Advanced Pipeline Monitoring for Flow Assurance with Fiber Optics

John D. Hedengren, Brigham Young University, john.hedengren@byu.edu

and

David Brower, Astro Technology, Inc., dbrower@astrotechnology.com

Bass Lite deepwater field in the Gulf of Mexico, at water depths of approximately 6,750 feet, commenced operation in February 2008. Natural gas is produced from Bass Lite via a 56-mile subsea tieback to the Devils Tower Spar. This project involved several innovations, one of which was the incorporation of a sensing system that measures real-time temperature, pressure and strain along the pipeline length. This is a first of its kind innovation that is in actual operation.

This report details the installation of the advanced instrumentation and resulting operational data from startup. To obtain the data, fiber optic sensors were used in this application for the long-distance signal transmission capability. In addition, fiber optic sensors are attractive in deepwater because of their multiplexing capability, immunity to electromagnetic interference, and ruggedness. Topside software provides analysis of the optical signals and displays data at platform locations and on-shore sites in real-time. As part of this project, a new web-based signal protocol was developed to increase the reliability of transmission over an intermittent connection with high latency. As the data is streamed to an on-shore server location, remote viewing capability has allowed operators, technicians, and management to retrieve current and historical data. In addition to viewing streaming data, analysis is performed to detect pig location, hydrate build-up, plug locations, and sensor validation. The Advanced Process Monitoring (APMonitor) software has enabled effective trouble-shooting and boundary value management.

The Upstream industry presents many opportunities for utilizing measurement technology to monitor the long term reliability of production systems. In particular, deep-sea pipeline monitoring poses a challenge due to the remote environment, intermittent weather incidents, and gradual fatigue factors. There is a desire for improved monitoring of existing and new projects to give insight into the conditions that lead to failure. Analytical models utilize the data to monitor the operational integrity for flow assurance and riser integrity. By using an optimization framework, a mathematical model simulates the corresponding measured values to present detailed information about the production system dynamics. This optimization framework uses a receding horizon of process measurements to capture the changing process conditions. The Advanced Process Monitoring (APM) approach has been utilized in the Downstream and Chemicals industry for a number of years and finds new application in monitoring of Upstream production systems. APM attempts to optimally estimate the true state of the dynamic system, given a real-time stream of measurements and a model of the physical process.

This monitoring is accomplished with a variety of measurement devices that give axial, hoop, and reference pipeline strains at multiple sensor locations. When viewed individually, they offer some insight into the dynamics of the production platform. When integrated together with an analytical model, the combined set provides a holistic view for flow assurance. Pressure, temperature, and flex strains are updated at 10 Hz frequency. This is important to accomplish objectives related to flow assurance, hydrate buildup monitoring, plug detection, and well-head valve monitoring.

As an extension to this project, Advanced Process Control (APC) is currently under investigation for platform gas processing, pipeline pressure, and pipeline temperature control. Preliminary results from this feasibility study are presented as a simulation of actual operational improvements. In particular, with a 56 mile sub-sea tieback line, there is significant flow, pressure, and heat transfer dead-time. Using a model-based approach, the delay is explicitly considered, leading to tighter control during start-up, shut-downs, and throughput changes.

As deepwater fields in the Gulf of Mexico, West Africa, offshore Brazil, and elsewhere are developed it becomes increasingly important to detect crucial engineering properties of subsea equipment and environmentally induced conditions. Such technology as described in this paper provides actual operational information and data for improved design. Advanced detection and mitigation of structural failure can greatly reduce the risk of unplanned hydrocarbon release.