Heavy rotation

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Floating production and mooring specialist SBM Offshore is supplying three of the largest FPSO mooring turrets ever ordered and is pushing the boundaries of disconnectable turret technology in a fourth project. Adrian Cottrill gets the details in this special report.

Of all variants of floating production system installed around the world, the ship-shaped unit outnumbers all the others put together. Impressively, such vessels have continued to hold their own as industry has moved into ever more challenging seas.

Other options such as the spar, tension-leg platform or semi-submersible may be more handily symmetrical in the way they face the worst of oncoming weather. But when conditions get beyond the capabilities of a spread-moored “static” monohull production vessel, its weathervaning sister has gone on to vie with the best of the competition.

Few would disagree that the mooring turret, which allows this weathervaning, is the beating heart of any leading-edge FPSO. This is where the transition from static seabed to moving hull is concentrated as the ship revolves majestically around the turret, allowing it to offer the line of least resistance to prevailing weather conditions.

It is where potentially huge mooring forces have to be transferred, as the vessel hangs off a turret that must handle the most extreme storm predicted. It is also where flow paths to and from the seabed are kept open via a stack of sophisticated toroidal swivels. In this way high-pressure fluids can be transferred from incoming risers into the process facilities on deck, along with other services such as power and control.

Right now, SBM Offshore, the market leader in providing leading-edge turrets, is working towards delivery of three of the most testing projects of this type it has ever carried out. These are the latest in a line of about 50 turrets the company has supplied around the world over the past 30 years.

It is hard to think that industry requirements will get much more challenging than the trio of huge permanent turrets being built for the Prelude and Ichthys floating platforms in cyclone territory off Australia, and for the Quad 204 unit on the UK’s Atlantic Frontier.

Even the Ichthys turret for client Inpex — the smallest and arguably the least demanding of this trio to design and build — weighs 9500 tonnes, stands 85 metres high and has a contract value of half a billion dollars. The other two sit even further on the frontiers of technology, but each in a different way.

The dominant aspect in the turret for BP’s Quad 204 project is the size and intricacy of the manifold and swivel stack being mounted on vessel Glen Lyon because of the high number of risers it will support.

“Quad is the most complex manifold we’ve done,” says SBM’s Andrew Newport. As technology director at the company’s base in Monaco, he heads up SBM’s development activities for turrets and moorings.

For Prelude — Shell’s pioneering floating liquefied natural gas (FLNG) mega-project — the lower turret is the main deal. This is hardly surprising given the scale of mooring load it has to handle. With its tanks full, the Prelude vessel will have a displacement of 600,000 tonnes, often quoted as the equivalent of half a dozen aircraft carriers. This and its 488-metre hull length make it the world’s largest floating unit.

While day-to-day sea conditions in the areas north of Australia, where Prelude and Ichthys will be moored, are far less lively than the West of Shetland Quad 204 area, the extreme conditions these two turrets are being designed to handle are definitely substantial.

The platforms are sited in Australia's "cyclone alley" and the design event they have to withstand is the strongest storm predicted possible in a 10,000 year period (see page 26). The top-of-the-scale category 5 cyclone in this part of the world is termed "extremely dangerous, with widespread destruction and winds gusting above 280 kilometres per hour".

For the mighty Prelude hull, the 10,000-year criteria results in an unprecedented mooring load of 10,000-tonnes of horizontal force, radiating out along four groups of four catenary mooring lines anchored to seabed suction piles. And, despite its smaller hull size, the Ichthys turret is also designed to handle 10,000 tonnes because of a more conservative assessment method for calculating the loads.

"Such a mooring load is about twice the level of anything we've ever designed for before," says Newport. Before this, "the highest we had dealt with is the 5000 tonnes of BP's Skarv unit in the Norwegian North Sea, which started up in January 2013".

That in itself is more than twice the 2250 tonnes currently being catered for in the Quad 204 project. The reason for Skarv's high figure is that BP wanted its turret pushed somewhat aft from the normally preferred position close to the bow because of overall deck layout considerations. This means the hull does not weathervane so easily, and thrusters are used to assist it.

"The Skarv system has to cater for loss of power to the thrusters at the same time as the vessel is badly orientated to the weather," Newport explains, "and it could therefore experience an unusually high load in that accidental case".

Just how much and how fast a vessel may weathervane varies greatly. "Some may sit in more or less the same position for months with very little movement," he says. On the other hand, he recalls being on a vessel off China "where it swung through 180 degrees in the course of an evening". Except in the rare case of a thruster-assisted unit, an FPSO rotates passively around its turret, simply reacting to changes in direction of weather.

Slewing system

Whether the challenge is to handle increasing mooring loads, or to provide a large diameter to give space for a high riser count, SBM has for more than 15 years adopted a proprietary bogie system as the basis for slewing its large internal turret designs.

In earlier days, when turrets were smaller, SBM used a system of three-race roller bearings running inside a single forged ring. This was the approach taken on projects such as Anasuria, Laminaria and Alba, says Newport. But such forged rings are only available to about eight metres in diameter.

To move beyond that limitation, SBM changed to a system of bogie wheels running on rails. "And because these bogies are standard units, if we need a larger diameter, or there is a higher load, we just add more bogies," he says. "So we can scale the system up and down."

This move had its origins in the bogie technology for cranes evolved by SBM's then-member company Gusto Engineering. "We extended that technology further and it has been the basis of our large turrets ever since," says Newport. "The first time we used bogies was for the Schiehallion FPSO (now being replaced by the Quad 204 unit), and this operated for 15 years without incident."

As well as one set of bogies to take vertical load, there is also a set of horizontal wheels to take radial load. All these are mounted at the top of the turret — more or less at deck level — so they are always in the dry, allowing easy inspection.

"And we design them so that we always have one more bogie than needed," points out Newport. "So if there were an issue, we have the option to change out an individual bogie, although this is not something we anticipate will be needed. With a bearing, you cannot change anything out."

So this is the weathervaning system adopted for the big three new turrets, as it has been for other large SBM turrets in the past — Skarv in the North Sea, Brazil's Espirito Santo, which combined steel lazy wave risers with an FPSO for the first time, and Petrobras' P-53, with its impressive count of 75 flexpipe risers.

"This type of bogie system and radial wheels is very robust and now a standard item," says Newport. Consequently, he describes the three new turrets as "more a continuing evolution than a step change for us".

One provision being used in Prelude and Ichthys is relatively new, however. This is an additional set of pads, called stoppers, down at keel level. "This avoids having to add a lot of bogies for the extreme event. In normal operation the stoppers will never be used." Only Skarv has featured them before.

The big turrets supplied by SBM generally break down into four or five major pieces, depending on the lifting capacity available at the sub-contractor building it or at the shipyard it is delivered to. First is the insert cylinder and support structure that is welded into the vessel, and where the turret is later lowered to sit on its set of bogies. This insert structure is there to isolate the bogie system from the hull's deformations as the ship gently hogs and sags and the moonpool area ovalises. The turret cylinder itself can often be split into two halves — an upper and lower section.

Above this is the manifold and stack of toroidal swivels, and finally the deck gantry. A major function of the manifold is to commingle fluids so that the number of fluid paths in the swivel stack can be kept as low as possible.

Quad 204 and Ichthys have the largest swivel stacks ever built by SBM. The Quad 204 stack has 14 swivels, stands 26 metres high, and weighs 265 tonnes. Ichthys carries 16 swivels and is 29 metres high.

In 1998, at the time of its start-up, it was Schiehallion — now being replaced by Glen Lyon — that held pole position in this area. SBM development studies manager Philippe Lavagna compared the two in a 2013 presentation at the Offshore Europe conference in Aberdeen. When installed, Schiehallion boasted the most complex manifold and swivel stack ever conceived by his company. But its turret, he pointed out, was only two-thirds the diameter of the new Quad 204 unit, and the stack just half as high.

The yards sub-contracted by SBM to fabricate the Prelude, Quad and Ichthys turrets are respectively Drydocks World of Dubai, and two in Singapore — Dyna-Mac and Keppel.

Looking ahead

Newport reckons the industry is not facing any particularly big technical hurdles for turrets that will prevent it going where it needs to in the foreseeable future.

For example the design for Prelude is generic, suitable for a range of applications around Australia and, he thinks, "essentially this generic design is as extreme as it will get for this type of FLNG system. Industry is unlikely to need to go to higher loads than this."

Design life is a further issue. Prelude calls for 50 years and will remain on station for half that time before dry-docking for inspection and overhaul. Ichthys has a 40-year design life. For projects like these a large emphasis has to be put on the integrity and reliability of components, the ability to intervene and inspect, and high allowances made for corrosion.

In the area of disconnectable turrets (see page 28), SBM is also currently engaged in delivering the Turritella vessel for Shell's early production project at the Stones field in the Gulf of Mexico. Floating in 2900 metres of water, it will be the world's deepest production development so far.

As well as the need to refine disconnection systems, the Lower Tertiary play in that part of the world brings with it the challenge of high reservoir pressures, and SBM has been keeping its eye on that ball.

“We now have a very high pressure swivel qualified at 830 bars, and we’ll re-qualify that later this year at higher pressures,” says Newport. “So we’re doing substantial development work on swivels to stay ahead of requirements. We don’t see any obstacles we can’t overcome.”

In general, he continues: “We spend about 1% of our revenue on R&D” — equivalent to about $35 million — “and have a number of developments going on in-house to improve systems. They are focussed either at higher integrity, or increased safety, or cost reduction.” However, he notes ruefully: “All this is going on in a situation where trends like deeper water, harsher environments and longer life requirements all naturally tend to push costs up.”