PLUNGER-LIFT; AUTOMATED CONTROL VIA TELEMETRY

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ABSTRACT

Controlling plunger-lift wells has always proven tricky, if not outright difficult. The advent of electronic controls dramatically improved the success of plunger-lift applications. The reliability of controls along with the varied programs available has made the job easier, and therefor improved the overall operation. Wells never before considered candidates are now regularly employing plunger-lift.

While the reliability and flexibility of equipment has improved, **most** plunger-lift wells are **still** operated at less than optimum levels of productivity. Today's busy well operators have less time available, making optimization difficult. Utilizing telemetry, along with the Auto-Cycle algorithm, has **shown** dramatic increases in production, eliminated down time, and maximized the pumper's time. It also serves to provide real time production and management data.

This paper looks at several fields where operators have maximized their time, and increased their production through field automation.

INTRODUCTION

After 20 years of increasing activity, popularity, education and success with Plunger-lift operations, it remains a misunderstood, often neglected and poorly operated method of producing wells. The reason being that it is service intensive. It is one form of artificial lift that cannot be installed, lined out, and forgotten. It requires supervision, and it requires that someone make decisions regularly on its operation to ensure efficient and effective operation with satisfactory results.

The advent of electronic controls in the late **70's** made plunger-lifting possible. Before electronic controls, it was very difficult to make plunger-lift work. The mechanical controllers were inefficient and unreliable. With electronics it became possible to utilize pressure, differential, plunger arrival, and many other options to cycle plungers. **This,** coupled with more efficient plungers, gave plunger-lift the credibility it lacked, and it became a regularly employed artificial lift system

PLUNGER VELOCITY

In the early 90's an algorithm was developed, and patented whereby plunger velocity became the pulse of the system, This method, made possible only because of the electronic intelligence that had been developed, proved very successful in advancing the success and acceptance of plunger-lift. In utilizing this automatic system, the controller was able to make changes in the plunger-lift cycles by monitoring plunger speed, and comparing it to a pre-programmed operating window. Changes in the cycles were made every time the plunger arrived outside of the acceptable range. The most acceptable method for plunger-lift optimization has always included timing the plunger arrival and then calculating an average velocity. This algorithm automatically made these calculations, thereby including optimization in every cycle.

One of the key advantages to using plunger speed was that it was not necessary to determine a pressure(s) or differential to decide when it was time to cycle a plunger. Plunger speed took all of these variables into account. If the plunger was not arriving within an acceptable range, the controller made the appropriate changes, and kept making changes until the plunger was operating within acceptable limits. The net results were better production with less hands-on necessary from the operator.

Not only did this increase production, it made possible the successful operation of plunger-lift in areas where adequate supervision was not always available. The clear choice among prudent operators became the use of plunger velocity to determine cycles. Plunger-lift again moved up another level on the acceptability scale of artificial lift.

As experience with automatic cycling increased, it became evident that even with auto cycling, there were wells that were still not realizing their potential. It was learned that "conservative" settings could be introduced that would show significant results, but with much closer supervision, the production improvements could be even greater. Frequent "tweaking" of the operational parameters produced positive results, both in produced liquids and gas. The problem was that there was simply not enough time for most operators to spend at each well to generate these results. As a matter of fact, the trend was in the other direction. Operators were typically being given more and more wells to look after in an attempt to make organizations more efficient, all the while making production less efficient. Again, technology came to the rescue. This time it was telemetry.

TELEMETRY

Many operators had been using telemetry in conjunction with gas measurement, SCADA, process controls, compressor call-out systems, and others. It was not, however, widely used in production control, especially with plunger-lift. It was a widely held notion that the often marginal plunger-lift wells couldn't generate enough revenue to justify the expenditure. What some operators were beginning to discover was that this was not the case.

In 1995 the first successful installation of the Auto-Cycle Plus system was completed. This well, situated in the D-J Basin of Colorado had been operating via plunger-lift for several years and had also been operating via automatic control by monitoring plunger velocity. It was generally felt that the well was operating as well as could be expected, and that the production was near its maximum.

For the test, the controller was replaced with an RTU (remote terminal unit), pressure transducers to monitor casing and tubing pressures, transducers for measuring gas through an orifice meter, a DC power supply, and a cellular telephone system.

The operation of the well was resumed and the previously existing cycles were programmed. Over the course of the next 125 days the well was checked via telemetry regularly. The well parameters were "tweaked" often, with minute changes to its adjustments programmed. The operating system provided a detailed graphical representation of the well's activity. This trending proved a useful tool in evaluating changes in settings, fluctuations in line pressure, etc.

At the start of this test, the well was averaging approximately 200 mcf/d, at the end of the 125-day test; the production was averaging 450 mcf/d (Fig. 1). The only difference was that the well had been monitored daily. And it was monitored and optimized from Tyler Texas, not from the well site.

In 1996 a project was started that would grow to in excess of 400 wells by the end of 1999, and is still growing today, and is also located in Colorado. These wells are in western Colorado, near Parachute. Once again, many of these wells were already being operated via plunger-lift. RTUs, DC power, transducers, a point to point radio system, tank level monitoring, and gas measurement were included in the system. Again, the results were similar, production was increased on the average of 25% (Fig. 2). Also, each operator who had been looking after 30 to 35 wells were now able to handle 55 to 60 wells per person. Instead of each operator heading out into the field each day to visit as many well sites as possible, to ensure that any problems were addressed, they were able to immediately direct their efforts toward wells that needed attention. At 6:00 AM, each morning, a report is automatically printed which shows well status, alarm conditions, etc. Simply, if there is not a condition that warrants attention that day, they don't have to spend their time going there. Instead they can *direct* their efforts to more productive activities.

In this field, there are a number of wells, which are situated atop a mountain and were not accessible during the winter months. As a result, these wells were shut in for several months each winter. After the automation system was installed, the wells were not again shut in due to weather. Each winter since the installation of automation, the wells have continued to produce throughout the Winter.

In addition, the Colorado ***Oil*** & Gas Association, because of the efficiency of their operation, gave this operator an award. This was due in part because of the automation system, which cut down on lease road traffic, dust, monitored tank levels, increased production, etc.

In east Texas, a small independent operator installed the Auto-Cycle Plus system on two wells, which are completed in the Travis Peak formation. The first of these older wells was already operating on plunger-lift. After installation of the telemetry system the well was monitored via cellular telephone. Again, it was checked daily. The trending data was studied, the cycles examined, and small changes in the cycle parameters were made. At the end of the first full month of production, the revenues on this well had been increased by approximately $6000.00 per month. In studying the production records via Dwight's software, it was discovered that this well was operating at levels it had not seen in excess of 30 years (Fig. 3).

In northern Mexico, 20 gas wells had been in operation using plunger-lift for a number of years. Even though several different types of controls had been tried over the years, these well continued to operate inefficiently, and were troublesome. Downtime was high, and the field-level understanding of efficient plunger-lift operation was low.

In **1998,** the State oil company decided to allow these wells to be operated by an outside contractor. Plunger lift operation and control was accomplished via the Auto-Cycle Plus system. This system did not initially include radios or telephones. The telemetry part of the system was done manually. In lieu of scanning each well via radio, each well was visited daily, and the information downloaded into a Laptop PC. Then, each evening the results would be studied, any cycle changes entered into the computer, and the changes uploaded the following day when the operator made his rounds. A rather tedious method of transferring data, which could have been accomplished in minutes with telemetry. In spite of the awkward method of transferring this data, these wells showed a ***58%*** increase in gas production. Once the telemetry link has been added, the results could be better. Certainly the time and expense of visiting each well each day will be vastly improved.

THE SYSTEM

The typical system (**Fig.4**) consists of a standard plunger-lift system, which includes a lubricator/catcher, a downhole spring assembly, a motor valve, and a plunger. In lieu of a typical stand-alone controller, the Auto-Cycle Plus production automation system was installed.

The AutoCycle Plus Production Automation System is made up of **two** basic groups: Hardware and Software. The hardware is usually comprised of several different pieces of equipment that allow the operator to not only monitor various processes at the wellsite on an instantaneous basis but to **also** store the historical data of those processes. Each wellsite is equipped with an electronic remote terminal **unit (RTU).** This **RTU** is powered by a solar power system, comprised of a solar panel, high capacity 12-volt battery, and charger/regulator assembly.

The electronic controller is **wired to** various **sensors** and devices depending on the application. **Those** sensors would include: 1) Electronic transducers for measuring of wellhead casing and tubing pressures. 2) Electronic transducers for measurement of gas through a sales orifice meter. These would include a **sensor** for differential pressure, static pressure, and line temperature. The system also has the capability of gathering the gas measurement data from a third party flow computer. 3) Electronic transducers for measuring glycol or unit temperature. **4)** Tank switches for detecting high fluid levels in both water and oil tanks. ***5)*** Remote latching solenoid valve for opening and closing one or two pneumatically controlled motor valves. 6) Plunger arrival **sensor** which enables the RTU to log the arrival of the plunger.

The electronic controller **(RTU)** is connected to a remote radio modem which allows for either downloading of stored wellsite data or for uploading data, such as a plunger setting change, from a host PC. This remote radio modem communicates with a host radio connected to a host PC usually located at a production office. This communications network may be as simple as a straight line of sight network or depending on the distance covered and terrain, may be comprised of a simple base station repeater or an elaborate network of tail end repeaters that greatly extend the range of communications over a great distance and/or over rough mountainous terrain.

The host software package uses a point and click interface and operates under the Microsoft 95, 98, or NT platforms. All pressure and temperature data retrieved from the electronic controller may be viewed either in a real time schematic format of graphical objects (Fig.5) representing typical wellhead piping, valves and gauges, or in a high resolution, historical trend profile **(Fig.6)** unmatched for analyzing well performance. The software includes a daily report, which can be configured by the operator to include daily averages of any or all of the pressures and temperatures monitored by the controller, production volumes, and overall performance of the plunger system. Other features of software include automatic or on demand data scan of any or all of the electronic controllers. The automatic scanning feature is user programmable. ***Alarm*** detecting on all sensors connected to the controller. Automatic shut-in on high tank level alarms and on demand control of one or **two** motor valves by the system user.

CONCLUSION

As stated earlier in this paper, both the popularity and the successes of plunger lift have grown dramatically over the last several years thanks in part to the improved electronics as well as improved mechanical equipment. **But** no matter how much the equipment improves, plunger lift efficiencies and production may never be maximized without the correct and timely supervision of the equipment. Unfortunately, with today's time constraints on most operators, it remains a challenge to spend enough time at each well to get the results that many wells have the potential to produce. ***As*** the examples in this paper have **shown,** the addition of the patented algorithm **(Fig. 7)**, along with the addition of telemetry to the plunger lift controller, give the operator the ability to monitor plunger lift operations while maximizing the production fiom plunger lift wells. The use of the computerized plunger lift program along with telemetry have helped to increase production and has made the entire plunger lift system more user friendly and more accepted by field operators. In addition, manpower savings, operator effectiveness, and overall well performance and plunger lift system efficiency are also realized.

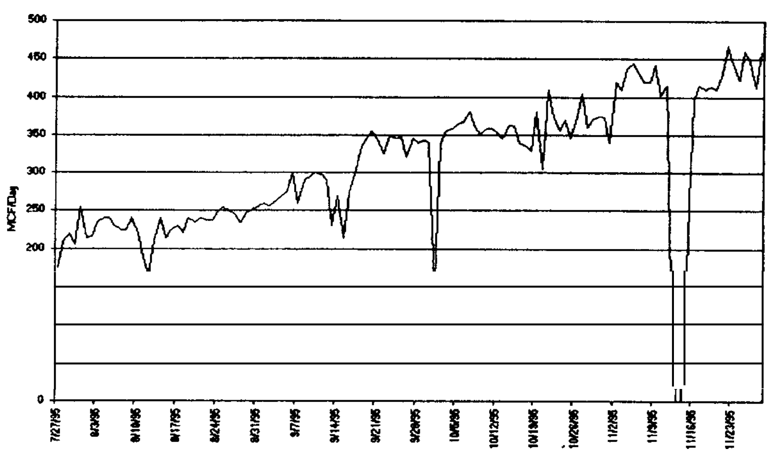


Figure 1

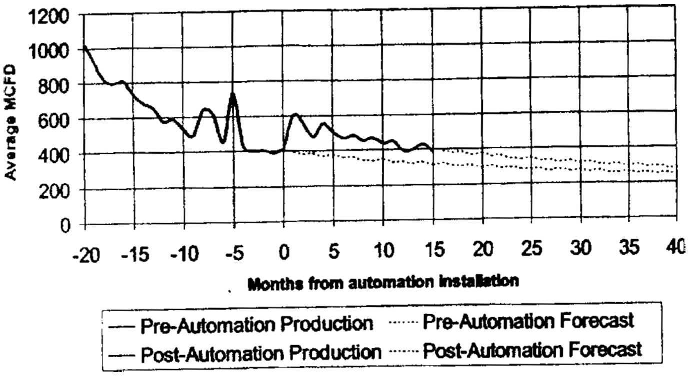
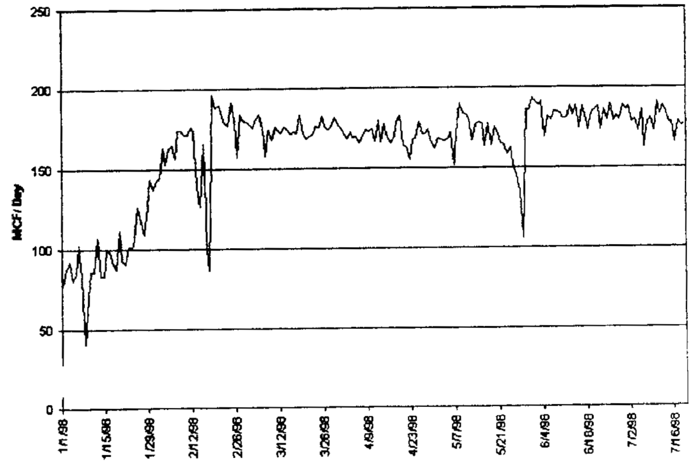


Figure 2 - Automation Effects on Production



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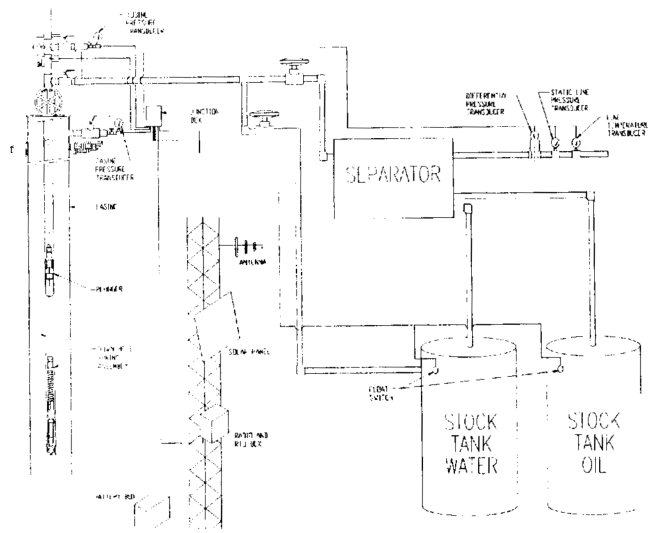

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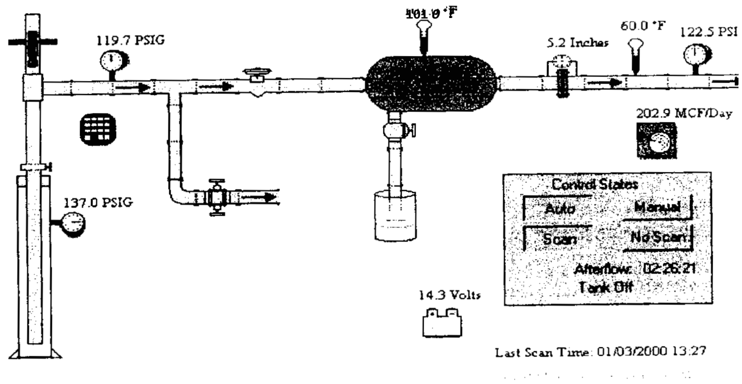

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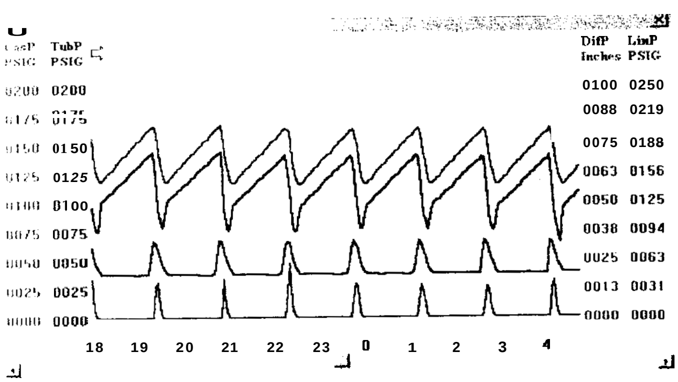

Figure 6

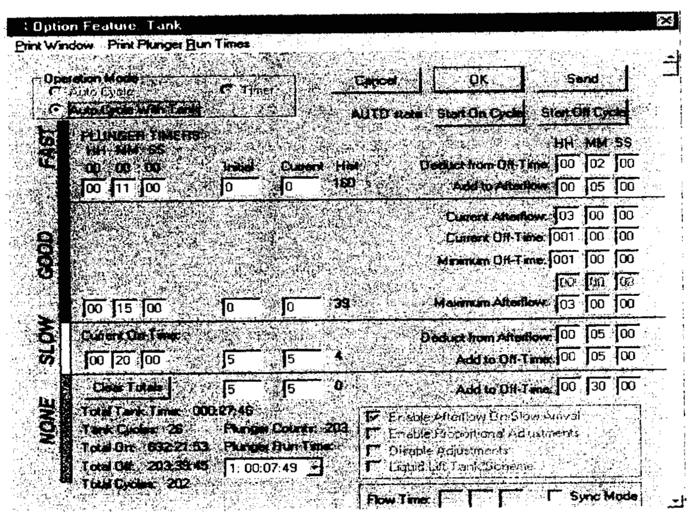

Figure 7