CASE STUDY

Water Alternating Gas Injection System Requires Compact Flow Measurement Solution

Authors: Nick Voss, Product Manager, McCrometer, Inc.

A major oil/gas producer in the Southeastern US needed to implement enhanced oil recovery (EOR) technology to boost production in a mature oil field. For the past 25 years the company had been using water-flooding, but this technology was no longer providing the desired output. The field's first well had been drilled in 1942.

The Problem

The oil/gas company's process engineers decided to implement a Water Alternating Gas (WAG) system to boost production by adding carbon dioxide (CO2) gas. WAG injection systems help recover the oil in mature reservoirs, which have been in production for many years.

Using WAG technology, significantly more oil is recovered by alternately injecting carbon dioxide (CO2) gas with water. The CO2 gas helps mobilize the remaining oil, while injecting water displaces the remaining oil and gas.

In this particular WAG system, the process engineers required a flow meter to be installed as a master meter at the source tanks for CO2 and water (Fig. 1).

A stainless steel piping split run was installed from the CO2 gas and water sources to support 16 well heads (Fig 2).

Figure 1: The V-Cone® Flow Meter as a master meter

Figure 2: Installed V-Cone Flowmeters

A single master flow meter was required to measure both the CO2 gas and water flow as they went out to the 16 well heads.

The oil/gas process engineers initially considered using a differential pressure (dP) technology orifice plate flow meter, but there was a problem. The installation area for the meter was already crowded with equipment, and the orifice plate flow meter required a long pipe straight-run to ensure accurate measurement. There simply wasn't enough room to accommodate the orifice plate flow meter.

The Solution

The oil/gas process engineers contacted McCrometer to discuss potential solutions. The flow specialist at McCrometer recommended installing a V-Cone® Flow Meter with its built-in flow condition technology, which reduces the typical pipe straight-runs required both upstream and downstream from the meter for accurate measurement.

The V-Cone's unique design and technology simplifies installation, saves on real estate, cuts pipe material costs and reduces technician maintenance. In addition the V-Cone met the company's requirement to measure both gases and liquids, which allowed the oil company to install one meter to measure both CO2 gas and water.

The V-Cone Flow Meter utilizes a centrally located intrusion that redirects the flow to the outside of the pipe and conditions the flow by reshaping the velocity profile, all but eliminating the need for straight pipe runs. The V-Cone requires straight pipe runs of only 0 to 3 pipe diameters upstream and 0 to 1 pipe diameters downstream. This smaller footprint, requiring up to 70% less straight pipe without being affected by flow disturbing equipment up or down stream, is more compact than any other differential pressure meters.

At this particular well site the WAG system CO2 gas requires stainless steel piping, which is much more expensive than standard piping. With the V-Cone's relatively short straight run requirements, there was a significant reduction in pipe costs. Many times this reduction in straight run requirements also means the pump house building can be smaller too, and there is a savings in construction costs.

The V-Cone Flow meter is a differential pressure type flow meter. The principle of operation is based on Bernoulli's theory of conservation of energy. In a closed system, as the cross sectional area changes, so must velocity. By placing the cone in the pipe, the cross sectional area is reduced forcing velocity of the fluid to increase. As velocity increases, pressure drops and it is that pressure drop that can be measured and used to determine the fluid flow rate. This system can be use used for both liquids and gases.

The difference in pressure is incorporated into a derivation of the Bernoulli equation to determine fluid flow. As the fluid moves past the cone, very short vortices are formed that result in a low-amplitude, high-frequency signal optimal for excellent signal stability (Fig 3). The V-Cone maintains +/-0.5% accuracy and +/-0.1% repeatability over a 10 to 1 turndown and the cone conditions the fluid such that there is relatively low permanent head loss.

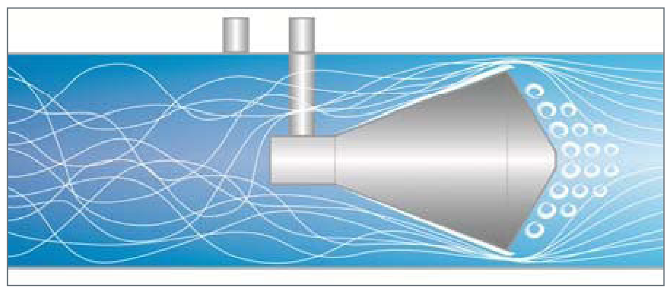

Figure 3: The V-Cone Operating Principal

Low permanent head loss achieved by the V-Cone Flow Meter results from the shape of the cone itself, which minimizes energy losses commonly caused by areas of low flow, cavitation and erratic flows. Each V-Cone Flow Meter is sized to meet desired application requirements and may be specifically designed to have high or low head loss. Regardless, the overall energy consumed by the V-Cone Flow Meter is minimized because of its inherent characteristics.

The rugged, no moving parts V-Cone Flow Meter measures abrasive, dirty, and particle-laden fluids over a wide range of Reynolds numbers without wear or clogging concerns, resulting in an unprecedented standard 25 year operating life with virtually no need for maintenance. Reynolds numbers are a measure of whether flow is laminar or turbulent. With maintenance costs an extremely important concern in a mature oil field, the V-Cone Flow Meter helps the company reduce total operating costs for the site.

The turbulent vortices produced by the V-Cone condition the fluid flow to be homogeneously distributed and extremely stable. It is this turbulent flow that actually protects the cone as well as the surrounding pipe. The turbulent flow forms a boundary layer against the pipe wall and cone protecting it from particle impingement which can cause deterioration or buildup on the surfaces.

Normal surface deterioration in flow meters, piping, and other equipment occurs as a result of fluid sheer stress. Shear stress creates a problem where there is a solid boundary layer in direct contact with the walls of the pipe. Shear stress occurs in laminar and unstable turbulent flows.

The V-Cone's very stable turbulent flow all but eliminates this shear stress and consequently results in no surface deterioration. Additionally, due to the shape of the cone, there is little chance of cavitation on the backside of the cone to erode the surface. Each V-Cone is calibrated during the manufacturing process and because the design is so robust, there is never a need for regular maintenance or recalibration after installation.

Given the distance between the sources of the CO2 gas and the water to be moved to the 16 well heads, the V-Cone's low permanent head loss results in much lower energy requirements to move the product. Cavitation, eddies, and areas of zero flow that can form on the downstream side of differential pressure devices are actually energy consumers. This energy loss directly equates to the need for larger pumps to move the desired amount of fluid.

Conclusion

By implementing a WAG system, the production in this field significantly improved from 350 to 4500 barrels per day. "We've used V-Cone Flow Meters in this application for three years without a single failure and no maintenance, and accuracy of the V-Cone has not changed a bit overtime," said lead process engineer for the project.

Even with the split run fluid stream to the multiple well heads, the V-Cone Flow Meter remains accurate. This level of accuracy is significant because the process injects 70 million cubic feet of CO2 gas per day, but the gas remains in the ground and is re-used in the process, which eliminates greenhouse gas pollution.

Engineers in the oil and gas industry have relied for over 25 years on the V-Cone Flow Meter to remain accurate in the toughest applications. Its low-maintenance, no-moving-parts design is proven to remain accurate for 25 or more years and all but eliminates the need to shut down production for calibrations, inspections or regular primary element replacement needed for an orifice plate. It saves money by increasing production up-time and reducing labor costs.

3255 W. Stetson Ave., Hemet, CA 92545 | **P.** 951-652-6811 | **F.** 951-652-3078 | www.mccrometer.com