PLUNGER CONVEYED CHEMICAL INJECTION SYSTEM

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As great as plunger lift systems are, economically and in ease of operation, there is a significant pitfall associated with this system. Aggravated tubing wear. Typically, metal-to-metal plunger contact in absence of lubricants (condensate or crude) and corrosion induced by produced water at elevated temperatures.

There have been several attempts to get various chemicals to the bottom of the well bore.
Capillary strings have limits in depth of deployment and batch treatments have some success in the absence of packers. Trickling chemical ‘down the backside” has proven to have very limited success in the absence of a carrier fluid. Tests suggest most chemicals stack up in casing pin gaps and tend to lose lighter ends, leading to deposits of thick, rubbery deposits stranded along the casing walls.

In flowing wells, “bull heading” chemicals in a diesel carrier down the tubing then, back-flowing to the surface is laborious, expensive and has limited success because the process usually results in thin film applications that do not last until the next treatment. High gas production velocities with produced water in mist flow up the tubing strips this film away.

Now comes a simple, economical system to combat tubing wear, corrosion attack and a mechanism to utilize other chemicals such as foaming agents, paraffin solvents, etc.
Research into non-metallic plunger components and a plunger design capable of transporting chemicals with every trip of the plunger began in 2003.

Various materials were tested in a lab environment in an attempt to identify those that suggested favorable performance as plunger component materials. Research of non-metallic component performance in well bore environments led us to sucker rod guides and wheeled rod guides.

From this research, glass filled plastics showed favorable performance. Although, other materials were tested as well. Amoco’s version of Delrin®, Phillip’s version of HDPE, Honeywell’s Raybestos® friction materials, DuPont’sTeflon® and Kevlar® were tested.
The lab, test well and field trial results are contained in the back of this paper.

Amodel® showed very favorable results in good (smooth) tubing applications. It did not survive tubing samples that exhibited pitting from corrosion attack. Phillip’s Ryton® with 10% glass indicated acceptable performance. However, Ryton ® with 25% glass actually increased tubing wear in lab samples. Honeywell’s friction materials did not perform in an acceptable manner and was dropped from the list.

The others were moved to the test well for performance evaluation before being tested in the field. Amodel®, Ryton® with 10% glass and 25% glass were tested in the field trials as components installed on typical brush plungers. Of the 3 samples tested, none performed very well in the well with the poor tubing conditions. But, the Ryton® containing 25% glass performed best in the well exhibiting better tubing conditions. The brush elements exhibited aggravated wear rates in both wells.

Now, plunger conveyed chemical. The volumes of individual plunger styles varied depending on design. The typical “PAD” plunger had the smallest volume due to the mandrel undercuts required for the pad springs.

Produce fluid volumes were usually in direct correlation to plunger cycles. This proved to be convenient in addressing required volumes to treat produced fluid volumes.

The surface equipment is simple in design. There are only four moving parts. A typical gas driven chemical pump is adjusted to the required daily volume to treat the well bore. That pump charges the chemical chamber attached to the top of the bumper housing cap. Upon plunger arrival, a valve in the bottom of the chemical chamber is opened and the chemical chamber discharges its contents into the plunger. The chemical pump continues to pump, uninterrupted.

The plunger, now loaded with chemical awaits the controller to shut-in the well allowing the plunger to free-fall to the bottom. Upon arrival at the bottom of the well bore, depending on the plunger design, the "plain end" plunger will land. There, heavier produced fluids will spill over, into the plunger, displacing the lighter chemical payload. The percolation effect of gas entering the well bore mixes and disperses the chemical in the free-standing fluids at the bottom of the well.

If the chemical payload is close to, equal to or heavier than the produced fluid, a "by-pass" plunger design is required. This plunger design functions much like a typical by-pass plunger. Upon arrival at the bottom of the tubing, the impact opens ports in the base of the plunger, allowing fluid and incoming gas to flow through the plunger, displacing the chemical with well bore turbulence mixing, dispersing the chemical. That completes the cycle of the plunger.

With chemical being transported every plunger cycle, all the produced fluids are treated and filming is applied to the tubing wall every trip.

Or, in the case of foaming agents, those are exposed to the free standing fluids in the well bore each and every time the plunger cycles. The chemical is dispensed in the correct location and in the correct volumes every time. This leaves nothing to chance where the use of batch treatments, bull heading or capillary strings have their own problems.

Failure of those systems are usually learned through the failure of well bore components.

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 TUBING #1 after	931.8210 g 930.7349 g	Amodel #1 before 75.5001 g		Amodel #1 after 74.0300 g
TUBING #2 before TUBING #2 after	952.6590 g 951.9347 g	Ryton #1 before 81.6143 g		Ryton #1 after 80.7431 g
TUBING #3 before TUBING #3 after	977.9321 g 966.0327 g	Ryton +25 before 81.5883 g		Ryton +25 after 80.9640 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 86.0133g
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 120.2573g		Honeywell #2 after 97.2528 g
TUBING #3 before* TUBING #3 after *	966.0327 g 965.9347 g	Honeywell # 3 before 107.8469g		Honeywell #3 after 104.8465g

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	**45.9342 g**	**43.8394 g**
Amodel #2	**43.8493 g**	**41.8439 g**
Ryton #1	**46.8495 g**	**45.0342 g**
Ryton #2	**44.9401 g**	**43.1934 g**
Ryton +10 #1	**46.9485 g**	**45.7498 g**
Ryton +10 #2	**47.0023 g**	**44.4982 g**
Ryton +25 #1	**46.9934 g**	**46.4998 g**
Ryton +25 #2	**46.9832 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	45.4294 g	38	34.9345 g
Amodel #2	44.0993 g	32	39.5156 g
Ryton #1	45.9404 g	45	40.3042 g
Ryton #2	44.9401 g	34	41.1934 g
Ryton +10 #1	45.9874 g	51	35.6557 g
Ryton +10 #2	47.6101 g	35	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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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.