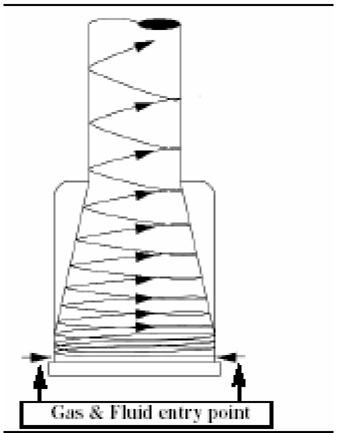
Vortex Flow Technology Finding New Applications *

By David A. Simpson, P.E., RMOJ Vol. 83, No. 45, October 31, 2003-November 6, 2003

As flowing bottom-hole pressures continue to decline in gas wells across the world, the opportunity for liquid loading to hinder gas production increases. All of the various artificial-lift methods require some amount of intake pressure to prevent their running dry. “Gas locking”, “cavitation”, “rod pound”, and “dry plungers” are all more prevalent in low-pressure regimes than they have ever been before. Operators throughout the oil and gas industry are clamoring for a solution to liquid-loading that can be applied reliably in low-pressure applications. The Vortex DX™ downhole tool has the potential to address these issues in many wells. Recent work at Texas A&M University and in 25 Rocky Mountain and Mid-Continent gas wells supports the contention that this tool can organize the flow stream as it travels up a wellbore into more energy-efficient configurations.



Vortex Flow Pattern

As a stream of gases and liquids enters the DX™ tool it is forced by a “bluff body” in the flow stream to spin rapidly. The high angular acceleration slings the heavier liquid toward the pipe wall. As this spinning flow moves up the tool, the configuration of the tool allows the spin angle to relax to a very efficient value. This efficient helix-angle will propagate and hold together over very long distances. The consequence of the liquid moving like the rifling on a gun barrel is that the no-flow boundary at the edge of the central gas flow is moving—resulting in a lower differential velocity between the bulk flow and the outer edge of the flow, which yields a lower shear force and a lower pressure drop due to friction. A second benefit is provided by eliminating the “slip” between liquid droplets in the flow and the gas stream.

Removing this slip force reduces the amount of work the gas must do as it moves up the wellbore and further reduces the total pressure drop through the tubing.

In high water-cut wells, the mechanism looks much like a tornado. The bulk of the flow is the organized liquid, meanwhile the gas is flowing at high velocities through the “eye” of the tornado. By capturing the gas within the liquid, the velocity gradient across the gas stream is greatly reduced and the gas isn’t required to drag liquid drops along. This phenomenon has resulted in wells with WGR greater than 1,600 bbl/MMCF flowing more steadily than they ever did with conventional artificial lift.

The Texas A&M University work was presented at the recent SPE Annual Technical Conference and Exhibition in early October by Ahsan Ali. Ali’s presentation and paper demonstrated that in laboratory experiments using A&M’s clear-plastic wellbore, the Vortex DX™ tool was able to lower the critical velocity required to prevent unloading by up to 30%. His work showed both the theoretical velocities required by several different multi-phase flow correlations, the actual point where the gas flow began to unload liquid without the DX™ tool, and the actual point where an organized flow pattern would begin to unload liquid. The DX™ tool consistently lowered the critical velocity over a wide range of flowing pressures, gas-flow rates, and water cuts.

The laboratory is not the field. We’ve all seen great ideas that just didn’t make the grade in field trials. After 5 months in the field, the DX™ tool looks like it is providing similar results in producing wells to what was seen in the lab. Marathon Oil and BP America have both installed DX™ tools in various well-flowing conditions with good results.

In the San Juan Basin of Northern New Mexico and Southern Colorado, BP has installed four tools in the over-pressured “CBM Fairway” and one well in the underpressured coal seam (the classifications refer to the pressure conditions at first delivery, current conditions are substantially different). The tool in the under-pressured 1,200 ft well replaced a pump jack that was moving 6 bbl/day while the well was flowing 80 MCF/d. Using the Grey (modified) correlation, BP predicted that this well needed 125 MCF/d to move 6 bbl/day up 2-3/8 tubing. After the DX tool installation, the gas rate fell and the water rate dropped to zero. BP decided to pull the 2-3/8 tubing and replace it with 1-1/2 tubing with the same 2-3/8 DX™ tool on bottom (the Modified Grey correlation predicted that the well needed 90 MCF/d to lift liquid with this tubing at the observed pressures). The well produced 8 bbl of water the first day at 80 MCF/d. After a month the gas rate is over 100 MCF/d and the water rate has stabilized at almost 8 bbl/day.

One of the BP over-pressured 3,000 ft San Juan fairway wells was experiencing severe liquid-loading (over 300 ft of water gradient measured with a pressure bomb while reservoir pressure was under 100 psig) and the flow rate had dropped from over 2 MMCF/d to under 1 MMCF/d. After the DX™ tool was installed, the rate increased to 2.2 MMCF/d and the flowing pressure gradient showed a liquid level below the bottom of the tubing. The large gradient that was restricting the well was caused by a restriction in the tubing that the surface-eductor was unable to break. Pulling the tubing to install the tool cleared the obstruction, but wells in this area have had an historical problem recovering from well work or any other disruption in steady flow. This well came back the day the rig moved off and has sustained these high rates for over 4 months.

The focus of the DX™ installations for Marathon has been the Powder River Basin coal. One well in the Anderson Coal was producing 130 MCF/d and water rates swinging between 40 and 340 bbl/d with an ESP (Electric Submersible Pump). This well is 530 ft deep. The ESP was experiencing frequent episodes of gas locking and both the gas and liquid production were very erratic. While the ESP was gas locked, the gas flow rate indicated on the wellsite equipment would read erratic and questionable values, and Marathon was unsure of what the gas rate on this well really was. The ESP was replaced by a DX™ tool in July, 2003. Since installation, the gas and water rates have become much more stable, the gas rate is consistently 120-130 MCF/d and the water rate has declined from almost 300 bbl/d down to 200 bbl/d. Surface indications of liquid level (which were so erratic as to be unusable with the ESP) are now showing a steady decline from 150 ft above the coal to 90 ft.

Another Powder River Anderson Coal well was showing severe signs of intermittent liquid loading with a PCP installed at 580 ft. Water production showed to be zero and gas production was less than the long-term trend line. Surface indications of liquid level showed about 40 ft. After the Vortex DX™ tool was installed in May, 2003, gas production showed a 30 day “flush production” period that was well above the trend line and then laid on top of the trend line for four months. Water production spiked during the flush period to 150 bbl/d and then declined to 30 bbl/d. Current gas production is 140 MCF/d.

These results and many others show that the Vortex DX™ tool can play a significant role in shifting liquid in gas wells. VortexFlow, LLC is working to produce new tools for other sizes of tubing, to amplify the flow pattern within a tubing string (for example a DX™ could be set just above the gas-lift valve in a gas-lift well to improve the efficiency of gas lift), and a tool that can be run on slick line without the need to pull tubing. These additional tools are in the development and testing stages at this time, and should come to market over the next few months.

** Editor’s Note: Our thanks to David Simpson for this leading edge report on new uses for the Vortex Flow Technology. David has 23 years experience in Oil & Gas and is currently the proprietor of MuleShoe Engineering. Based in the San Juan Basin of Northern New Mexico, MuleShoe Engineering can address issues in Coalbed Methane, Low Pressure Operations, Gas Measurement, Oil Field Construction, Artificial Lift, and Project Management wherever your operation is. For more information go to www.muleshoe-eng.com A Professional Engineer with his Master’s degree, David has had numerous articles published in professional journals and has spoken at various conferences, including the large SPE Conference recently held in Denver.*

*Readers may recall our original article on the **flowline** application of the Vortex device, which we have re-printed in column 2 of this page. Vortex now has over 200 of its flowline devices installed in surface applications, as it continues to fulfill its potential as outlined in our original report. The company is receiving strong endorsements from leading companies, who are now adopting its technology to help them increase production and lower operating costs.*

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