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Deepwater dry tree semis are here

New deepwater floaters present operators with improved motions and space and construction savings.

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As the oil and gas industry moves farther offshore into ultradeep water, the need for drilling and production platforms becomes more acute. The dry tree semisubmersible is an application of proven technologies. It offers small in-place motions, large open deck areas, dockside commissioning and minimum offshore hookup.

The ability to install and commission topsides at a dockside location mitigates risks and significantly reduces the costs associated with mobilizing equipment to install the topsides and commission the system offshore. The structural components can be built at numerous shipyards worldwide, thus offering flexibility in resource capacity and delivery logistics.

The economic advantage

The economic advantage of having direct vertical access into reservoirs from deepwater floaters is well known in the offshore oil and gas industry. When a reservoir structure is suitable for direct access development, it allows the operator to drill, complete and work over the well directly from the same platform. Onboard drilling eliminates the requirement to hire a mobile offshore drilling unit (MODU) for development drilling and subsequent workover and allows more flexibility in the drilling and workover programs. This type of flexibility in the development brings revenue on stream earlier to defray capital and operating expenditures.

The difference in designs

Top-tensioned risers (TTRs) with dry trees allow direct vertical access to production wells. The main requirement for a floater to support TTRs is low heave such that the relative motion between the hull and the riser is within the limits of the tensioner while applying sufficient tension to the riser without over-stressing. The two traditional deepwater hull forms that support TTRs are the spar and the tension-leg platform (TLP). Design selection based on one of these floaters is guided by different criteria.

Considerations include the operating environment, availability of fabrication facilities and suitability to the operator's development plan. Sometimes an operator's propensity toward a certain design comes into the equation because of familiarity with the system and the infrastructure in place to manage delivery of a specific floater type.

For production depths exceeding 5,000 ft (1,525 m), present TLP designs have their own challenges with tendon design and installation. These limitations left the spar as the sole candidate for production above this depth.

The truss spar, illustrated in Figure 1, is characterized by a hard tank containing void tanks and variable ballast tanks, a truss section with a number of heave plates, and a soft tank at the keel to hold heavy fixed ballast. The purpose of the heave plates is to provide added mass and damping, which gives the spar a heave natural period well above the range of wave energy periods, thus avoiding heave resonance conditions.

The overall length of the spar hull is usually limited to accommodate transport vessel size if it is to be transported by a heavy-lift vessel. Because of its length (draft), the spar has to be wet-towed horizontally to the installation site and upended before the topsides can be installed.

The dry tree semi alternative

An innovative deepwater floater design is one that has the motions of the spar and the functionality of a semisubmersible. To this end, FloaTEC, a joint venture of Kepple Fels and J. Ray McDermott, is progressing solutions that involve semisubmersibles with heave plates. Two of these designs are illustrated in Figure 2. Both dry tree semisubmersibles have similar design philosophies and feature a semisubmersible hull and a truss section with heave plates supported beneath the hull.

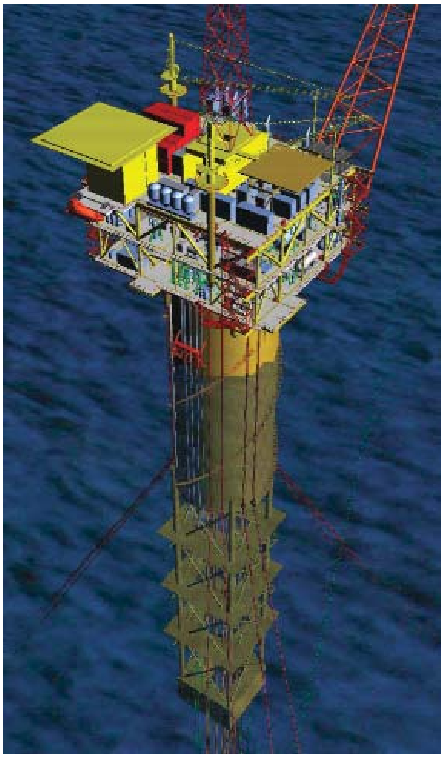

Figure 1. A truss spar has been a traditional deepwater option with heave plates to minimize platform heave at sea. (All graphics courtesy of FloaTEC LLC)

These designs follow the same hydrodynamic principles as the spar. The main difference in the two designs is the installation method.

The Truss Semi can have the truss and heave plate section installed at the deployment site or near shore in a water depth sufficient to position the truss under the hull. Obviously, this would require an installation vessel to handle the truss. The size and handling capacity of these vessels required to position the truss are relatively small compared to the

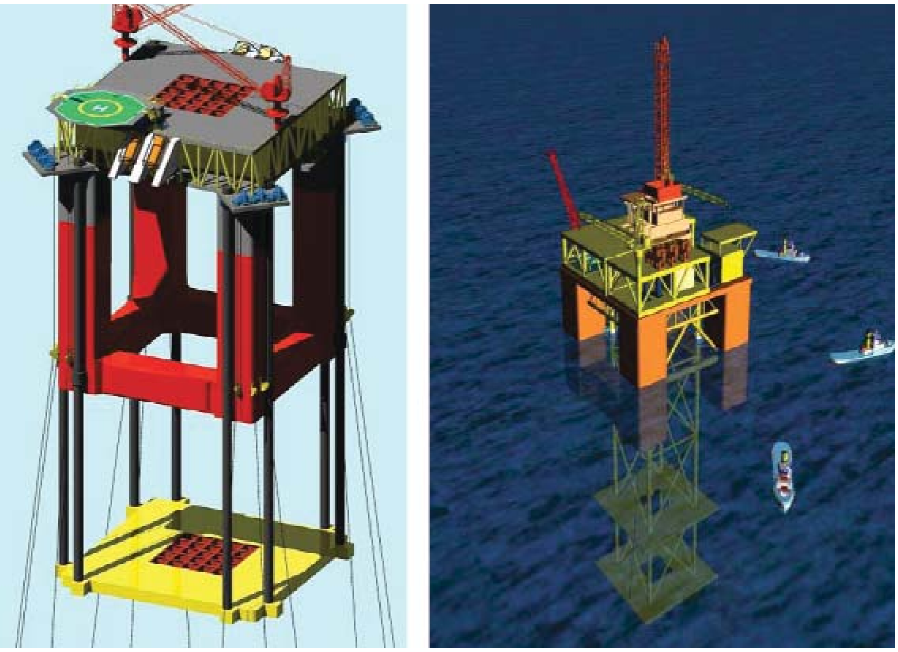

Figure 2. The ESEMI II and Truss Semi minimize heave effect on equipment.

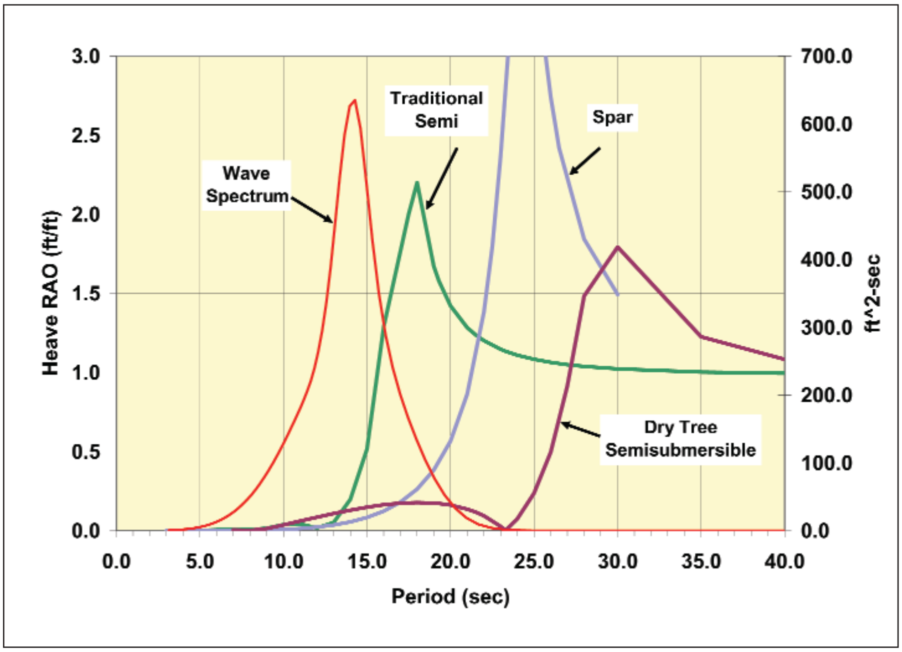

Figure 3. Heave responses vary among platform types.

vessel size needed to lift topsides modules. Therefore, they can be procured from a large fleet base. Alternatively, the truss section could be set on the sea bottom and the semisubmersible ballasted down over the truss to subsequently pull it up into the hull for connection. This operation could be carried out without the aid of a vessel to handle the truss. Analysis of related operations verifies that either method provides a low-risk mating.

The ESEMI II is a self-installing version of the dry tree semisubmersible. This design retracts the single heave plate installed dockside under its keel. The semisubmersible would be transported to the installation site with the plate retracted. Once moored on site, the plate would be lowered into position and secured. This design would be particularly suitable in situations where an installation vessel was not available.

How the dry tree semi works

The motion that has the greatest influence on whether dry trees can be used on a floater is heave. Consequently, the design objective is to minimize heave motions. Figure 3 compares the heave response of a conventional semisubmersible, a spar, and a dry tree semisubmersible. These curves, called the "response amplitude operators" (RAOs), show the unit heave response per unit wave amplitude as a function of wave period.

The semisubmersibles' response curves are characterized by a small rise at the lower periods. They fall to a near zero value called the "cancellation period," in this case at approximately 12 seconds. Above this period, the RAO increases steeply to a resonant response at a higher period. This cancellation period occurs where the hydrodynamic forces on the pontoons are practically equal to the forces on the columns, and the heave response therefore tends to zero. Since the spar does not have a pontoon, its RAO does not show a cancellation period. However, the spar's response is very small in the lower period range due mainly to its deep draft.

The conventional semi has a larger RAO than the dry tree semi and cannot be used to support dry trees. To a certain extent, the magnitude of the heave RAO and the cancellation period can be controlled by designing the hull such that the hydrodynamic force interaction among the columns, pontoons and heave plate are kept to a minimum along with the heave response. In order to illustrate this interaction, Figure 4 shows the forces on a traditional semisubmersible hull and the attached heave plate as well as the sum of the two forces.

Without the heave plate, the semisubmersible has a cancellation period of about 12 seconds. The RAO above this period is very high, and the resonance period falls within the wave energy period, which causes a large heave response. When the heave plate is attached, the cancellation period is increased to approximately 23 seconds, which is well above the range of wave energy periods.

Figure 5 shows a comparison between the responses of the spar and a dry tree semisubmersible. These responses were computed for a Gulf of Mexico storm condition.

The comparison shows that the offset of the two vessels is approximately equal. The dry tree semisubmersible, however, shows a larger heave range, though the value is within the acceptable limits. There is a significant improvement of the maximum heel angle and deck acceleration in the dry tree semisubmersible compared to the spar. Maximum riser strokes on the two are within 2 ft (.61 m) of each other. A comparison of these motions demonstrates that TTR designs presently used on spars can be ported directly to the dry tree semisubmersible.

Design advantages

The spar has a number of stacked decks because of its single-column form, whereas the semisubmersible offers a large open-deck area. These design traits translate into a number of operational advantages for the semisubmersible.

One advantage is greater flexibility in the wellbay layout. The spar hull structure is not conducive to any wellbay shape other than a square. However, the dry tree semisubmersible can easily accommodate rectangular layouts, which reduces the span of the skid beams for a rig. Reducing the span reduces the spanning structural weight and lowers the center of gravity.

Another advantage the semisubmersible offers over the spar is lower accelerations at the drilling deck. The large deck area of the dry tree semisubmersible accommodates equipment arrangements on a single level. On a spar, this equipment has to be installed on the third deck. This additional deck typically includes the drill floor and is relatively higher above the center of gravity than that of a dry tree semisubmersible. The horizontal accelerations induced by pitch at this elevation are larger on the spar than they are on the dry tree semi. This effect is evident in the deck accelerations compared in Figure 5. As a result, drilling operations can continue on the dry tree semisubmersible in conditions that would normally suspend operations on a spar. The obvious result is more drilling uptime on the semisubmersible.

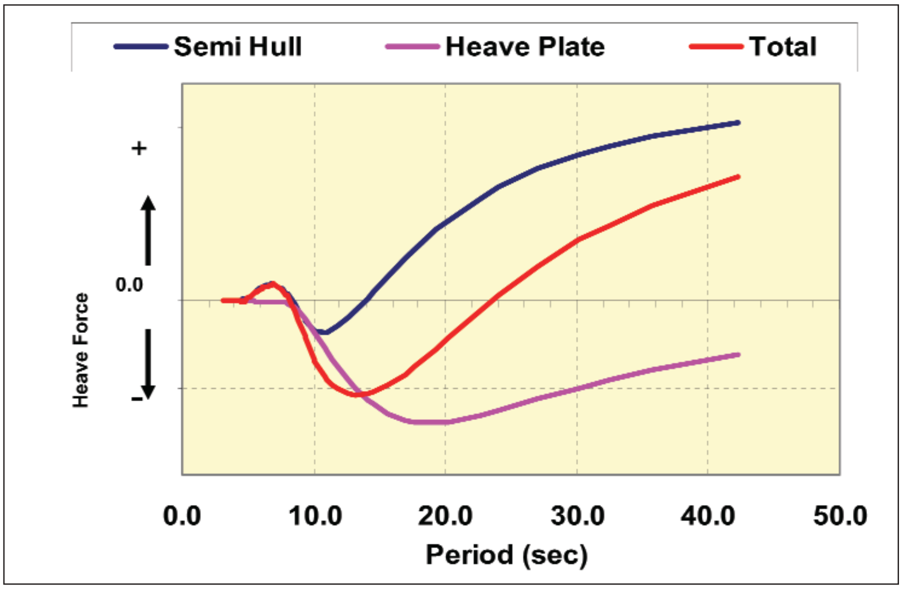

Figure 4. A heave plate significantly subdues forces at work on a platform compared with a semisubmersible without heave plates.

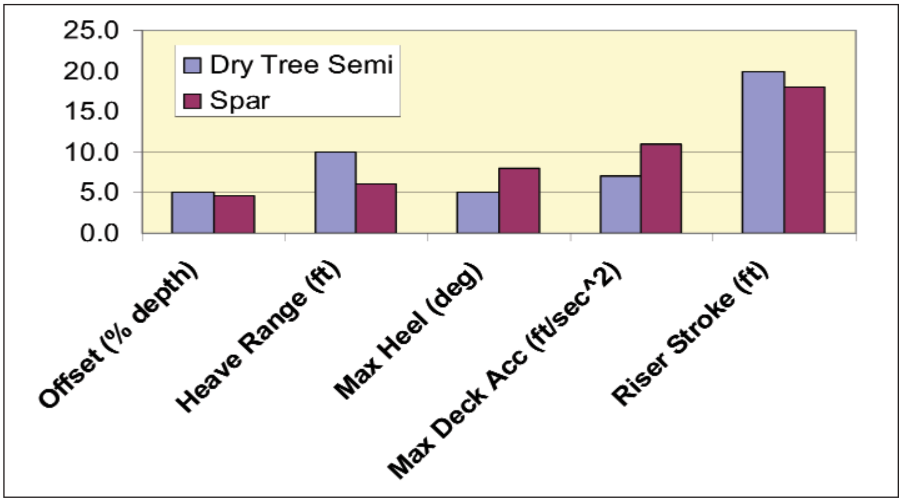

Figure 5. Deck acceleration on a tall spar platform would force it to stop working in seas that a dry tree semisubmersible could handle.

Faster delivery and commissioning

The dry tree semisubmersible offers a number of construction and delivery improvements over the spar design. Those improvements translate into cost savings. Although it is impractical to provide a detailed comparison of a delivery model for a spar and dry tree semisubmersible, a comparison of the distribution of durations for each major activity carried out in a delivery demonstrates the relative advantages. These are illustrated graphically in Figure 6. The graph compares the duration of each activity, indicated as a percentage of the total time required to deliver each system.

The schedule assumes a topsides payload of approximately 20,000 tons. The weight would require several offshore modules lifts to install the topsides on a Spar. This payload is proportionate to a system with16 top-tensioned dry tree risers, including full drilling capability, and equipment to handle a throughput of about 100,000 boe/d. For simplicity, the

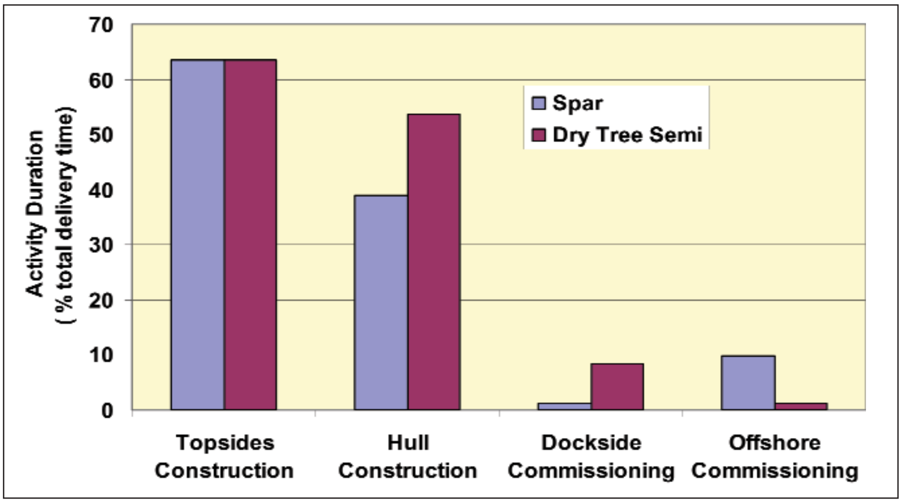

Figure 6. Semisubmersibles require fewer hours of expensive at-sea assembly and commissioning time than spars.

comparison assumes that the total delivery times are approximately equal for both systems.

The graph shows that topsides construction takes about 63% of the total time required and is on the critical path for both hull designs, as is the case for most offshore topsides deliveries. The spar hull construction takes less time than the dry tree semisubmersible and thereby offers flexibility in the construction schedule.

The most significant difference is the amount of commissioning performed dockside as compared to commissioning performed offshore. The spar commissioning takes about 1% at dockside and about 10% offshore. The opposite is true for the dry tree semisubmersible, which spends about 7% of the delivery time at dockside commissioning and about 1% offshore. The costs associated with this offshore activity can have a multiplier of 1.8 times the cost of carrying out similar work at the dockside.

This increase in cost is due to the additional equipment and manpower logistics to complete the work at the installation site.

Assuming analyst Douglas-Westwood is accurate in the prediction that by 2011 more than US $18 billion will be spent on deepwater operations, the industry definitely needs more designs like the dry tree semisubmersible. E&P