Clamp-on to African production surveillance

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First published by Oil Review Africa, October 2015

In a perfect world, production and reservoir engineers would have unlimited access to accurate production data on every field with flow measurement details down to each individual well, no matter how remote or limited the infrastructure. This wealth of data would keep production reporting on track, facilitate a fuller understanding of the behaviour of each well over time, improve inputs to reservoir models, and ultimately enable better decisions to improve overall field production.

The unfortunate reality is that the world most of us operate in is not as straightforward. Time constraints, testing budgets, loss of production, logistical obstacles, security issues, and ongoing operational considerations are just a few of the influences that force us to make production testing compromises, ultimately resulting in our acceptance of what is essentially an inadequate volume of production surveillance data.

One route to vastly improving this utilises a flow meter that has been designed with operational simplicity, minimal disruption, and yet accuracy in mind. Expro's non-intrusive clamp-on PassiveSONAR and ActiveSONAR flow meters are installed by a single technician on existing pipework with no process shutdown, and allow data to be logged and processed, providing the end user with multiphase flow reporting in a range of applications.

Tracking vortical structures

Sonar array processing is used in this type of flow measurement to determine the rate at which naturally occurring flow turbulence, known as coherent vortical structures, move past an array of sensors. These coherent vortical structures are created by the flow in a pipe, due to the pipe wall shearing mechanism naturally present in practically all flow streams. These vortical structures maintain their characteristic shape, hence the term coherent, for a distance of approximately 20 - 40 times the diameter of the pipe. This fundamental coherence allows the structures to be tracked as they pass through the sensor array, the speed of which is a direct indication of volumetric flow rate (Figure 1).

Tracking of the flow-generated vortical structures through the sensor array is accomplished by looking at the relationship between the spatial wavelength (distance) and temporal frequency (time) of sensor signals. Sonar processing looks at the spatial wavelength/temporal frequency over a range of values, which are typically determined based on the flow velocity and pipe size.

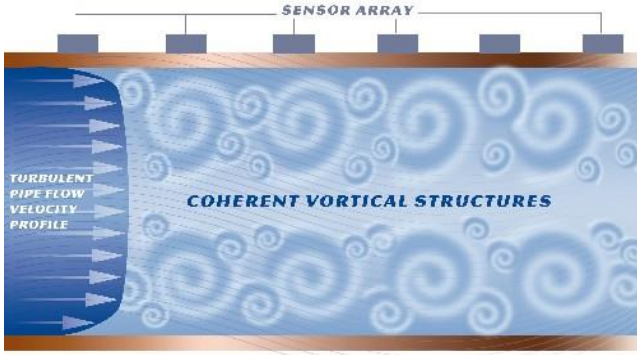

Figure 1 Vortical structures pass through sensor array.

Two different methods of sonar flow measurement have been developed, PassiveSONAR and ActiveSONAR flow meters. The PassiveSONAR meter utilises a passive array of strain-based sensors clamped-on to the outside of the pipe. These sensors listen to the strain generated by the naturally occurring flow turbulence. These signals are amplified and processed using sonar algorithms to determine the flow rate of the medium in the pipe.

The ActiveSONAR meter utilises an active array of sensors clamped-on to the outside of the pipe, which transmit a signal through the pipe and flow medium to receiving sensors at the opposite side of the pipe. The received signals are amplified and signal processed using sonar algorithms to determine the flow rate of the medium in the pipe.

Multiphase flow surveillance

Sonar meters measure the velocity of the mixture flowing through the pipe. For reservoir surveillance at the wellhead, the typical requirement is to provide rates of individual phases – produced gas, oil/condensate and water. To provide these multiphase measurements, Expro has developed the Total Production Surveillance (TPS) system for multiphase reporting of black oil (naturally flowing, Electric Submersible Pump (ESP) and gas lifted) and gas condensate production wells. The TPS system leverages a combination of PVT models and multiphase flow correlations.

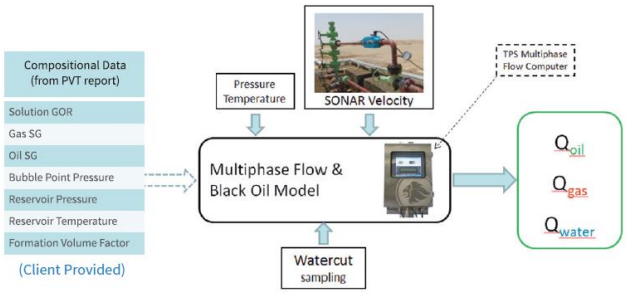

Figure 2 TPS platform using SONAR multiphase surveillance.

The TPS (TPS1000) System utilises PassiveSONAR™ and ActiveSONAR™ flow meters (depending on the application) to clamp-on to wellhead piping to measure mixture volumetric flow rate at actual conditions. The measurement is then combined with process pressure, temperature, and user supplied compositional information to determine individual phase flow rates (Figure 2). This process is broadly applicable to a wide range of production and injection flows. The TPS1000 system can be applied on gas condensate, black oil production wells, gas lifted black oil wells and black oil wells fitted with ESPs.

The TPS1000 system complements a programme of conventional well testing by offering a quick, reliable, and cost-effective solution for applications requiring recurring production surveillance, especially where the reservoir conditions remain fairly stable over time.

Flexibility and simplicity in operation

Across various areas of the globe, operators have already started utilising the benefits of sonar technology, from zero flaring and reservoir monitoring on oilfields in the Middle East[(1)] to optimising production in liquid loading prone offshore gas wells in Europe[(2)]. In Africa, there is also an increasing demand and usage of this type of technology, with early adopters already operational with sonar in Cameroon for ESP production testing, Nigeria for production optimisation in gas lifted oil wells and Equatorial Guinea for gas condensate production surveillance.

What makes clamp-on sonar distinctly appropriate for the African region is its flexibility and operationally simplistic approach. Expro can deploy clamp-on sonar technology through one of two delivery methods; SONAR*Monitor*™ and SONAR*Test*™.

SONAR*Monitor* gives operators the ability to purchase a flow meter system for permanent installation; the meter is installed, commissioned and tied into the existing facility data acquisition system. This delivery method is suitable for critical applications that require 24/7 flow surveillance for reservoir management. It is also used by operators to non-intrusively replace meters that are faulty or out of operating range, consequently saving the operator costly shut downs.

The SONAR*Test* method deploys the company's sonar meter and technician on a rental basis for periodic surveillance campaigns or one-off production/injection well tests. It allows operators to acquire reservoir data periodically for large volumes of wells without the need for capital expenditure. The acquired production data is presented to the client in the form of a SONAR*Test* report.

Thus far, SONAR*Test* has been the most appropriate method of operating in Africa, mainly due to the simple approach. Considering a complete clamp-on sonar system (equipment, cabling, even personnel) is compact enough to fit in an SUV or helicopter, accessibility to remote well locations on land, offshore, or even in the swamp becomes a lot simpler. Power supply from the site, SUV vehicle, or a portable power unit can be selected as appropriate to the location. Not only does this simplify logistics, but it also keeps the operations on a low profile when moving to location and while operating, which is important when considering relations with local stakeholders and remaining discreet for security purposes.

Production optimisation and reservoir management in Nigeria and West Africa

An operator in Nigeria was one of Africa's early adopters of sonar and did so by launching a campaign in their field aimed at production surveillance and gas injection optimisation. The field operator compared SONAR*Test* results against those from a conventional test separator. Sonar technology was considered to be a viable alternative based on different criteria including increased testing frequency, reduction in lost production opportunities as well as cost and ease of portability (small footprint). The pilot test was considered a success, with the meters successfully acquiring reliable data on the production lines (black oil multiphase flow) as well as the gas injection lines. Going forward, Expro's sonar technology is expected to play a significant role in reservoir management and production optimisation for this field.

Recently, another operator launched a testing campaign in a gas condensate field in Equatorial Guinea. Sonar technology was used for flow surveillance on the wellhead flow lines as well as the separator gas outlet. The testing campaign is ongoing, but early results have proven to be very encouraging, particularly with regard to comparison with the test separator data. The primary advantage of the sonar testing campaign (especially on the wellhead flow lines) is the reduction in lost production which occurs while swinging each well individually through the test separator.

In summary

In a challenging oil and gas market, it is more important than ever to optimise production and minimise capital and operational expenditure. Throughout the world, and increasingly in West Africa, field operators are using clamp-on sonar technology to obtain production and injection flow data in a cost effective way with minimal HSE impact. This data is used as an important part of their production optimisation strategy.

References

1. Morra, G., ‘Zero Flaring and Reservoir Monitoring in South Iraq Oilfield’, SPE workshop ‘Iraq Field Development Experiences’, Basra, Iraq (April 2014).
2. Shields, C. A. and Dollard, M., Marathon Oil UK LLC; Sridhar, S., Dragnea, G. and Illingsworth, M., Expro Meters, ‘Use of Sonar Metering to Optimize Production in Liquid Loading Prone Gas Wells’, SPE 166652-MS, Offshore Europe, Aberdeen, UK (September 2013).