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Bonga—Flow Assurance Benchmarking via Field Surveillance

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Abstract

Bonga - the first Deepwater development in Nigeria - commenced production in Q4 2005. At an early stage of the project, flow assurance was identified as a key factor for successful development, noting: (i) complexities of the subsea network, including local downhill flow, (ii) logistical challenges of a new Deepwater basin, and (iii) reservoir fluids' propensity for solids formation, including additional risks posed by full-field waterflood.

This paper discusses the key elements of the Bonga flow assurance strategy and its implementation in design and operations, with particular focus on the flow assurance performance of the subsea system during initial start-up. Comparisons of field data with analysis predictions include: (i) steady-state thermal-hydraulic performance, (ii) system thermal response during cold start-up, (iii) cooldown performance of subsea hardware and flowlines, (iv) system blowdown effectiveness, including the effect of riser gas-lift and (v) terrain slugging severity and gas-lift requirements.

Introduction

Bonga is operated by the Shell Nigeria Exploration and Production Company (SNEPCo) on behalf of the Nigerian National Petroleum Corporation (NNPC) under a production sharing contract, in partnership with Esso Exploration and Production Company Nigeria, Nigeria Agip Exploration, and Elf Petroleum Nigeria.

Bonga is comprised of subsea wells in approximately 1000 m water depth tied back 2-10 km - via five production manifolds and a dual flowline network - to a spread-moored FPSO. Gas from Bonga is exported to the Nigeria Liquefied Natural Gas (NLNG) plant at Bonny, and oil is transported via tanker offloading. As a vital part of the field development plan, full-field waterflood was initiated in conjunction with initial production. See Figure 1 for a schematic of the Bonga subsea layout.

Flow Assurance Strategies

Solids characterization of the Bonga reservoir fluids and related flow assurance mitigation strategies addressed in the project design are summarized below.

Reservoir fluids

Bonga is comprised of several reservoirs, which exhibit the following variability in fluid properties over the anticipated field life:

- Reservoir temperature: 128-208 ºF
- Oil gravity: 29-33 ºAPI
- Gas-Oil ratio: 550-1200 scf/stb
- Watercut: 0% (initial-life) - 80% (late-life, reflecting waterflood)

Asphaltenes/Wax/Scale

Analysis of the reservoir fluids' production chemistry was based on several downhole oil samples acquired from early appraisal wells. Laboratory evaluation of Shell-standard asphaltene screens indicated stability of individual reservoir crudes with respect to asphaltene precipitation (i.e. no production difficulties expected). Later analysis confirmed asphaltene stability of various crude blends at anticipated subsea and topsides conditions, as well as stability in presence of riser-base gas-lift.

The fluid wax assessment consisted of cloud and pour point measurements, HTGC (high-temperature gas chromatography), kinetic wax deposition rate measurements, and coupled modeling of oil thermodynamics and flowline thermal-hydraulics. Analysis indicated critical wax deposition temperatures (CWDT) in the range 98-115 ºF. Due to relatively low (kinetic) wax deposition rates and use of pipe-in-pipe flowline insulation (required for hydrate management; see below), annual maintenance pigging (or hot-oiling) was found to be sufficient for wax management.

Analysis of available water samples indicated minimal risk of barium-sulfate scale formation at all anticipated operating conditions. The potential for calcium-carbonate scale formation is predicted to be limited to early-life low watercut conditions, and only at high-temperature, low-pressure conditions (i.e. not typical for subsea operations). Owing to the limited availability of water samples, capability for scale