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Plunger Conveyed Chemical System for Plunger Lift Wells

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THE FINAL TECHNICAL REPORT

December 30, 2004
Composite Engineers, Inc.
Subcontract No. 2554-CE-DOE-1025

Lab tests on various non-metallic materials were selected and tested in an attempt to find suitable materials for use as plunger components. This effort was intended to identify materials that could perform adequately and still reduce abrasion caused by metal-to-metal contact during plunger travel in the absence of lubricants.
Lab tests conducted on the selected materials have some favorable and unfavorable results as noted in the attached data. Due to poor performance during the lab tests, some materials were omitted from the performance evaluations conducted in the test well. Wear data established by the test well paralleled the lab data for most samples. The samples containing glass performed far superior to all other samples in the test well. **Amodel®** samples suggested acceptable wear rates behind **Ryton®** samples. Documented expansion characteristics of **Amodel®** suggested performance improvement in certain well bore temperatures that enhanced expansion. Caution would be needed to prevent too much expansion in certain well conditions causing possible plunger sticking.

After studying the test well data and comparing it to the lab data, the producers of the wells to be used in the field trials were consulted, the test data was presented and a brush plunger design was selected. Composite wanted to be able to test non-metallic components for comparative analyses with the lab and test well data. Several plungers were modified to allow the installation of "wobble washer" components on the plungers run in the field trials.

Upon investigation of the tubing during well work, it was discovered the condition of the tubing string in the Doucet #1 was far from acceptable. The producer was not willing to replace the entire string of tubing. Instead, only the bottom 10 joints were replaced.

The wells changed ownership during the field trials. The new owners expressed a desire to add a foaming agent to be injected along with the corrosion inhibitor in the Doucet #1. The idea was to keep it unloaded better. Composite tested that application in the test well to determine if the foamed produced water adversely affects the plunger performance i.e, lift rates/plunger speed. No conclusive data could be generated with the test well only being 200' deep. No appreciable plunger speed difference could be determined and the re-circulation of the same produced water soon became saturated with the foaming agent.

Additional chemical pumps, tubing and connections were delivered to the Doucet #1 and installed. The chemical manufacturer didn't have any concerns with mixing the corrosion inhibitor and the foaming agent in the chemical chamber as the chemical pumps were timed to run in alternating cycles. Corrosion inhibitor volumes were maintained at 2-1/2 quarts per day and the foaming agent was adjusted to a rate of 1 quart per day.

The design modifications changing the ported segment of the plunger was completed. Four prototypes were produced. The modifications eliminated the ports completely and that eliminated the small cup that was required to block the ports in the plunger during the trip to the surface. This eliminated several machining operations and the part inside the plunger.

The difference in the specific gravity of the corrosion inhibitor and the produced water (being heavier) allowed the produced water to enter the plunger from the top and displace the lighter chemical. Observations in the lab suggested the flushing of the chemical from the plunger once it entered the fluid level at the bottom of the well had one negative effect. The negative change is that the chemical leaves the plunger at a slower rate than it did when the produced gas was allowed to "percolate" up, through the plunger, mixing the corrosion inhibitor as it displaced the chemical. The gas was observed mixing the chemical in the same manner as if it was flowing up, through the plunger. It just happened as the chemical was displaced out the top of the plunger. The agitation caused by the gas bubbles migrating up, past the plunger still allowed for complete dispersion of the chemical throughout the standing fluid level in the bottom of the well. The costs savings by eliminating the ports and "cup" in the bottom of the plunger could offset the additional costs to install a ball and seat valve mechanism in the base of the chemical chamber, another modification believed to improve the life of certain components.
Upon determining the application of the plunger without any ports, the specific gravity of the produced water will need to be a determining factor in the selection of plunger configuration. Costs to produce the non-ported plunger should also be a factor in plunger selection.

Honeywell has not shipped any more friction material since the copper impregnated samples. In a phone conversation with one of the engineers, the suggestion of shipping samples with high ceramic content probably will not happen. Poor performance of the samples tested, have caused Honeywell to re-think their involvement.

Work on pad segments produced from **Amodel ®** or **Ryton®** is moving slowly. Negotiations for injection molding of the pad segments are moving slowly. Pad segment design changes are being considered to help cut estimated production costs.

The data generated during the past 14 months is attached.

WEAR RATE COMPARISONS of NON-MATALLIC MATERIALS
LAB

Controls-Tubing samples positioned at 45°
Non-Metallic samples on ¾" x 6" long mandrel reciprocated 4" @ 20 SPM
Submerged in produced water @ ambient temperature
Duration- 1000 strokes

TUBING #1 before	931.8210 g			
		Amodel #1 before 75.5001 g		Amodel #1 after 74.0300 g
TUBING #1 after	930.7349 g			
TUBING #2 before	952.6590 g			
		Ryton #1 before 81.6143 g		Ryton #1 after 80.7431 g
TUBING #2 after	951.9347 g			
TUBING #3 before	977.9321 g			
		Ryton +25 before 81.5883 g		Ryton +25 after 80.9640 g
TUBING #3 after	966.0327 g			

TUBING #4 before TUBING #4 after	899.9348 g 891.7342 g	Ryton+10 before 80.9440 g		Ryton+10 after 80.0313 g
TUBING #5 before TUBING #5 after	902.7823 g 902.0041 g	Poly #1 before 66.4312 g		Poly #1 after 61.0012 g
TUBING #6 before TUBING #6 after	910.3497 g 909.7594 g	HMWPE 89.4990 g		HMWPE 86.0133 g
TUBING #7 before TUBING #7 after	970.4973 g 969.7594 g	Honeywell #1 before 101.8349 g		Honeywell #1 after 81.9374 g
TUBING #8 before TUBING #8 after	931.8210 g 930.7349 g	Honeywell # 2 before 104.8323 g		Honeywell #2 after 87.2849 g
TUBING #9 before TUBING #9 after	961.3310 g 959.4944 g	Honeywell # 2 before 120.2573		Honeywell #2 after 97.2528 g
TUBING #3 before* TUBING #3 after *	966.0327 g 965.9347 g	Honeywell # 3 before 107.8469		Honeywell #3 after 104.8465

Honeywell Sample #1- standard automotive brake pad materials
Honeywell Sample #2- Hi-temp automotive brake pad materials
Honeywell Sample #3- Formulated brake pad material containing copper
* This tubing sample was re-used to monitor brake pad material in a more favorable environment being,
a polished interior surface caused by testing Ryton + 25% glass.
The Honeywell Sample performed much better in the “conditioned” tubing.

FEP and Kevlar samples failed totally before any appreciable data could be established. That data is not included in this report since none of the samples survived the time/cylces established as an acceptable test period. Additional research indicated established plunger manufacturers’ commercialization of Teflon plunger components have limited success. As a result of these findings, Teflon was dropped as a possible component material for future tests.

WEAR RATE COMPARISONS of NON-MATALLIC MATERIALS
TEST WELL

	Before	After
Amodel #1 **Amodel #2**	**45.9342 g** **43.8493 g**	**43.8394 g** **41.8439 g**
Ryton #1 **Ryton #2**	**46.8495 g** **44.9401 g**	**45.0342 g** **43.1934 g**
Ryton +10 #1 **Ryton +10 #2**	**46.9485 g** **47.0023 g**	**45.7498 g** **44.4982 g**
Ryton +25 #1 **Ryton +25 #2**	**46.9934 g** **46.9832 g**	**46.4998 g** **46.0799 g**

All samples listed above were machined into rings or wobble washers and installed on a modified brush plunger. One ring was positioned immediately above the brush segment and one ring of like material was positioned immediately below the brush segment of the plunger.

Test well data suggests the Ryton®+25% glass samples performed best of those selected from the lab data. However, in review of the lab data, excessive metal loss was detected.
So, the Ryton®+10% glass was actually the best performer of the Ryton® group.

The Amodel® performed second best to the Ryton® group as far as comparitave material loss. Data gathered from dimentional investigations of the Amodel® samples re-inforced data gathered from other industry users. In that, when samples were exposed to produced water at slightly elevated temperatures (80° F+), the material expanded dimensionally.
Note: Material loss was within boundaries suggested by data from lab tests. Dimensionally, the material expanded to some degree even though the mass was reduced from appearant abrasion.

WEAR RATE COMPARISONS of NON-MATALLIC MATERIALS
FIELD TRIALS

	Before	Plunger Cycles	After
Amodel #1 Amodel #2	45.4294 g 44.0993 g	38 32	34.9345 g 39.5156 g
Ryton #1 Ryton #2	45.9404 g 44.9401 g	45 34	40.3042 g 41.1934 g
Ryton +10 #1 Ryton +10 #2	45.9874 g 47.6101 g	51 35	35.6557 g 44.4665 g

Ryton +25 #1	46.4581 g	47	36.4004 g
Ryton +25 #2	46.9832 g	24	45.3430 g

All samples #1 were tested in the Doucet #1 and samples #2 were tested in the Prejean #1. (the Doucet #1 had the tubing with the most advanced state of deterioration due to corrosion)

Samples tested in the field trials were difficult to compare due to the variables beyond control, the number of cycles in each respective well and the condition of the tubing strings of each well.

As plungers failed due to wear, the different materials were installed on replacement plungers.

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Test well data suggests the Ryton®+25% glass samples performed best of those selected based on lab data. However, in review of the lab data, excessive metal loss was detected.
So, the Ryton®+10% glass was actually the best performer of the Ryton® group.

The Amodel® performed second best to the Ryton® group as far as comparitave material loss. Data gathered from dimentional investigations of the Amodel® samples re-inforced data from other industry users. In that, when samples were exposed to produced water at slightly elevated temperatures (80° F+), the material expanded dimensionally.
Note: Material loss was within boundaries suggested by lab tests. Dimensionally, the material expanded to some degree even though the mass was reduced from appearant abrasion.

Upon completion of the wobble washer tests, the final modified plungers were installed in the 2 respective wells as brush only plungers, . Assuming the wobble washers run during the tests improved the interior finish of the tubing strings to some degree, the brush segments run during the final stages of the field trials suggested the wobble washers only had limited effect on retarding the brush segment wear of the early plungers run. Composite Engineers felt there were too many variables to come to any finite conclusions on “brush only” performance. Brush plunger performance has been proven time and again by the commercialization of the plunger design. During the field trials, the ownership of the two wells changed and the new owners allowed Composite to finish the tests. However, about 2 weeks prior to termination of the tests, a representative of the new owners attempted to adjust the controller on the Doucet #1 and caused the plunger to surface “dry” (without a column of water on top of the plunger). The extreme velocity of the plunger striking the lubircator severly damaged the chemical chamber and the plunger, requiring replacement. The standard plunger and lubricator cap were installed until Composite personnel could deliver replacement parts to the well site. The only plunger available at the time was a wobble washer type with all non-metallic washers of different materials. That plunger was installed and seemed to perform very well, even in the poor tubing condition. It ran for 13 days (# of cycles unknown) and was recovered with minimal wear. The top washer (Ryton®+10% glass) exhibited more wear than that of the lower washers. But, all were in very good condition.
The field trials were concluded with recovery of all Composite equipment.

CORROSION COUPON TEST RESULTS DURING FIELD TRIALS

Mild steel coupons were installed in the wellheads of 2 wells in South Louisiana to establish a base line for metal loss due to corrosion.

CORROSION COUPON # 34294 before initial installation in Doucet #1= 36.80625g
CORROSION COUPON # 34294 after 93 days service in Doucet #1= 30.43877g
Material loss based on chemical supplier's lab results= 17.3% 6.36748g

CORROSION COUPON # 34294 before initial installation in Prejean #1= 31.54938g
CORROSION COUPON # 34294 after 93 days service in Prejean #1 30.03501g
Material loss based on chemical supplier's lab results= 4.79% = 1.51437g

CORROSION COUPON TEST RESULTS DURING FIELD TRIALS

Mild steel coupons were installed in the wellheads of 2 wells in South Louisiana after deployment of chemical injector system to establish metal loss due to corrosion.

CORROSION COUPON # 34294 before second installation in Doucet #1= 30.43877g
CORROSION COUPON # 34294 after 93 days service in Doucet #1= 30.43877g
Material loss based on chemical supplier's lab results= 6.13% 1.86589g

CORROSION COUPON # 34294 before second installation in Prejean #1= 30.03501g
CORROSION COUPON # 34294 after 93 days service in Prejean #1 28.52064g
Material loss based on chemical supplier's lab results= 3.02% = 1.51437g

The addition of a foaming agent in the last 21 days of corrosion treatment in the Doucet #1 may have affected the results. Until another test is conducted, the findings will stay as determined for this report.

Understanding the entire system is fairly simple in design and has few moving parts. The field trials did not encounter any significant operational problems. The intended target of the research was to reduce corrosion damage to the tubular goods in the respective wells. The data suggests that goal was accomplished with resounding success. Composite Engineers, Inc. feels additional field trials of longer duration would offer additional information on performance capabilities of the system. Discussions with well operators in the Permian Basin, San Juan Basin, Rio Grande Valley and The Barnett Shale are ongoing. Some additional time will be needed to generate a viable supply of plungers to address all these possible applications. Additional efforts to incorporate a ball and seat sealing system for the chemical chamber is also being addressed.

This is the final report for DOE Grant # 2554-CE-DOE-1025 to the Stripper Well Consortium as of December 31, 2004.

Respectfully,

Sam Farris
Composite Engineers, Inc.