DESIGN CONSIDERATIONS OF DEVELOPMENT USING FPSOs AND FLEXIBLE RISERS IN MILD DEEP WATER

Shan HUANG & Stephen HATTON
2H OFFSHORE ENGINEERING Ltd, Woking, England

SYNOPSIS

INTRODUCTION

Many recently filed developments in West of Africa share the following common features.

- Water depth is large
- Extreme wave height is small in comparison with
- Current
- Subsea infrastricture
- Intervention

Although each field is different and has its own inherent technical problems to be solved, a general strategy is using FPSOs with flexible risers and wet trees.

VESSEL SELECTION AND MOORING CONSIDERATION

The floating production storage unit is generally a tankerlike vessel which offers large deck and storage capacities required. It is either converted from a ship or a new build. Although most vessels are built of steel, concrete barge may prove to be more economic in the furture.

A typical floating production storage vessel has a length between 200m to 300m with typical tonnage of 100te. The vessel genrally has a large block coefficient, up to **. Among vessel motion considerations, roll motion is the most important one and often bilge keels are required to supress large roll motion.

In a hush environment, turret mooring is the only feasible option for the vessel stationkeeping. The vessel is equipped with thrusters to control vessel weathervaning heading. The turret is located either .. The turret also serves as the attachment point for risers. For a large number of mooring lines and risers, conjestion and interference may become a problem.

In contrast, vessel mooring is significantly simplified in a begnin and highly directional environment. Spread mooring is feasible with the vessel haeding fixed towards the predominant weather direction.

Vessel relative location with respect to subsea wellheads can be optimised. The target is to achieve the minimum total length of risers and flowlines. However, other factor will also affect the final vessel position. For example ...... Often factors need to be considered are contradictory to each other. The objective is therefore to achieve a balance between these factors.

VESSEL AND FLEXIBLE RISER INTERFACE

As a result of the spread mooring and the elimination of turret, the flexible risers are supported from riser porches over one or both sides of the vessel. The porches cantiler out from the vessel side for a short distance to ensure clearance between the hull and risers. Longitudinally, the porches should be located near the amid ships to reduce pitch-induced heave motion.

In a section near the point where the flexible riser is connected to the porch, the flexible riser can be subjected to large local bending moment due to both vessel offset effect and vessel motions. Local riser protection measures must be considered. Some arrangments are considered below.

- Bend Stiffner
  The bend stiffener is fiited over the flexibel riser and limits riser curvature. It has varying bending stiffness which is designed to suit a particular application. The key parameters in determine a stiffener includes riser tension, inclination angle and ....
  In comparison with other options, the stiffener has the advantages of relative small size and good protection of the flexible riser. In addition, installation of the bend stiffener is relatively simple due to the dry connection of the riser at deck level.
  The bend stiffener is made of polymer with or without reinforcement. It is important to ensure that long term aging due to heat and sunlight does not cause unacceptable deterioration of performance.

- Bell Mouth
  Riser curvature at the vessel interface can be controlled by pulling the riser through a flared guide tube or bell mouth. This arrangement has been adopted in North Sea and Gulf of Mexico on both flexible risers and umbilicals.
  The advantages
  The disadvantage

- Arch
  Another possible vessel interface arrangment is

SUBSEA COMPLETION STRATEGY

DYNAMIC RESPONSE OF FLEXIBLE RISERS

In a mild environment, simple drape catenary option is the prefered configuration option for its simplicity and cost effectiveness. The main drawback of this option is that it can only accommondate moderate vessel offset, typically up to 20% of water depth in a mild environment.
In addition, the riser touch down point moves on the seabed over a large distance.

In this option, the riser response is sensitive to the riser length. Large curvature occurs at the riser touch down point where the vessel moves towards the riser and in this case interference between the vessel hull and the riser near surface may become an issue. When the vessel moves away from the riser large tension arises in the risers which may be detrimental to the subsea template to which the risers is connected, particularly if there is not a sufficient free riser length lying on the seabed.

(wave effect) In a mild environment,

(similitude) Often there is a set of risers of different diameters

An alternative to the simple drape catenary configuration is buoyant lazy wave option. Buoyancy is fitted around the riser over a section which forms a mid-water arch. In comparison with the simple drape configuration, the lazy wave has smaller top and bact tensions which is beneficial to both the vessel/riser and seabed template/riser interfaces. Futhermore, the lazy wave option can accommodate much larger vessel offset and the riser touch down point has much smaller movement on seabed.

AN ALTERNATIVE TO FLEXIBLE RISERS

In West of Africa, the relatively benign environmental conditions makes it ideal to consider the alternative to flexible risers, ie. rigid steel risers.

Rigid steel risers have been implemented on the Auger TLP and are proposed for other fields both in harsh and mild environments. The rigid steel riser offers a number of benifits, such as for example large riser diameter in deep water, which are difficult to be realised by alternative riser systems.

The key feature of the rigid steel pipe riser, which distinguish itself from the flexible riser, is its high bending stiffness. Its application to FPSOs is often limited by the difficulties encountered at the riser/vessel interface and the touch down point, particularly in a shallow harsh water. However, in a deep benign water the problems are significantly alleviated which makes rigid riser a very atractive alternative to the conventional flexible risers.

In the table below, the key parameters of a flexible riser and a rigid steel riser are compared. Both are proposed for a field development in West of Africa.

	Nominal Diameter 8 Inch	
	Flexible	**Rigid**
OD (mm)	279.5	219.1
ID (mm)	203.2	193.7
Layers	Carcass Pressure sheath Zeta wire Rilsan 1st armour Rilsan 2nd armour High strength tape Rilsan	A homogenous steel pipe layer with coatings on both sides
Wall Thickness (mm)	38.2	12.7
Weight in Air (kg/m)	109.24	65.1
Weight in Water filled with Water (kg/m)	81.77	56.35
Min Radius (m)	1.82	50.6
Relative Elongation for 50kN	0.04%	0.0029%
Max Damage Pull (kN)	3536	3689

Table 1 Comparison of 8 Inch Riser Properties

In the table, the minimum bending radius and maximum damage pull are calculated based upon radius or tension required to yield pipe independently.

An analysis study is carried out to investigate the dynamic responses of both risers in the extreme environmental conditions. Results indicate that both risers are acceptable with a simple drape configuration. To prevent it from overstressing at the touch down point, the rigid riser configuration should be slightly taut than the flexible and as a result a small increase in the maximum riser inclination angle at the vessel interface. However, the maximum top tension is reduced significant as the rigid riser is about 30% lighter than the flexible riser in water.

Analysis is also carried out for the buoyant lazy wave option... However, less buoyancy is required in the rigid riser case.

CONCLUSIONS

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