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Gulf of Mexico Field of the Future: Subsea Flow Assurance

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Abstract

Subsea operations represent a critical component in the production value chain of most Gulf of Mexico Deepwater assets. These operations provide many unique challenges, including flow assurance of the production streams. Complexity in production fluid chemistry, avoidance and management of problematic production conditions (slugging, gas lift control, hydrates, wax, asphaltenes, etc), and management of the overall subsea facilities for optimum production are all parts of the subsea flow assurance area.

The main objective of this paper is to describe the work that was performed during a pilot test of a real time based flow assurance tool built for operations support. The tool consisted of a real time information system kernel coupled with an offline model for "what-if" scenarios and automatic look-ahead functions. The simulator supports operations through intelligent alerts to operators and technical subsea experts. The tool entitled, "Advanced Warning System (AWS)," was built and tested on-line for several weeks at one of Na Kika's oil loops.

Introduction

Subsea operations represent a critical component in the production value chain of most Gulf of Mexico Deepwater assets. Flow assurance of the production streams constitutes one of the many unique challenges these assets face. Avoidance and management of problematic production conditions such as slugging, gas lift control and hydrates are flow assurance issues that deserve special attention.

With this motivation, a BP Gulf of Mexico Deepwater project team initiated a pilot project to implement an online tool coupled with alarm systems and independent analytical tools to run non-specific scenarios. The Na Kika North Oil Loop was chosen for this implementation due to its unique configuration, complexity and level of instrumentation.

Field Description

The Na kika base development consists of five oil and gas fields in the Mississippi Canyon area of the Gulf of Mexico tied-back to a central floating oil and gas processing facility. The water depths for each of the fields range from 5,800 ft to 7,000 ft and are offset between 6 to 13 miles from the facility.

The individual fields are named Ariel, Kepler, Fourier, Herschel, and east Anstey. Additionally, the fields are developed utilizing three unique gathering flow loops with their produced fluids routed back to the floating production facility.

The Ariel and Kepler oil fields were developed with a 10" x 16" pipe-in-pipe (PIP), 25-mile flowloop to the northwest of the production facility. These fields include five subsea oil wells (i.e. Ariel: A1, A2 and A3 and Kepler: K1 and K2); each one of them daisy-chained within the northern loop route. The north loop is unique as the flowline route is generally downhill towards the host. The water depths along the route range from approximately 5,800 ft (shallowest) at the well locations to 6,340 ft at the host. This oil loop was selected for the pilot.

Flow Assurance Concerns in Na Kika's North Oil Loop

In 2004, during the initial startup of the Na Kika North Oil Loop, some operational difficulties resulting from flow assurance issues caused several subsea system shut-ins.

These issues are in the broad sense common to most deepwater developments in the Gulf of Mexico[1]. Hydrate formation during shut-in periods, severe slugging during production and upset conditions induced by pigging or during re-start operations are all issues that required special attention. Following is a description of some of the most important concerns addressed in the AWS:

Cooldown Times. Seawater temperature at the water depth where the subsea production system is located can be as low a 39ºF. This puts wellheads, jumpers and large portions of the flow lines at high risk of hydrate formation during shut-in conditions. In the North Oil Loop injection of hydrate inhibitor and displacement of production fluids with dead oil are the main mitigation strategies considered to prevent hydrates during a shut-in condition.

If a planned or unplanned shutdown of the system is performed, there will always be a certain amount of time that it will take for the fluids to cool down and enter the hydrate formation region. Cooldown times will depend not only on thermal properties of the materials and fluids; which can be assumed constant for practical purposes, but also on the flow