Production of Heavy Crude in Deep Waters

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Abstract

Early production of heavy crude in deep waters of Brazil has since October 2002 been carried out at the Jubarte field in the state of Espirito Santo with the “Seilean”, a Dynamically Positioned (DP) Floating Production Storage and Offloading (FPSO) vessel on contract to Petrobras.

Three years of deep water production has clearly demonstrated that it is feasible and economically viable to explore new opportunities of heavy crude production as the technological advances are continuously progressing to find solutions to arising challenges.

The objectives with an early production system could be to reduce the time from a made discovery until first production, or it could be to determine well stream evidence and reservoir characteristics to handle challenging crude properties of low API grade and high viscosities to declare a field commercial and to plan for a life of field production system, optimized and designed from obtained results from the early production phase. During the phase of early production, attractive cash flow can be generated to contribute to field development funding.

The paper will identify challenges with production of heavy crude in deep waters which is proven in Brazil with an unparalleled concept applicable to other deep water areas world wide.
Introduction

The discoveries of heavy crude in deep waters in recent years are demanding solutions to handle low API grade crude, high viscosities and contents as sulfur and acids. Uncertainties of well stream evidence and reservoir characteristics makes it difficult to design and optimize a life of field production system without first deploying a test and early production phase to obtain the required data. Experience from Brazil has since 2002 proven that heavy crude can be produced in deep waters and new ventures are under way to make it viable to efficiently produce difficult crude properties in deep waters.

Uncertainties related to the production process of heavy crude

- Reservoir performance
- Flow assurance
- Processing
  - Oil-water and gas-oil separation performance
  - Oil storage
  - Offloading operations

Could this field be considered commercial?

Appraisal

Need for more data

Flow conditions
The Seillean DP FPSO – Concept

The Seillean is a DP class 2 redundant FPSO equipped for test and early production operations in up to 2,000 meters water depth. The FPSO is highly self contained with a full size derrick to handle the rigid production riser and subsea equipment, resulting in very fast mobilization and demobilization times, experienced to less than three days mobilization time in 1,325 meter water depth from arriving on the well location at Jubarte field until the production riser has been connected to the well and production has started.

Offloading of produced crude is carried out to a shuttle tanker with a flexible floating hose connected between the two vessels.

Seillean DP FPSO – Particulars

- Length Over All: 249.7 meter
- Breadth: 37.0 meter
- Crude Production Capacity: 22,500 bpd at API 17 with higher capacity for lighter crude
- Crude Storage Capacity: 300,000 bbls
- DP System: Class 2
- Main Power: Total 22 MW, diesel generator sets and dual fuel gas/diesel turbines
- Thrusters: Total 21 MW
Production Riser System – General

- Riser handling system on rig floor and in the derrick
- Rigid riser, size 6 5/8” drill pipe, 5” bore
- Multi functional control system
- Lower Riser Assembly with an Emergency Disconnect Package (EDP)
- Riser carriage and swivel suspended by a tensioning system
- Electrical Submerged Pump (ESP)
Offloading System – General

- DP class 1 shuttle tanker required in Brazilian waters for export of crude for operations in environments with significant wave heights up to 5.5 meters.
- Mooring hawser connected between the DP FPSO and the DP Shuttle tanker
- Flexible floating hose system to offload crude to a shuttle tanker
Jubarte Field – Operated by Petrobras

Fast track from discovery to production of heavy crude in deep waters

- Field discovery 2001
- Drilling and test of horizontal well 2002
- Water depth 1.325m
- Crude properties API 17
- Extended Well Test (Seillean) 2002
- Petrobras declared Jubarte field commercial 2002
- Early Production (Seillean) 2002 - 2005

Pre-studies to prepare DP FPSO Seillean for production of heavy crude at Jubarte

- Extra heating capacity – Process plant
- Cooling related issues – Process plant
- Crude temperature, heat loss – Production riser
- Crude storage temperature, heat loss – Cargo storage
- Electrical Submerged Pump (ESP) Variable speed drive – Production riser
- Crude properties concerns, foaming, viscosity – Process plant
- Electrical umbilical with 1” pipe for liquids – Production riser
- Production stoppages, flushing of riser with diesel oil – Production riser
- Emergency Disconnect Package (EDP) and Christmas Tree – Production riser
Upgrade onboard DP FPSO Seillean before start production at Jubarte

- Extra heating capacity, steam supply to crude oil heater – Additional crude oil heater
- Power requirement for ESP – Variable speed drive
- Crude oil metering system – New equipment
- Foam detection system – New equipment

Challenges onboard DP FPSO Seillean during production at Jubarte

- Cooling related issues – Process plant
- Foaming – Process plant
- Water content in crude – Process plant
- High crude temperature in separators – Process plant
- Heater design parameters – Process plant
- Crude storage temperature – Cargo tanks
- Corrosion – Process plant
- Similar density of crude and water – Process plant

Lessons learned

- Efficiency of crude oil coolers deteriorating over time due to scaling, high temperatures above 70 DgC building up solid sediments in coolers
- Chemicals more efficient than cyclones to prevent foaming
- Compared to lighter crude, higher cost for use of chemicals and inhibitors, more man hours required to operate and maintain the process plant
- Water related subjects, corrosion in pipes and heaters
- Design and optimize process system for anticipated higher water content over time of producing the same well
- High process temperature required for separation, additional crude oil cooling capacity built in to system for more efficient operation and redundancy
- Requirement to insulate piping and equipment due to high temperatures
- ESP effective to boost production
- More time required for separation due to similar density of crude and water
- Maintain storage temperature in cargo tanks above minimum requirement not as critical as anticipated, procedure in place for loading crude (storage tank heating coils not available) to maintain crude temperature above 35DegC for approx. 10 days until crude offloaded to shuttle tanker
- Tank cleaning and maintenance of equipment more difficult and time consuming than for lighter crude qualities
- Pumps running on higher loads during offloading to shuttle tanker to maintain minimum crude transfer temperature
Next production phase for Jubarte

Petrobras intend to employ FPSO P34 to produce from 4 wells, 60,000 bpd

Conclusions

The Seillean DP FPSO concept for test and early production in deep and ultra deep waters is based on a proven concept from Frontier Drilling do Brasil’s operations in Brazil in deep waters since 1998, and can be deployed to accelerate field development and first production in made deep water discoveries.

The concepts has a proven experience of 6 years of operations in Brazil with an average uptime of 98% whilst in production mode, with more than 170 offshore offloading operations without any incidents to the environment. An Electrical Submerged Pump (ESP) has been installed in the production riser system to boost production of heavy crude oil in deep waters, a proven technology contributing to make it feasible to produce heavy crude oil discoveries in Brazil and world wide.