded by the following:

Technological issues

To build SFT will encounter various scientific and technical difficulties, such as the hydrodynamic shape of tunneltube design, the cable system configuration, the connection design between tunnel tube and shore terminal, the installation of SFT structures, the placement of foundation block, etc [13, 14]. Furthermore, the threat of snap force caused by tether slack would be serious issue related to stability and safety aspect [15]. Actually many researches have been carried out to answer the aforementioned issue and many issues have been solved.

No one dares to start

This is a challenge to give something worth for science. The classic and significant issue is the cost beside other issues. To reduce costs, the first stepmay be, it can be started to build prototype in small dimension, short crossing length and in area with moderate environment. The next step, if getting a success this will stimulate many people to follow this success to build more SFT. If finding difficulty, more people will make researches and try to solve it.

CONCLUSIONS

This paper is an attempt to give a simple overview of submarine pipeline development concept using the SFT. The keywords of the state of the art in this pipeline concept is fully protection of submarine pipeline and sea water free oil pollution. The usage expansion of the pipeline placement in the SFT in the oil and gas industry has been described. Advantages and disadvantages are discussed. For the first time, the challenge to build SFT and to place pipeline in SFT would be better if offered to oil companies because they have an interest on it. Of course it is just a prototype which has a small dimension, short crossing length and built in moderate environment. Finally who dare to accept this challenge?

REFERENCES

[1] Veritas Offshore Technology and Services A/S. 2000. DNV-RP-F101 Submarine Pipeline Systems.

[2] Hickman L. 2012. Oil companies going unpunished for thousands of North Sea spills, http://www.theguardian.com/environment/2012/oct/25/oil-companies-north-sea-spills, 20 Januari 2016.

[3] ONGC. 2011. India: ONGC Reports a Leak on Its Offshore Pipeline, http://www.offshoreenergytoday.com/india-ongc-reports-a-leak-on-its-offshore-pipeline/.

[4] Sujay Mehdudia. 2011. Oil spill off Mumbai coast, http://www.thehindu.com/news/national/oil-spill-off-mumbai-coast/article1108248.ece, New Delhi, India.

[5] Etkin D.S. 1999. Estimating Clean up Costs for Oil Spills, International Oil Spill Conference, #168 1999.

[6] Bai Y., Bai Q. 2005. Subsea Pipelines and Risers, Elsevier.

[7] Guo B. *et el*. 2005. Offshore Pipelines, Elsevier.

[8] Offshoretechnology.com. 2014. Underwater arteries-the world's longest offshore pipelines, http://www.offshore-technology.com/features/featureunderwater-arteries---the-worlds-longest-offshore-pipelines-4365616/, 10 September 2014.

[9] DNV GL Floatpipe: A pipeline Concept for Challenging Seabed and Deep Water Condition. 2015. Offshore Mediterranean Conference and Exhibition, 25-27 March Ravenna, Italy.

[10] Wahyuni, E., Tethool, Y. 2015. Effect of Vierendeel Panel Widths and Vertical Truss Spacing Ratio in Staggered Truss Framing System under Earthquake Loads, International Journal of Civil Engineering, Vol. 13, No.2, 213-221.

[11] Wahyuni E., Budiman E., Raka IGP. 2012. Dynamic Behaviour of Submerged Floating Tunnels under Seismic Loadings with Different Cable Configurations, IPTEK the Journal for Technology and Science. 23(2), 82-86.

[12] Lee P.E, Jaeyoung. 2009. Offshore Pipelines and Riser, CSO AKER Engineering Houston, Texas.

[13] Long X., Ge F., Wang L., Hong Y.S. 2008. Effect of Fundamental Structure Parameter on Dynamic Response of Submerged Floating tunnel Under Dynamic Load, Acta Mech Sin, DOI 10.1007/s10409-009-0233-y.

[14] Wahyuni, E., Komara, I. 2016. Evaluation of Bouyancy Weight Ratio in Submerged Floating Tunnel under Hydrodynamic Loads. A case study of Seribu Islands, IABSE Conference Guangzhou 2016 Proceedings, 938-945.

[15] Lu W, Ge F, Wang L, Hong Y. 2010. Slack phenomenon in Tethers of Submerged Floating Tunnel under Hydrodynamic Loads, Procedia Engineering. 4: 243-251.