PREVENTING SCALE DEPOSITION IN OIL AND GAS PRODUCTION TUBING BY INTRODUCING PLUNGER WITH INTERMITTENT GAS LIFT.

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Abstract

A mineral salt deposit that may occur on oil and gas wellbore tubular and components as the saturation of produced water is affected by changing temperature and pressure conditions in the production conduit. In severe conditions, scale creates a significant restriction, or even a plug, in the production tubing. Scale removal is a common well-intervention operation, with a wide range of mechanical, chemical and scale inhibitor treatment options available. An innovative permanent solution for scale deposition is to introduce a mechanical sealing interface between fluid (oil and gas) to be lifted and the injected gas in the oil and gas production tubing with intermittent gas lift. To increase oil production from existing wells in an oil field we have to focus much on optimizing oil production. One way to optimize oil production is to find an alternative to existing intermittent gas lift technology. As we study big oil field currently with huge oil and gas operating companies, the gas injection line network is very old and new intermittent gas lift installations on new wells has been connected to the existing network. Now this creates gas starving for the new installations and resulting in inadequate amount of gas production from the well. By introducing Plunger lift technology of artificial gas lift along with existing intermittent gas lift can provide a fool proof solution to the problem and also reduction in injected gas requirement also. This paper discusses in detail about an innovative method for increase in oil production, reduction in injection gas requirement and reduction in scale deposition on oil and gas production tubing.

***Keywords**: scaling, plunger lift, intermittent gas lift, liquid fall back, exhaust emissions, injected gas*

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1. INTRODUCTION

In mature gas wells, the accumulation of fluids in the well can impede and sometimes halt gas production. Gas flow is maintained by removing accumulated fluids through the use of a beam pump or remedial treatments, such as swabbing, soaping, or venting the well to atmospheric pressure (referred to as "blowing down" the well). Fluid removal operations, particularly well blow downs, may result in substantial methane emissions to the atmosphere. Installing a plunger lift system is a cost-effective alternative for removing liquids. Plunger lift systems have the additional benefit of increasing production, as well as significantly reducing methane emissions associated with blowdown operations. A plunger lift uses gas pressure buildup in a well to lift a column of accumulated fluid out of the well. The plunger lift system helps to maintain gas production and may reduce the need for other remedial operations.
The use of plunger lifts has increased dramatically during the past decade and has led to increased oil production. Improved technology, computers, better equipment dependability, and additional services have contributed to this increased use. Plunger lift is available in complex computer controlled models and simple basic systems.

How Plunger Lift Works: A wing valve control on the wellhead closes the flow line to the tank battery, and this stops the flow of fluids up through the tubing to the tank battery. The bumper housing and catcher on the wellhead release a free falling gas lift plunger, which drops by gravity from the wellhead downward through the tubing. An open valve in the plunger allows fluids from below to pass through it as it falls. Gravity continues to make the plunger fall all the way to the bottom of the well. When the gas lift plunger strikes bottom, it makes contact with a foot piece spring, closing the valve. Downhole pressure continues to build up and also allows oil and water to accumulate on top of the plunger. After a specified time or tubing pressure level, the controller causes a flow line motor valve at the surface on the wellhead to open, allowing the gas and fluids accumulated in the tubing to flow toward the tank battery. The differential pressure

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change across the plunger lift valve causes the plunger to travel toward the surface at a rate of 500-1,000 feet per minute, depending on adjustable choke settings, fluid loads, and bottomhole pressure. As the plunger moves upward pushed by the built-up formation pressure below it, the fluid above the plunger is lifted to the surface. On oil wells and weak gas wells, the arrival of the plunger at the surface activates a magnetically controlled sensor that immediately closes the flow line motor valve, conserving tubing and formation gas pressure until the next cycle. The catcher in the bumper housing releases the plunger. The plunger again starts falling, and the cycle begins again, repeating itself as often as the settings and pressures allow.

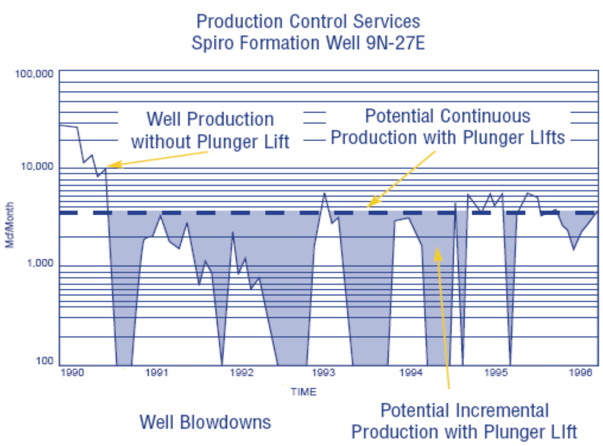

Fig1: Plunger lift cycle (courtesy PCS)

Benefit of Plunger Lift: The benefits of converting a marginally producing flowing well to a lift system can be enormous in many situations. Some of reasons for choosing a plunger lift system over other type include:

- Reduce lifting costs.
- Conserve formation gas pressure.
- Increase production.
- Produce with a low casing pressure.
- Prevent water buildup
- Avoid gas-locked pump problems
- Reduce gas/oil ratio.
- **Scrape tubing paraffin / scale.**
- Improve ease of operation
- Use pneumatic or electronic controllers.
- Reduce installation and operating costs.

Note: When a plunger system is installed, a gauge ring of the same size as the proposed mandrel to be used in the plunger lift system should be run down the well. This will identify any problems that could prevent the plunger from free-falling through the tubing.

Reduce lifting costs: Plunger lift has a lower lifting cost than most other systems of artificial lift. The well itself supplies the gas pressure needed for operation. The more complex electrical systems require very little power and this can be supplied with a solar panel.

Conserve formation gas pressure: As quickly as the plunger arrives at the bumper housing at the surface, the flow line is shut in, stopping any additional formation gas from flowing to the tank battery and into the gas system. The gas needs to remain in the formation as long as possible to drive additional oil to the well bore in the future.

When the formation gas is gone, the well will stop producing. The conservation of formation gas is one of the outstanding benefits of plunger lift, and no other lift system can offer this advantage.

Increase production: Through productivity testing where the well is produced under many different time limits and situations, the most productive parameters can be determined and followed to result in the highest possible production. By reducing the column of fluid lifted and lifting it more often, production can usually be increased.

Scrape tubing paraffin: While the plunger is traveling up the tubing each cycle, it acts as an excellent wiper to remove paraffin that may cling to the tubing. Paraffin leaves the formation suspended in the oil. As the wellbore temperature drops, the paraffin comes out of solution and is deposited in the tubing. The plunger can also remove scale that is still soft.

Improve ease of operation: The basic operation of plunger lift systems is simple. Even the more complex systems are becoming easier to operate with new developments in technology. Advances in personal computers and electronic miniaturization allow controllers to perform functions that were not possible a few years ago, almost to the point of making decisions.

Avoided emissions when replacing beam lifts: In cases where plunger lifts replace beam lifts rather than blow downs, emissions will be avoided due to reduced workovers for mechanical repairs, to remove debris and cleanout perforations, to remove mineral scale and paraffin deposits from the sucker rods. The average emissions associated with workovers have been reported as approximately 2 Mcf per workover; the frequency of workovers has been reported to range from 1 to 15 per year. Due to well-specific characteristics such as flow during workover, duration of workover, and frequency of workover, avoided emissions can vary greatly.

Economic and Environmental Benefits: The installation of a plunger lift system serves as a cost effective alternative to beam lifts and well blow down and yields significant economic and environmental benefits. The extent and nature of these benefits depend on the liquid removal system that the plunger lift is replacing.

- Lower capital cost versus installing beam lift equipment. The costs of installing and maintaining a plunger lift are generally lower than the cost to install and maintain beam lift equipment.
- Lower well maintenance and fewer remedial treatments. Overall well maintenance costs are reduced because periodic remedial treatments such as swabbing or well blow downs are reduced or no longer needed with plunger lift systems.
- Continuous production improves gas production rates and increases efficiency. Plunger lift systems can conserve the well's lifting energy and increase gas production. Regular fluid removal allows the well to produce gas continuously and prevent fluid loading that periodically halts gas production or "kills" the well. Often, the continuous removal of fluids results in daily gas production rates that are higher than the production rates prior to the plunger lift installation.
- **Reduced paraffin and scale buildup**. In wells where paraffin or scale buildup is a problem, the mechanical action of the plunger running up and down the tubing may prevent particulate buildup inside the tubing. Thus, the need for chemical or swabbing treatments may be reduced or eliminated. Many different types of plungers are manufactured with "wobble-washers" to improve their "scraping" performance. Scrapping job for scale removing is about 40,000 INR for a single job.
- Lower methane emissions. Eliminating repetitive remedial treatments and well workovers also reduces methane emissions. Natural Gas STAR Partners have reported annual gas savings averaging 600 Mcf per well by avoiding blow down and an average of 30 Mcf per year by eliminating workovers.
- Other economic benefits. In calculating the economic benefits of plunger lifts, the savings from avoided emissions are only one of many factors to consider in the analysis. Additional savings may result from the salvage value of surplus production equipment and the associated reduction in electricity and work over costs. Moreover, wells that move water continuously out of the well bore have the potential to produce more condensate and oil.

Fig2: Scaled oil and gas well production tubing.

2. PRODUCTION OPTIMIZATION

It involves the determination of optimum well controls to maximize an objective function such as cumulative oil production or net present value. In practice, this problem additionally requires the satisfaction of physical and economic constraints. Plunger lift was originally developed and used to unload liquids from gas wells. Later its use was extended to produce oil from high GLR wells. Production optimization ensures that wells and facilities are operating at their peak performance at all times to maximize production. Frequent changes in well and surface equipment down time, maintenance work, evolving reservoir conditions etc. usually make it impossible for the team to keep the asset tuned for optimal operating conditions.

The current manual production optimization approaches are both time consuming and error prone due to the complexity and large volume of data that have to be considered. In the present work, several tasks and processes have been streamlined and automated with effective linkages to achieve a near real time optimization. The measure calculate-control cycle is implemented every twenty-four hours, a procedure which maintains the system at optimal operating conditions almost all the time. A multi-disciplinary team approach has been used to implement the process of Optimization using Internet, computer network, communication links, timely team meetings and corporate database. The focus has been on reducing the cycle time for conversion of data to information, decisions, and actions by developing an appropriate system. The benefits of optimization are significant. Gains include a moderate improvement in uptime, along with a significant improvement in produced volume and overall reduction of lifting and operating costs.

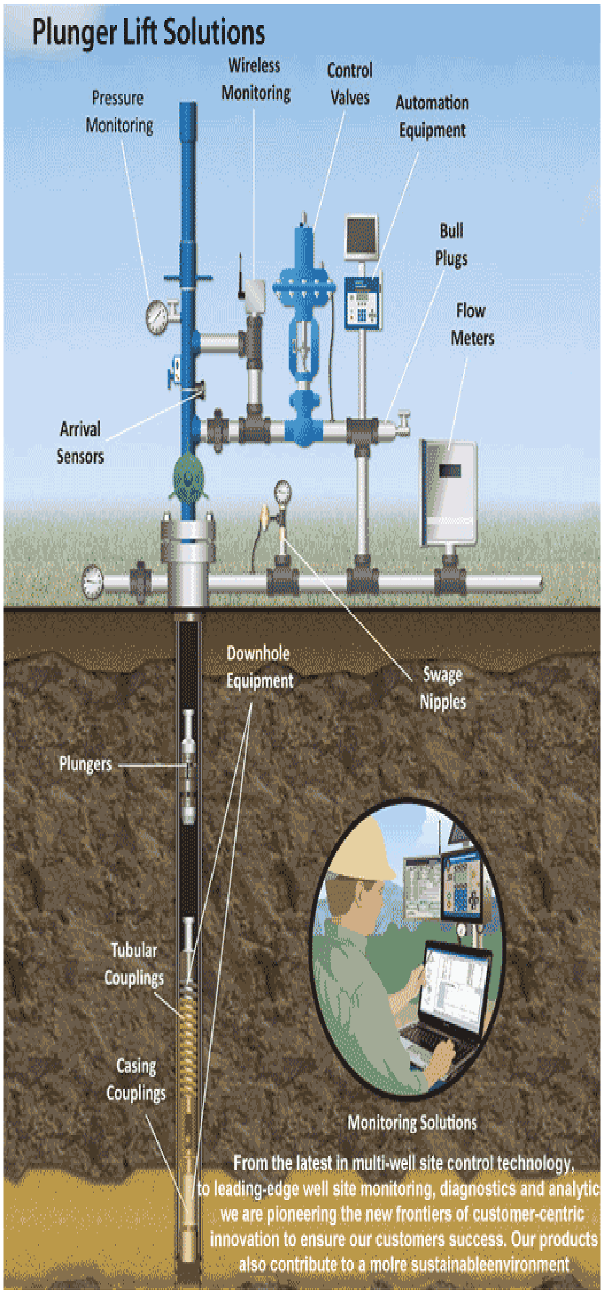

Fig3: Plunger lift (Courtesy pcs)

Conventional plunger lift uses the energy of the gas stored in the tubing casing annulus to lift a liquid slug accumulated in the tubing. Conventional plunger lift is possible in an oil well only if it has a minimum required formation GLR. If the GLR is less than the minimum required, gas will have to be injected into the tubing-casing annulus to lift the plunger with the liquid slug.

There are a large number of intermittent gas lift wells operating in fields spread over many operating Regions. In intermittent gas lift wells, the injected gas penetrates the liquid slug causing some of the slug fluid to slip downward with the consequent loss of oil production.

It is estimated that **5-7 % of the starting slug per thousand feet of lift fallback** during the upward movement. As well, a large part of the gas is notable to perform useful work in piston-pushing the oil slug above it.

The inherent inefficiency of intermittent gas lift owing to fluid fall back from the liquid slug during its upward travel can be overcome by introducing a solid interface between the slow moving liquid and the fast-moving gas in the form of a plunger. This type of installation is termed **plunger-assisted intermittent gas lift** or PAIGL. **A decrease of injection gas requirement and possible increase of liquid production** can be expected by converting intermittent gas lift wells, to plunger-assisted intermittent gas lift mode. Intermittent gas lift wells which have paraffin deposition problems are also suitable candidates for installation of this lift mode. The tubing will be kept free from paraffin, with the up and down motion of the plunger, which would work as scrapper. This will result in savings on regular scrapping jobs.

The report discusses the conventional plunger lift (for high GLR oil wells and gas well liquids unloading applications) and then plunger assisted intermittent gas lift. The design of plunger lift system, description of the down hole and surface equipment required, guidelines for installation, operation and monitoring of the plunger lift installations and some case histories have been given. This mode of lift has been used on a big scale in wells operated by BP Amoco and other companies and has resulted in increased liquid production and substantial injection gas savings.

The plunger-assisted intermittent gas lift as an alternative mode to intermittent gas lift mode is attractive since the increase in liquid production and savings in injection gas is expected and capital investment is also low. No extra surface equipment except the plunger, bumper spring, lubricator containing striker pad, catcher assembly, bumper spring and flow outlets with chokes/valves are required. However, plunger lift will not perform well in wells producing appreciable sand with the oil.

AUTOMATION FOR PLUNGER LIFT:

Automation can enhance the performance of plunger lifts by monitoring wellhead parameters such as:

- Tubing and casing pressure

- Flow rate
- Plunger travel time

Using this information, the system is able to optimize plunger operations

- To minimize well venting to atmosphere
- Recover more gas
- Further reduce methane emissions

Methane Recovery: How Smart Automation Reduces Methane Emissions. Smart automation continuously varies plunger cycles to match key reservoir performance indicators

1. Well flow rate
2. Measuring pressure
3. Successful plunger cycle
4. Measuring plunger travel time
5. Plunger lift automation allows producer to vent well to atmosphere less frequently.

RESULTS & DISCUSSION

Action	Potential Gas Saving from Incremental gas (Mcf/Year)	Value of Gas Saved (s) and avoided scrapping job for scale removal	Typical Setup and Installation Costs (S/well)	Typical payback
Install a plunger lift system	4700-18250 per well	$14100-$54750	$2000-$8000 per well	<1 year

Expected Performance with PAIGL
Well No A-1

TABLE 1: PRODUCTION DATA

Injection gas /day	Avg. BHP	Expected liquid production
1720	16.97	13.66
2018	16.22	13.75
2416	15.47	13.78
3080	14.7	13.89

TABLE 2: ESTIMATED PERFORMANCE WITH INTERMITTENT GAS LIFT MODE

Tubing load (% of casing press)	Pressure build –up time in minutes	Starting slug height in Meters
65	13	98.3
60	10	83
55	6	67.5
50	2	52

TABLE 3: ESIMATED PERFORMANCE

Tubing load (% of casing pressure)	Pressure build up time	Starting slug height
65	26	98.2
60	20	82.8
55	14	67.4
50	9	62

TABLE 4: GAS INJECTION AND CYCLES PER DAY

Cycle time in Minutes	Cycles per day	Injection gas per cycle in M^3
23	61	86
19	73	84
16	91	82
12	118	80

TABLE 5: PRODUCTION AND INJECTION DATA

Injection gas per day M^3 / day	Average bottom hole pressure in Kg / cm^2	Expected Liquid production in M^3 / day
5226	18.65	12.41
6113	17.64	12.57
7439	16.61	12.52
9406	15.56	12.57

TABLE 6: EXPECTED OIL GAIN AND SAVING OF INJECTION GAS

Expected oil gain by PAIGL	Saving in injection gas with PAIGL
1.25	1843
1.28	2145
1.30	2677
1.32	3345

TABLE 7: GAS PER CYCLE DATA

Cycle time	Cycle per day	Injection gas per day
35	40	43
30	48	42
24	59	59
19	77	77

CONCLUSION

1. Savings in injection gas with plunger assisted intermittent gas lift technology is about 1843 m3/d.
2. 1 MMSCFD = 28316.847 M^3D
3. 672695 M3/YEAR = 23.755 MMSCFD of natural gas is saved / year.
4. 1 MMBTU = 2.7 US $ current rate
5. 1000 ft3 = 1 MMBTU
6. 1 M3 = 35.31 FT3
7. 23752860 FT3 / YEAR
8. 23752.86 MMBTU/ YEAR
9. 64132.722 $ / YEAR SAVING IN GAS CONSUMPTION.
10. Savings in maintenance cost of well by avoiding **scrapping jobs for scale related problems**.
11. Large amount of reduction in harmful gases emission by application of PAIGL as natural gas required for lifting oil is reduced thus reducing the amount of compression required.
12. Plunger with intermittent gas lift can be used as a permanent solution for avoiding scaling up of production tubing. Thus, improving and optimizing production of oil and gas.

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