Development of Artificial Seabed Technology and Pre Drilling Tests in South China Sea

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Abstract

This paper discusses something about research and practice of new method, which is involved with the artificial seabed technology, to fabricate relative equipment and carry out the pre trial well in South China Sea in June of 2008 by COSL.

The market of deepwater drilling in the world has been enlarged for 10 years recently but there are few drilling vessels or semi-submersibles to suit to drilling in deepwater or ultra deepwater in international.

The situation of China is the same as the world, need to more equipment of deepwater drilling to carry out operation in the sea. COSL (China oilfield Services Ltd.) has some semi-submersible vessels, also called MODU, and they are only suit to operate lessen to 475 meters of water depth. The new technology of the artificial seabed to has been researched and improved, according to experiences from Norway's and America's experts in deepwater by COSL since 2004. It is hoped to match semi submersible by COSL to drill well in approximate 1000 to 1500 meter. The paper will induce the process of research and improve of fabricating and upgrading equipment for deepwater drilling. The pre trial well had been executed in South China Sea in June of 2008, where is water depth of near 500 meter. And the trial well will be drilled about 2009 in the same place of the South China Sea by COSL.

Keywords: ABS unit, deep water, model test, feasibility, the maximum loading forces, Pre Trial Well.

Introduction

China has been producing and importing lots of oil/gas every year to satisfy the domestic consumption. The big oil companies and service companies have found out more ways to explore new oilfields both offshore and onshore, to increase the production of oil and gas. A deepwater gas field was discovered in Liwan, deeper up to 1470 m in South China Sea by both CNOOC and Husky Co. in the summer of 2006. Big or gas fields are discovered in the areas of deepwater in China, especially South China Sea.

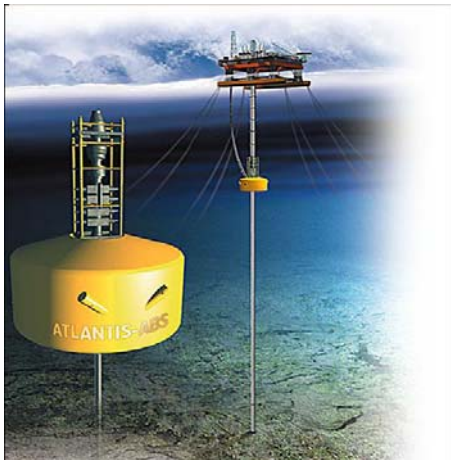

Fig. 1 Principle of concept of ABS

There are many difficulties in entering the deepwater oilfield in China. One of them is short of deepwater vessels or ships. As the biggest service companies of the petroleum industry in China, COSL (China oilfield services Ltd.) have only three semi submersibles which could operate in maximum water depth of 475 m. However, the water depth in Liwan gas field is 1470 m.

To drill in the deepwater, a new vessel of COSL, the sixth generation drilling rig, was in construction in 2006. COSL selected two ways to step to deepwater. One is to build a deepwater semi submersible in cooperation with other company, the other is to modify and add some equipments to existing semi submersibles to become the deepwater drilling rigs. It needs long time for fabricating the vessel for deepwater drilling, approximate 4-5 years, so COSL plans to adopt proper facility to improve existing semi submersibles for drilling in deepwater. The improved semi submersibles will drill in deepwater before new deepwater vessels start in operating.

Of course, the cost of improved semi submersibles would be lower than that of an ordinary deepwater vessel. It is estimated that new fabricating semi-submersible will drill in water depth

ranging from 1500m to 3000m and the improved semi submersibles will operate in shallower water of 1500m.

Principle of Atlantis concept for deepwater drilling

It is simple about Atlantis concept, also called ABS (Artificial Buoyancy Seabed) concept to drill in deepwater. The concept of Atlantis was invented by a Norwegian in 1993, and the main principle is to form an artificial seabed by a buoyancy module between the under section of semi-submersible and mud line. The upper section of the buoyancy module connects to the risers and lower section of the buoyancy module will connect to seafloor or mudline through some special casings, called tie pipes in general. The convention BOP (Blow out Preventer), rather than sub-sea BOP, is installed at top of the buoyancy. The ABS provides a buoyancy assisted stable semi-submersible 200 to 400 m below the sea surface using a tieback 22-in casing string from the first casing in the well as an anchoring system. This means that the BOP and riser do not have to be run to the seabed in deepwater. Less expensive rigs can carry out the drilling, anchored by taut-leg polyester moorings, and sub sea equipment will not be subjected to very low temperatures with associated flow assurance problems. Installation of the buoy can be achieved by standard anchor handlers, avoiding the need for heavy lift vessels. The profile of the system is shown in Fig. 2.

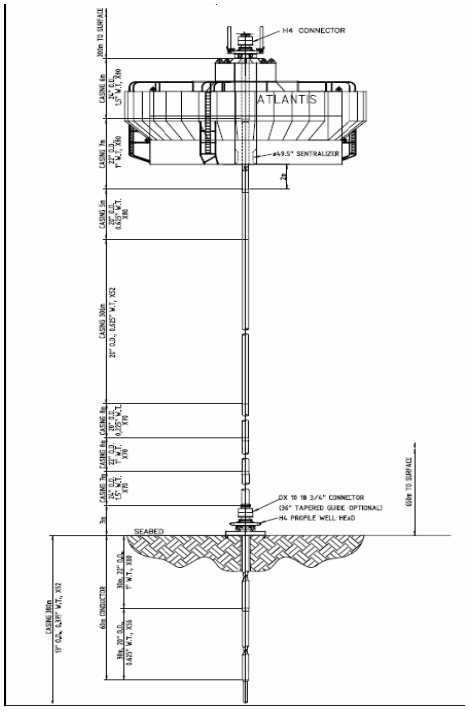

Fig. 2 Illustration of ABS

Tests for proven feasibility of ABS concept

After reviewing the concept of Atlantis or ABS, COSL started to design and execute a series of tests in labs, pools, and even lakes of the south and west of China. To prove the feasibility of the concept to drill in deepwater, a buoyancy was fabricated in 2002 and a marine trials carried out in Stavanger city of Norway in April 2003, as shown in Fig.3. They were conducted by the cooperation of both COSL and the company, ADTH, from Norway.

Fig. 3 ABS unit‘s Marine trials in Stavanger city of Norway

Below are main conclusions from the marine test:

- The towing operation can be successfully performed.
- The ABS unit can be submerged to 200 meters water depth in a controlled manner with the chain weight method. This operation can be done in less than one hour.
- Control of subsea valves, change of trim and level control are verified.
- ROV activities in 200 meters depth can be carried out.

There were 8 tests being designed and carried out. Some of them were designed to prove the feasibility of the facility, and others to prove the performances of the facility. The contents of tests to prove feasibility of the facility are showed in the Table 1.
A series of feasibility reports about this concept were based on the summary of the tests. And several seminars or workshops

were held in the cities of China to discuss the concept. It is concluded that the ABS can be a replacement of the deepwater drilling vessel to operate in area of depth ranging from 500 m to 1500m.

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Table 1 Tests to prove feasibility of ABS unit in deepwater drilling

No.	Time	Places	Method	Purpose of Test
1	August, 2004	Shanghai Jiaotong University	Simulating by Sea Construction software of computer	Instruction Strength
2	August,2004	Shanghai Jiaotong University	Model test in pool of 5 m depth	Instruction Strength and stability
3	March, 2005	Harbin Engineering University	Simulating by FEM software of computer	Static response between drill semi-submersible and the facility
4	March, 2005	Xian Jiaotong University	Simulating by FEM software of computer	Dynamic response between drill semi-submersible and the facility

COSL will carry out more tests before upgrading the facility of ABS and starting the trial well for this concept.

Tests to proven feasibility of facility

After completing the feasibility report, COSL arranged a lot of tests again as presented in Table 2. Meantime, a test about the mechanic properties of facility was conducted by ADTH in Marintek Ocean Laboratory, Trondheim , Norway.

Table 2 Tests to prove performance of the facility in deepwater drilling

No.	Time	Places	Method	Purpose of Test
1	March, 2005	Shanghai 708 Shipping Institute	Review to history casing and Simulating of software	Risk analysis of for facility in operation
2	March, 2005	Beijing Marine Institute	Motion Analysis by history casing and simulation of software	Motion Analysis
3	March, 2005	Qingdao Ocean Environment Institute	Review to history casing and Simulating of software	Predicting the effect of environment to the facility
4	March, 2005	Shanghai Jiaotong University	FEM Simulating further	Analysis of Mechanics in details
5	April, 2005	Marintek Lab of Norway	model test in pool of 10m depth	Disconnect in case of emergency
6	April, 2005	Kunming city	Big model test in the lake of 140 m depth	Simulating operation in deepwater

The purpose of the tests is to acquire some data about properties of the facility, including mechanics of not only static but also dynamic, hydraulic, and environmental and so on. The tests show that data shall be obtained about the maximum resistant force under the current impact, the maximum offset of the facility during bad weather, the maximum lift force when

buoyancy is vacuumed, and the maximum bend when current impacting become biggest.

Large model test in lake

To prove both feasibility and properties of the facility, COSL designed and executed a large experiment in the lake of 140 m depth in Kunming , China.

1 Procedure of the Test

The test in Kunming is a large scale experiment for deepwater drilling, took almost one month. The test not only used 10 tons of steel to build the model and modify the vessel but also installed 4 sets of monitor instrument. The key stage lasted 2 days to perform the load testing of the facility in the lake. The model in this test consists of the pipe of 6 inches with length of 150 m.

It is not only important but also necessary to carry out a large-scale model test before drilling a test well. The principle of the test is to use the analogy method in mathematics to design a series of models, in the lake of 140 m depth to simulate drilling procedure in the deepwater.

Not only geometry similarity but also physical similarities are applied to the tests. In the geometry analogy, the engineers were ruling a factor, 1:10, meaning the radio between the model and the prototype. The pipe would be simulating to the casing of 20 inches in deepwater environment. There are 27 inspecting points by the sensors of both stress and strain, from above of water to under water, until the bed of the lake.

2 Testing Program in the Lake

- Investigate the environment of the lake;
- Draw the rough charts about the trial of the ABS unit model;
- Calculate main data for the trial work, such as geometric and physical and hydraulic data;
- Invite some experts to check the results, and hold a seminar to put forward the suggestion by them;
- The report of calculating had been sent to a special committee for review, then it was approved by the committee;
- To purchased materials and manufactured facilities for simulating deepwater drilling in the lake according to the data calculated;
- To install the frame of simulating the rig of the deepwater drill in the vessel, and other measuring instrument in relative vessels that would be a part of the experiment;
- Start to operate in the lake after finishing the ready for trial of ABS unit model;
- Review and dispose the data transmit from various instruments during trial in the lake, and explain the result of tests, then made out the final report about the lake test for model of the ABS unit.

3 Acquire Data from the Test

In addition to, there were many ways to get data and information, such as the face and under of water cameras, the instrument of measuring inclined, and other instrument of measurement. The engineers have not looked for relative materials, to prove that there are no other experiments of deep water drilling in other place of the world. Fig. 4 is about the situation of the test for deepwater drilling in a lake of Kunming.

Recently, COSL has decided to drill a test well for the facility, called on ABS, to try to drill wells by using a semi-submersible attach to the facility in deepwater. It is schedule at the beginning of 2009.

Fig. 4 Situation of the test of deepwater drilling in a lake of Kunming, China

Some test results

1 Dynamic Roll and Pitch Motions of Atlantis Unit

The measured roll and pitch motions at the natural frequencies of the Atlantis Unit, were in general small, with amplitudes of about 0.2 degrees.

The largest dynamic roll and pitch motions of the Atlantis Unit

were measured at a towing speed of 2.5m/s. The maximum measured dynamic roll and pitch amplitudes were 0.21 and 0.18 degrees respectively.

2 Dynamic Bending Moments at Upper End of Casing

The maximum measured bending moment amplitudes in roll and pitch around the natural frequencies of the Atlantis Unit, were about the same in roll and pitch directions. At a towing speed of 2.0 m/s, the maximum dynamic moment amplitude was about 23% of the mean pitching moment (static moment). At a towing speed of 2.5 m/s, the maximum dynamic moment amplitude was about 14% of the mean pitching moment (static moment).

Procedure of the drilling operation

The result of using the facility is that operation in deepwater will be the same as shallow water. It will improve the capability of the semi submersible if ABS facility would be used when drilling, which could increase the depth of water of operation, from 457 m to almost 1500 m. The procedure of drilling operation about the making use of ABS facility is shown below, step by step:

- Drilling of well commences at seabed
- Set Casing And Cement At Seabed
- ABS Towed Towards Rig
- ABS Ready For Submersion,
- Prepare to run tieback casing.
- ABS in Position Below Drilling Rig
- Tie-back Casing Entering ABS
- Connector Above Seabed
- Tie-back Casing Connected At Seabed
- ABS Being Raised
- Wellhead Landing Out
- Air Being Pumped Into ABS
- BOP Above ABS
- BOP Landed On ABS
- Ready To Drill Ahead

Conclusions

Some preliminary conclusions have been achieved through above discussions.

- The concept of Atlantis is feasible according to the results of tests and simulations by both pool and software being carried out so far.
- The concept of Atlantis has some advantages comparing with DP drilling ship, such as lower cost, and more convenient to operate in some deepwater area, and more effective in operating the semi submersibles, etc.
- More research and tests are required before such a concept gets to industrial application.
- Whatever, the concept of Atlantis has been a prospect for the deepwater drilling, especially as an alternative to DP drill ship in area of depth between 500 m to 1500 m.
- The concept of Atlantis has some defects, for example, the operation period is longer than DP ship, and would have more risk when operating than other way to drill in deepwater.

Pre Trial Well in South China Sea

1 Site for preliminary trial:

- The site of preliminary trial well will be in the South China Sea. Location coordinates 18.685 N, 112.478 E (18 42 N, 112 26 30.12”E) Water Depth of 476m
- Preferably at or near actual trial well site/with same current conditions of trial well site.

2 Purpose：

This document provides an overview of requirements and procedures for a preliminary offshore trial of the Atlantis Unit.

Fig. 5 Pre Trial Well in South China Sea.

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The primary purpose of this trial is to assess vessel capability / develop the particular ship handling skills required for deployment, station keeping and recovery of the AU, thereby reducing the risk of accidental events during the actual trial well. A secondary purpose of the exercise is to function test and calibrate the umbilical, control systems and ROV facilities, with the intention of further reducing the MODU's exposure to risk, during the actual trial well.

3 To carry out pre trial in sea

- To execute pre trial in the South China Sea from May 29th to 7th;
- It is located the eastern of Hainan island of 250 km;
- There were 3 AHVs took part in the operation.

CONTENTS OF PRE TRIAL OPERATION

- Drawing the buoyancy in long distance;
- To install the weight chains;
- The test of sunk buoyancy;
- The test of stability of buoyancy under 250 m of surface of the sea;
- The test of shift of buoyancy by both AHVs;
- Operating of ROV when the buoyancy sinking;
- The buoyancy float testing;

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