NEW TECHNOLOGIES FOR HANDLING PRODUCED WATER-DOWNHOLE OIL/WATER OR GAS/WATER SEPARATORS

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BOTTOM LINE

Downhole oil/water separators (DOWS) or gas/water separators (DGWS) are a relatively new technology that can help reduce water handling costs and produce more hydrocarbons to the surface per day. DOWS installations are expensive and not cost effective for all wells. Features critical for success include a high water-to-oil ratio, the presence of a suitable injection zone that is isolated from the production zone, compatible water chemistry between the producing and injection zones, and a properly constructed well with good mechanical integrity.

PROBLEM ADDRESSED

DOWS are devices placed in the bottom of the well that separate water from the oil and gas stream. Some water is reinjected into another formation or horizon, while the oil, gas, and remaining water are produced to the surface. DOWS have a great potential to save money and reduce the environmental impacts of managing produced water at the surface. Because the technology is still in its infancy, not all problems have been solved. Success has been mixed. The cost of installing DOWS, including the well workover, is substantial. With continued high oil prices, DOWS are likely to find wider popularity and use.

KEY WORDS:
Class II Injection Well
Downhole Gas/Water Separators (DGWS)
Downhole Gravity Segregation
Downhole Oil/Water Separators (DOWS)
Hydrocyclone
Produced Water Handling

TECHNOLOGY OVERVIEW

Treatment and disposal of produced water represent significant costs for operators. DOWS separates oil and gas from produced water at the bottom of the well and reinjects some of the produced water into another formation or another horizon within the same formation, while the oil and gas are pumped to the surface. Since much of the produced water is not pumped to the surface, treated, and pumped from the surface back into a deep formation, the cost of handling produced water is greatly reduced. In cases where surface processing or disposal capacity is a limiting factor for further production within a field, the use of DOWS to dispose of some of the produced water can allow additional production in that field.

Based on a workshop sponsored by PTTC's Midwest Region on July 14, 2000 in Lansing, Michigan.

SPEAKERS:

Michigan DOWS Regulations
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Hydrocyclone Downhole Separators
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Advantages of DOWS or DGWS include reduction of salt water produced to the surface, elimination of single purpose injection wells, increased daily production, and use of off-the-shelf components. Typical DOWS configurations include a well that produces oil-water from a reservoir and injects into a hydraulically isolated oil-water reservoir as part of a water flood process. A second well could be used to produce from the water-flooded zone and inject into a disposal zone.

Two basic types of DOWS have been developed. The hydrocyclone has long been used to remove oil from produced water. It is currently available from Baker Hughes/Centrilift as off-the-shelf units that fit 5 ½-inch and larger casing. Fluid handling capacity, as large as 24,000 bfpd, is greater than DOWS units using gravity separation concepts, but cost is significantly greater.

Dual Action Pumping Systems (DAPS) employ a downhole oil/water gravity segregation system. Limitations for DAPS include natural gas in the fluid, presence of fines, and injection pressure. There must be sufficient vertical space between injection and production zones to allow for gravity separation. Residence time in the separation zone and oil droplet size must be sufficiently large to allow for separation. The tool was devel-

oped by Texaco and licensed by Dresser-Axelson. Quinn Pump has developed another system. The tool will fit into 4 ½-inch and larger casing. Fluid capacity is up to 1200 bpd.

Conversion of a well from regular pump to DOWS is relatively expensive. Total costs include the DOWS tool itself and well workover expenses. Costs for the hydrocyclone-type DOWS are fairly high. For example, the cost of an electric submersible pump-based DOWS system is approximately double to triple the cost of replacing a conventional electrical submersible pump and is often in the range of $90,000-250,000, excluding the well workover costs, which can often exceed $100,000. Costs are somewhat lower for the gravity separation-type DOWS, ranging from $15,000-25,000, and the cost of a complete gravity separator-type DOWS installation is about $140,000.

DOWS installations are not cost-effective for all wells. Knowledge of the reservoir and historical production are important before selecting a well for DOWS installation. Favorable well characteristics for DOWS installations include, among others, a high water-to-oil ratio, the presence of a suitable injection zone that is isolated from the production zone, compatible water chemistry between the producing and injection zones, and a properly constructed well with good mechanical integrity. DOWS installations in wells that meet these requirements must still remain in good operating condition for long enough that the accrued monthly savings can offset the initial purchase costs of the equipment. The track record of existing installations is mixed, with some DOWS installations remaining in service for more than two years, but with others failing within a few days. It must be remembered that this technology is relatively new, and that fewer than 40 DOWS have been installed in North America through mid-1998.

Regulatory Considerations

DOWS have been declared Class II injection wells by Oklahoma, Kansas, New Mexico, and Texas. Texas looks upon DOWS installations as oil and gas injection wells requiring a RRC permit. Permit applications are considered on a case-by-case basis according to the tool used, production-injection geometry, and injection parameters. All DOWS wells are required to pass an initial test and another test each time the tool is pulled. Hydrocyclone installations are required to use down-hole pressure sensors to track injection rates and pressures. DAPS installations have been allowed to calculate injection parameters from surface dynamometer data.

In Michigan, DOWS wells are classified as Class II wells that can be permitted and are subject to state and UIC regulation. The wells must pass a mechanical integrity test when equipment is being installed and after workovers. In lieu of subsequent integrity tests, operators submit documentation of fluid levels in the annulus.

Field Results

Four areas with DOWS installations were discussed at the workshop:

- *Alberta Reef Trend*–The test case consisted of nine DOWS wells. After installation of DOWS, average oil production increased 102% (46 to 93 bopd) and average water production decreased 85% (1,001 to 148 bpd). Net dollars/month increased from approximately $3,200 to $51,300. Analogous reservoirs in the U.S. include Canyon, Edwards, and Michigan reefs.

- *E. Alberta Manville Sands*–The test case consisted of seven DOWS wells, of which one was a gravity separation unit. After installation of DOWS, average oil production increased 61% (28 to 45 bopd) and average water production decreased 79% (715 to 148 bpd). Analogous reservoirs in the U.S. include Weber, Wilcox, and other strong water-drive sands.

- *Canadian Williston Basin*–The test case consisted of seven wells, four with hydrocyclones and three with gravity separation. After DOWS units were installed, average oil production increased 29% (51 to 66 bopd) and average water production decreased 87% (1,229 to 156 bpd). Analogous reservoirs in the U.S. analogs include the Mission Canyon in Montana and North Dakota.

- *East Texas*–The test case consisted of five wells, including four gravity separation units. After DOWS units were installed, average oil production increased 112% (8 to 17 bopd) and average water production decreased 41% (226 to 134 bpd).

In three cases involving Gulf Canada, payout occurred within 1.5 to 3 months. Cost for DOWS conversions were $150,000 in each case. Oil price varied between $15 and $30/bbl. Cost of water handling was between $0.20 and $2.00/bbl. In each case, oil revenues per month increased more than 500%

A U.S. Department of Energy (DOE) report on DOWS (January, 1999) indicated that in a larger study of 37 trials, the volume of oil increased in 19 trials, decreased in 12 trials, stayed the same in two trials, and was unspecified in four trials. The top three performing hydrocyclone-type units caused oil production increases ranging from 457-1,162%, while one well lost all production. The top three gravity separator-type units caused oil production increases ranging from 106-233%, while one well lost all oil production. All 29 trials for which both pre-installation and post-installation water production data were available showed a decrease in water brought to the surface. The decease ranged from 14 to 97%, with 22 of 29 trials exceeding 75% reduction.

According to the DOE report, some of the installations experienced problems that impeded the ability of the DOWS to function properly. At least two installations suffered from low injectivity in the receiving zone. In both cases, incompatible fluids contacted sensitive reservoir sands, which plugged part of the permeability. Several installations noted problems of insufficient isolation between the producing and injection zones. If isolation is not sufficient, the injected water can migrate into the producing zone and then short-circuit into the producing perforations. The result will be recycling of the produced water, with oil production rates dropping to nearly zero. There are some risks pertaining to pressuring the disposal zone, which may have conduits to drinking water. A second perceived risk is pumping oil into the disposal zone or water into a producible reservoir. Fines or sand has plugged some DOWS units. Several trials were canceled prematurely because of corrosion and scaling problems. Finally, some of the early installations suffered from poor design features.

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