The dry drilling technique, which has also been applied by several other operators in the area, was an attempt to limit the amount of solids introduced to the productive interval. The additional water introduced was initially considered not to be a problem, since co-production moved large volumes and should make that volume back in a short time. However, production results on these wells have been poor. Response time was long, and it is difficult to quantify the impact of flushing the zone with 15,000-20,000 barrels of freshwater.

From both operational and reservoir standpoints, the results achieved with the Aphron system have been the most consistent. Each well has successfully reached total depth, casing has been run and cemented to total depth without difficulty, and production response has typically been very good. Minimal H_2S corrosion problems and reduced safety issues have been added bonuses.

Cost is generally comparable for each system. Despite the fact that the Aphron system is by far the most expensive drilling fluid, the additional fluid cost has been offset by smaller acid stimulation treatments (or even no stimulation, as was the case with the Conoco State No. 6), reduced freshwater hauling costs, the elimination of remedial cementing jobs, and faster production response times. ❐

Editor's Note: The preceding article was adapted from SPE/IADC 67743, presented at the Society of Petroleum Engineers/International Association of Drilling Contractors' 2001 Drilling Conference, Feb. 27-March 1 in Amsterdam.

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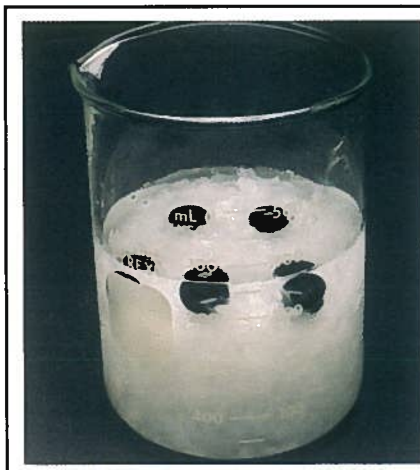
Fiber Solves Hole Cleaning Problems

By Keith Davis

GROVE CITY, PA.–From stuck pipe to failed logging runs, hole cleaning problems can lead to long, sleepless nights and expensive down time. In this day of increasing day rates and inexperienced personnel, synthetic fiber suspension fluids offer a quick, clean and simple method of preventing problems associated with insufficient hole cleaning.

Synthetic fiber suspension fluids are fluids that have been treated with a new synthetic fiber fluid additive. These 21 micron-diameter, 0.5 inch-long fibers, dispersed in fluids, greatly increase the carrying capacity and solids suspension qualities of the drilling fluid without increasing fluid viscosity. Used as needed, these fluids are run in sweep form with the fiber and carried solids being removed by the solids control equipment. With approximately 850 miles of fiber per pound, this additive is very efficient in very low concentrations. The inert fibers can be used in clear water, brines and water-based muds, as well as oil-based or synthetic fluids.

Synthetic fiber sweeps are very effective when run at casing points or prior to logging. They prevent or cure tight connections while drilling or on trips, and allow for greater depths while drilling with water or brines. The sweeps have proven to be very effective for removing metal fragments generated during milling operations without the use of a high yield point milling fluid. Whether sweeping large-diameter deepwater risers or horizontal holes, synthetic fiber suspension sweeps are quickly finding a niche in many applications in the drilling industry.



The specially treated synthetic fibers allow for rapid dispersion and uniform flowability in a wide range of fluids. Here, the fibers suspend standard 0.5-inch glass marbles in water.

Effective concentrations of the synthetic fibers range from one-tenth a pound per barrel in a viscosified fluid to one-half a pound/barrel in clear water or brines. The fiber is mixed through the mud hopper at a predetermined concentration in a premix pit, and pumped down hole in a slug or pill form. The sweep and entrained solids are removed from the fluid by the shale shaker without the fluid losses associated with screen blinding.

Clear Water Drilling

The ability of the fibers to disperse and suspend in water or brines without the need of a viscosifier makes these

TABLE 7

Corrosion Data

Sample	Exposure Time, Hours	Weight Loss, mg	Corrosion Rate, mpy
Aphron Fluid	24	0.7	1.3
Aphron Fluid	24	0.5	0.9
Aphron Fluid	24	0.5	0.9
Aphron Fluid	48	0.6	0.6
Aphron Fluid	48	0.6	0.6
Aphron Fluid	48	0.6	0.6
Lafayette Fresh Water	24	7.8	14.4
Lafayette Fresh Water	24	4.8	8.9
Lafayette Fresh Water	24	4.7	8.7
Lafayette Fresh Water	48	22.9	21.2
Lafayette Fresh Water	48	18.8	17.4
Lafayette Fresh Water	48	19.2	17.8

dently or in various combinations. Multistage cementing tools–with and without external casing packers–have also been employed.

Results have been as varied as the procedures. Despite attempts to lighten cement densities, results were the poorest on the two wells that used the dry drilling technique, and remedial cementing was required on both. As might be anticipated, the best results were achieved when returns were maintained during drilling. The four conventionally drilled wells generally had good results during cementing since returns had been regained with LCM pills. All seven of the Aphron wells had very good cementing results. Since casing was set above the zone on the three air-drilled wells, cementing was not an issue. This was originally seen as a major benefit of air drilling since openhole completions ensured that cement could not be lost to the formation. However, it became necessary to set casing across the pay section when Kerr-McGee introduced high-volume lift (co-production) to produce its properties in the field.

A typical cementing procedure now involves pumping a lightweight Class C cement slurry (at ±13.2 pounds/gallon) across the Upper Pennsylvanian section. A multistage cementing tool with an external casing packer is set just above the top of the formation and the final 2,000 feet is cemented with a standard lightweight slurry.

Lessons Learned

As the redevelopment of the Indian Basin Field has progressed, the focus has been on minimizing damage to the Upper Pennsylvanian carbonate reservoir. The extremely high permeability of the fractured, vugular dolomite, coupled with the field's low bottom-hole pressures, present a significant drilling challenge. The air/mist system limited and even eliminated fluid losses to the formation, but adopting the co-production method effectively eliminated this technique as an option because of the need to set casing through the pay zone.

The conventional method of fighting lost returns with LCM has generally yielded successful results in as much as the wells have reached the desired depth, allowing casing to be set through the zone. However, this method has typically resulted in the need for large acid stimulations and slower production response because of the volumes of drilling mud and LCM lost to the reservoir.

Severe drag and hole fill problems are eliminated as this 8.75-inch well in Dickens County, Tx., unloads following a sweep using cut brine with fiber additive.

fibrous suspensions useful in maintaining a clean hole while drilling with fast drilling fluids. Reducing valuable rotating hours, the sweeps allow for greater depths on water prior to mud up. Unlike clay viscosifiers, fibrous suspensions are unaffected by common contaminates or strong inhibitive floculants. In the proper concentrations, these synthetic fibers are able to continually suspend solids for extended periods (days, weeks and even months) in static conditions.

A 70 well development drilling program in Mitchell, County, Tx., used the Super-Sweep® fiber from Forta Corp to drill Clear Fork wells to a depth of 3,400 feet. While drilling with a clarified inhibitive brine from Mudsmith Ltd. in Midland, Tx., the fiber additive was used to total depth to flush the bore hole free of cuttings, enabling the operator to avoid any additions of attapulgite viscosifiers that retain solids and slow the rate of penetration. The operator averaged 70 rotating hours on these wells, versus 120 hours on previous multiwell drilling programs in the same field. With the inhibition of the floculant treated brine and the hole cleaning of the fiber additive, it became routine to come out of the hole "laying down" at total depth prior to logging or running pipe. Savings on brine, cement and rig time were well in excess of the investment in drilling fluid additives required to achieve these results.

In another application, this one in Dickens County, Tx., the operator encountered severe drag and hole fill at 3,600 feet while making pipe connections during the drilling of an a 8.75-inch hole. This was several hundred feet prior to the scheduled mud up depth. With a penetration rate of 40 feet an hour and pump output of 7.8 barrels a minute, a hole sweep was performed by mixing 30 pounds of Super-Sweep fiber with cut brine through the mud hopper directly into the suction pit over a four minute period. After approximately 30 minutes of circulating, the hole began to unload heavily. The sweep continued to bring large volumes of cuttings, fines and slivers of shale for 15 minutes, before gradually tapering off. As a result of the sweep, the problem with tight connections and hole fill were alleviated, allowing the drilling to continue to mud up depth with brine.

In Pecos County, Tx., problems with hole fill had been experienced in previous 17.5-inch wells drilled with brine while logging intermediate sections at 4,200 feet. This also resulted in the intermediate casing string having to be washed to bottom. On a subsequent well, the 17.5-inch diameter, 4,200-foot section was swept with 30 pounds of fiber mixed with 100 barrels of brine. As a result, several logging runs were successfully completed and casing was set to bottom with none of the hole fill problems associated with the previous wells.

Milling

Synthetic fiber sweeps allows for milling with drilling fluids as opposed to high yield point milling muds. The jagged edges of metal fragments, slivers and burrs generated during milling operations become mated within synthetic fiber suspensions, greatly enhancing the transport of this debris to the surface. Synthetic fiber sweeps used in an oil-based or synthetic fluid eliminate the need to displace the drilling fluid with a high yield point milling mud to cut sim-

Metal fragments, slivers and burrs generated during milling operations become mated within synthetic fiber suspensions, greatly enhancing transport to the surface. Metal fragments recovered from a section milled at 11,200 feet in a well onshore Louisiana are shown here.

ple window, only to switch back to an oil-based or synthetic fluid to resume drilling. Synthetic fiber sweeps can be used in low yield point water-based fluids for milling without having to water back a milling mud to a drilling mud, reducing mud product cost as well as rig time.

In a milling operation in a deepwater well offshore Louisiana, sweeps were required to remove metal fragments cut from a window at 5,800 feet using a 6.125-inch mill of the 7.0-inch casing before going in the hole with a PDC bit. Several 60-bbl sweeps with 0.25 pound/bbl Super-Sweep fiber were circulated during milling, with an additional 60-bbl sweep after the milling was completed. The sweeps successfully cleaned the hole of metal fragments, and the magnets were cleaned and left in place for three additional days with no additional metal recovered.

Sweeps were also required to recover metal fragments after milling a portion of an 11.75-inch intermediate casing section in a well onshore Louisiana. The hole had been previously swept using a high-viscosity xanthan polymer sweep, and was presumed to be clean. The magnets were removed, cleaned and replaced. A trial using the fiber additives was then performed in the hope of eliminating the viscosity increases and backwatering that occur from conventional high-viscosity sweeps. A 30-bbl pill with Super-Sweep at 0.25 pound/bbl was circulated in the hole. More metal fragments were recovered with the sweep, and the magnets were packed with additional fragments upon removal. The fiber additive proved to be a more efficient hole-cleaning agent than the polymer sweep, even at a depth of 11,200 feet in dense fluids.

Horizontal Drilling

Synthetic fibrous suspension sweeps are routinely being used in lateral drilling to prevent the buildup of cutting beds. These suspensions in low concentrations are able to maintain a clean hole without negative effects on measurement-while-drilling tools or mud motors.

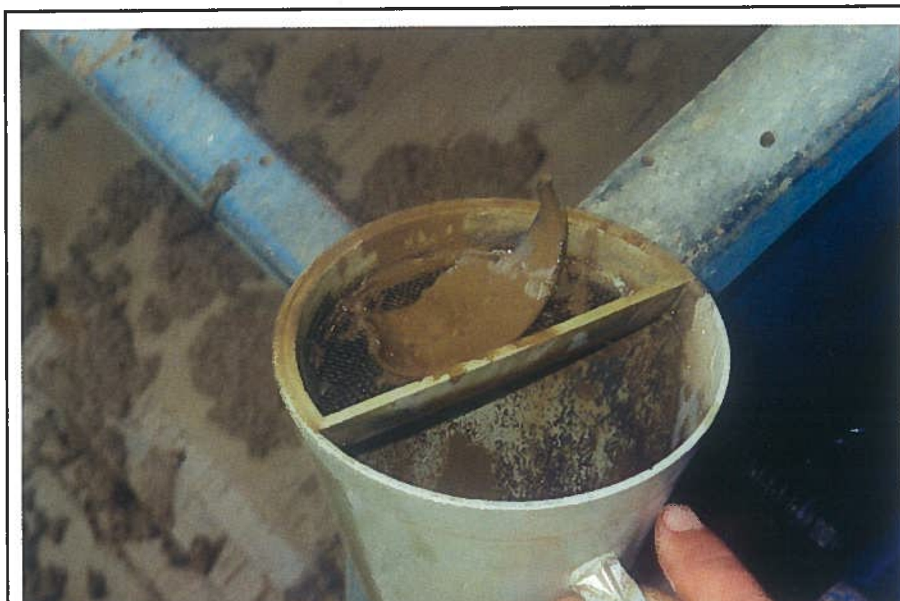
In a horizontal re-entry in Nolan County, Tx., after milling a window at 6,300 feet with fresh water, a sweep was ran using one 15-pound carton of Super-Sweep fiber to remove any metal fragments left in the hole. The mill was tripped out and the hole was re-entered with slim hole drilling assembly that included a 1.875-inch MWD tool and 3.5-inch mud motor. The fresh water used for milling was displaced with Ellenberger crude to drill the lateral in the Ellenberger formation. The 4.75-inch bit was kicked out and drilling began.

While building radius to the horizontal section, 60 barrels of fluid was treated with 0.25 pound/bbl (15 pounds) of fiber additive. Twenty-barrel sweeps were pumped from the premix pit to maintain hole cleanliness. The sweeps were run with no adverse effects on the MWD tool or mud motor, and the shaker with no blinding of the screen removed the fiber and cuttings. As the lateral section progressed, the concentration of fiber was increased to a 0.5 pound/bbl with no ill effects to the MWD tool or mud motor.

Weighted Fluids

The ability to remove fibrous suspensions with a conventional shale shaker makes the synthetic fiber sweeps especially useful in weighted drilling fluids. Conventional high-viscosity sweeps used for hole cleaning become entrained in the fluid system and can result in excessive increases in drilling fluid viscosity. This can result in having to dilute the system back to a desired viscosity, which may require the additional expense of reconditioning the fluid.

An onshore well in South Louisiana required hole cleaning without increasing the viscosity of the heavily weighted mud system. A sweep was needed on this 15,200-foot deep well with 5.0-inch liner before logging, after drilling out a cement float collar. The operator applied the fiber additive at the rate of 0.25 pound/bbl of mud. Upon reaching the surface, the fiber material was easily



This piece of a cement float collar and additional cuttings were recovered after sweeping a well onshore South Louisiana drilled with a heavily weighted mud system.

KEITH DAVIS

Keith Davis is product manager for Grove City, Pa.-based Forta Corp., which manufactures and distributes the patented Super-Sweep fiber technology. Davis is the inventor of the Forta-assigned patents. He has previously served as president of an environmental testing, consulting and project engineering firm, as well as worked as a manufacturer's representative for a number of drilling fluid suppliers.

screened out over the shaker screens with no resulting mud losses, blinding or sticking. Several pieces of the float collar, along with additional cuttings, were recovered. Pump pressure, which had increased from 2,850 to 2,970 psi during circulation, returned to normal after the sweep. The fiber additive proved a safe and effective alternative to a high-viscosity polymer sweep.

The ability of synthetic fibrous sweeps to perform in low doses allows for cost-effective transportation to remote rig sites. A 15-pound carton of these hole cleaning fibers can do the work of thousands of pounds of clay viscosifiers, and result in significant savings in mixing time. The fibers can be used to add strength to weak gel fluids such as PHPAs or guars. In areas prone to lost circulation, synthetic fiber sweeps can be utilized to allow the use of lower-viscosity fluids, reducing equivalent circulation densities and resulting in less fluid loss.

Maintaining a clean hole with routine sweeps helps reduce the density of fluid in the well bore, lowering hydrostatic pressure and reducing fluid loss. Highly propelled by the fluid, the fibers can be used to measure bottoms-up lag time. When hole cleaning problems show themselves in the form of high torque or drag, a synthetic fiber sweep can be mixed, circulated and have the hole unloaded long before the viscosity of the mud system can be increased. In addition, a synthetic fiber sweep can be used at total depth to determine hole cleanliness, or to simply improve the odds of getting a logging tool or a long string of casing to bottom. ❒

EIA Still Predicting Oil Prices Will Rise

WASHINGTON–Despite stock building by Organization for Economic Cooperation and Development (OECD)-member companies in early summer, the U.S. Energy Information Administration is still predicting stronger oil prices by year-end.

In its *Short-Term Energy Outlook* update released in early July, EIA notes that world oil prices weakened throughout June as commercial oil inventories in OECD countries continued their climb from below-normal levels earlier this year to normal levels by the beginning of summer. "The U.S. average imported crude oil price in June was $25 a barrel, up $1 a barrel from May, while the U.S. benchmark West Texas Intermediate price averaged $27.60 a barrel," EIA observes. "The OPEC basket price, which usually tracks closely with the imported crude oil price, averaged $26 a barrel."

However, EIA says it still expects world oil prices to strengthen over the course of the summer as the cutback in Iraqi production in June negatively affects OECD commercial oil inventories. "OPEC has said that it will not increase production quotas to make up the lost Iraqi oil supplies," EIA points out. "With no major increases in world oil production, WTI prices are projected to rise by another $2 from June levels, and approach $30 a barrel by September. With no major changes in OPEC behavior expected for 2002, the WTI price is expected to average $28 a barrel in 2002."

Although OECD commercial stocks at the beginning of 2001 were well below normal levels, EIA says its data and that from the International Energy Agency indicate that they rose to normal levels by late spring. Rising oil demand during the second half of 2001, combined with the loss of Iraqi oil-for-food exports in June, is expected to move U.S. and other OECD commercial stocks to below normal levels by end-summer, EIA states, adding that OECD commercial stocks are then expected to remain there for most of 2001.

Crude Oil Supply

Meanwhile, EIA says it expects Iraqi exports to ramp back to May levels by the end of August. However, it is assumed that Iraqi production in 2001 will not exceed the 3 MMbbl/d reached as recently as October 2000, the agency adds.

EIA says its projections for the past several months have assumed that any disruptions in Iraqi oil supplies would be temporary, and that further OPEC cutbacks would not be needed to maintain world oil prices at or above its target levels. Further OPEC quota cuts would place additional upward pressure on world oil prices, the agency reasons.

"We assume for the base case projection that total OPEC crude oil production will be 27.3 MMbbl/d in the third quarter," EIA states. "While this represents a 1.6 MMbbl/d increase above the estimated June level, because of Iraq's disruption of supplies, it is only a 200,000 bbl/d increase over the second quarter OPEC average. There should be enough demand growth to absorb the implied increase in world output and reduce the extent to which inventories have risen above year-ago levels."

Non-OPEC production is expected to increase by 900,000 bbl/d in 2001, according to EIA, with much of the increase coming from Russia. Although the Caspian Pipeline consortium has begun filling its new pipeline to transport oil from Kazakhstan to world markets, EIA says this is not expected to support greater Caspian production levels until 2002.

Average U.S. oil production is expected to decrease slightly (0.1 percent) this year, EIA says, to 5.82 MMbbl/d. For 2002, EIA says it expects a 0.7 percent increase to an average 5.86 MMbbl/d of oil for the year.

Lower-48 crude oil production is expected to decline 0.1 percent in 2001, followed by a decline of 17,000 bbl/d in 2002. EIA points out that Shell started production in 1999 from its Ursa Field, which will peak late in 2001. Shell's Brutus platform is expected to start production in the third quarter, with peak oil production of 100,000 bbl/d in 2002. "Oil production from the Mars, Troika, Ursa, and Brutus federal offshore fields is expected to account for 8 percent of the lower-48 oil production by the fourth quarter of 2002," EIA mentions.

Alaska is expected to account for 18 percent of the total U.S. oil production in 2002, the agency adds. Alaskan oil production is expected to remain flat in 2001, followed by a 5.9 percent increase in 2002.

Oil Demand

EIA reports that world oil demand this year is expected to grow at a slower rate than during 2000 because of a gradual economic slowdown in industrialized countries. EIA has lowered its projection for world oil demand growth to 1.2 MMbbl/d in 2001 (higher than its June prediction of 900,000 MMbbl/d demand growth), with slightly higher demand growth expected for 2002. EIA says non-OECD Asia is still expected to be the leading region for oil demand growth over the next two years, although this growth now appears to be weaker than previously assumed.

Total U.S. petroleum demand in 2001 is projected to climb 220,000 bbl/d, or 1.1 percent, from 2000, followed by a further increase of 280,000 bbl/d, or 1.4

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