MULTI-WELL CONTROL AND OPTIMIZATION OF PLUNGER LIFT PAD SITES

by

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Plunger lift optimization of wells on a multi-well pad facility is a relatively new scenario being addressed by several RTU functionalities. Traditional plunger lift has few restrictions, other than controlling line pressure, which can affect the performance of the system. When plunger lifting or intermitting of the well is utilized at a pad site, there are several variables that need to be taken into account. The main issue is controlling the ability of the wells to open due to the typical mixture of stronger and weaker wells. By defining a period of time between wells being allowed to open, it provides a mechanism to allow a well’s plunger to arrive before allowing another well to open and provide backpressure on the other well. Additionally, sales line capacities may dictate that not all wells on a pad site may be open at a time, therefore, the ability to limit this site’s total production pressure or volume may be accomplished by reaching a maximum number of open wells then holding any additional well off until capacity is available. This may have a slight impact on plunger optimization depending on conditions at each site, but to date has not proven to be of much consequence. Further, low volume wells
may also be physically piped through common equipment such as separator or measurement facilities. This scenario call for logic that can control not only which wells are allowed to be on, but also manages the measurement tube switching to the appropriate measurement database relate to the well to accurately record production volumes.
# TABLE OF CONTENTS

1. Abstract................................................................................................................... Preface
2. Table of Contents .......................................................................................................... 1
3. List of Figures................................................................................................................... 2
4. Description of current situation.................................................................................. 5
5. Physical construction as additional impediment ..................................................... 7
6. Description of the requirements in designing the system........................................ 9
7. Solution to the requirements ...................................................................................... 11
   a. Historical Perspective.............................................................................................. 13
   b. Today’s solution ..................................................................................................... 15
   c. Tomorrow needs and possible solutions.............................................................. 17
8. Benefits from this solution........................................................................................ 19
   a. Carbon Footprint.................................................................................................... 19
   b. Health & Safety Benefit........................................................................................ 20
   c. Operator/Operation Benefit................................................................................... 21
9. Statistical Field Data.................................................................................................... 22
LIST OF FIGURES

Figure 1.1 – Example Pad-Site and Remote Wellheads
Figure 1.2 Example Multi-Level Pad Schedule

Example Data Setup Information
Total Number of Wells: 10
(12 including 2 pseudo runs in master schedule)
Total Number of Schedules: 3
1 – Master Schedule
2 – Sub – Schedules
Total number wells allowed "ON": 6
Time Between "OPENs": 00:10:00
Algorithm Employed: Round-Robin
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GLOSSARY

Word. [Click and type definition here.]
SITUATION

Environmental and operating restrictions have caused production companies to look for compliant, efficient and environmentally friendly ways to operate leases where they have drilled multiple wells. As an example, the company has a lease on a certain acreage that has several opportunities for productive drilling. The operator drills several wells, but environmental regulations require the operator to minimize the physical footprint of the operation to an acceptable level, & operationally, the operator wants to minimize the capital cost of the producing facility. Part of the ability to reduce capital costs leads to use of common equipment within the facility, such as shared separators and common pit or tank facilities. The solution becomes a centralized collection, measurement, and liquid storage facility the will house the separators, meter runs for measurement, and tanks for liquids (Figure 1.1 is a rough estimation of a typical system with no reference to scale). This is becoming an increasingly popular method in several areas of the US.

PROCUCERS NEED

Defined Need: Due to the consolidation of equipment somewhat remotely from the wellheads, there are several needs to be met when operation a facility in this manner. The idea of using a single RTU was defined at a corporate level along with scalability features that would lend the RTU to future growth needs not only for facility expansion, but additional logic for extensible programming as facility requirements evolved and the need to further customize evolved. The request was to be able to fulfill this requirement without replacing the existing RTU. As such, the initial requirements were defined as:
1) Wireless communications, monitoring, and control between the battery and multiple wellheads for control and monitoring. Trenching for wellhead wiring is typically cost prohibitive due to the distances covered.

2) Ability to measure multiple wells production simultaneously and on demand in situations where the wells share common equipment.

3) Monitoring and measuring liquid production from either each well individually or as a community, depending on the lease type.

4) Tank monitoring for levels that would dictate Emergency Shut-down criteria, both for flowing wells and holding off other wells to prevent a spill.

5) Ability to trend remote data points as they relate to the production and operation of each well.

6) Ability to monitor, control, & optimize multiple plunger wells according to their own operating parameters.

7) Control the site’s production volume based on output availability of the sales meter and pipeline.
PHYSICAL CONSTRUCTS IN DICTATING CERTAIN OPERATING CONTROLS AND CONFIGURATION

As mentioned earlier, certain governmental requirements have made it necessary to physically build the gathering site in certain ways. Typically there are a couple main features that require controller accountability to effectively manage the facility. The main issue for this type construction tends to be the sizing of the sales line to the gathering system and its capacity to haul the production volume. Many times existing lines are reused, but do not have sufficient capacity to accommodate additional new well production. With the lines being full, this tends to cause somewhat unstable line pressure. As line pressure tends to be probably the most critical limiting factor for plunger lift, it becomes more critical when co-mingling new strong wells with older weak wells.

The issue with this is apparent when in this type setup is that if a weaker well is in a plunger arriving state and a stronger well or even another weak well opening during this time could cause enough back pressure above one or both plungers to cause them to fail to arrive. To combat this back pressure effect, the current solution is for the operator to define an amount of time between when well 1 opens and when well 2 is allowed to open. Hopefully, giving well 1’s plunger time to come to the surface; in its simplest form; when any well opens, all others are put into a hold state for a specified amount of time. Special scheduling algorithms, round robin and priority, further control which wells come on when. This theology has the opportunity of having an effect on the optimization of wells operating on pressure parameters, but to date has not proved to be of substantial consequence.

Line pressures and capacity restrictions may dictate that the site may need to be restricted in its production to some degree as not to overload the gathering system. By way of example:
An operator has expanded an existing area utilizing the pad facility type technology. The facility is connected to the existing gathering system via a 3” line that has a capacity of move 500mcf/hr. Cumulative production of the wells on the facility now exceed the ability of the sales line has the ability and opportunity to overpressure the gathering system. The ability to control, at a rough level, the number of wells that are allowed to be “ON” at any given time gives the operator an avenue to regulate the production at a rate something near the limit of the gathering systems ability (Figure 1.2 is an example of the scheduling algorithm that could be utilized on a typical site).

As the wells fall further down the decline curve in their lifecycles, it may become more important to keep the gathering line full as possible by using additional control logic at the site level that would look more at the production rate of each well as they relate the gather line’s capacity and adjust production priority accordingly.

An additional facet that is deployed as a cost reduction is where two or more weaker wells will share common equipment such as separators and metering facilities. In cases where wells share common production equipment such as separators and metering equipment, additional controls have been put in place to ensure the appropriate, accurate allocation of the gas produced by each well. In these situations, a simple tube switching algorithm is used such that when a well is commanded on by the system, the associated measurement tube is enabled for allocating the production to the leaseholder, while the other common measurement tubes a put in an off or hold state to ensure appropriate allocation of royalties. When the well is commanded off, the associated measurement tube is simply put into a hold state, thereby allowing other plunger and measurement systems to take control of the common facility. Utilizing a subset of the site restricting algorithm as mentioned above that has the ability to hold off certain
wells for a time, wells sharing common equipment utilize the same algorithm to limit the number of “ON” wells to one.
SOLUTION

The solution to these needs is occurring in 3 phases: the initial setup of RTU with then current technology (Historical Perspective, with Pros & Cons), the current solution employing advanced RTU capabilities (Current Solution, with Pros & Cons), & derived new needs and thoughts (Tomorrow’s Solution).

Historical Perspective: The initial solution to this scenario was to loop together multiple single or dual measurement and plunger lift control units, placed on each measurement run for each plunger well and connect them via RS485 communications mediums using the Modbus protocol. Site control and management would be additional programming in a master control unit. Wellhead controls were accomplished via modbus I/O radios attached at each wellhead to control a solenoid valve, monitor pressures from transducers, and sense plunger arrivals all talking back to a the master control unit at the pad facility.

Advantages:

a. Multiple wells controlled from a single, central location.

b. Controller failure resulted in minimal impact, unless it was a master controller.

Disadvantages:

a. Expensive to install. The operator had to purchase a controller for every meter run/wellhead.

b. Difficult to install & configure due to the amount of communications required between the units.
c. Difficult & expensive to maintain when considering multiple batteries, solar panels & complexity in troubleshooting communications and configurations.

d. Multiple points of failure.

This solved some of the requirements in operating these facilities, but it was not as efficient or intelligent and did not completely offer the capabilities necessary to perform all the functions necessary. In order to reach the current solution of operating multiple wells from a single controller, several issues had to be resolved:

a. The system had to have more processing capability (i.e. 32-bit processor).

b. The system had to have more file space and available memory.

c. The system had to have intelligent control algorithms, not only for operating and optimizing each plunger lift system, but also intelligent site management controls.

d. The system had to have highly scalable I/O pending individual site requirements.

e. The system had to do and have all these things yet be economical to install and operate and be easy to configure according to site needs.
TODAYS SOLUTION

The current solution was incorporated and deployed in a beta test for the first installation at a site near Loveland, Colorado during February of 2008. This solution allows for up to 24 plunger lift wells to be controlled and optimized while sacrificing no measurement accuracy in the production data. Also, monitoring and recording trend data (Casing Pressure, Tubing Pressure, Line Pressure, Flow Rate, & Plunger Arrival Times) for each well, as well as trending tank and pit levels, separator temperatures, among other data points. Additionally, the RTU monitors and alarms on tank levels among other safety criteria that have the ability to shut-down and shut-in the facility should a condition occur with customizable restart logic that allows for local manual, remote, or automatic reset once the alarm condition is cleared in the system.

Advantages:

a. Controls a large number of wells (up to 24 plungers and measurement tubes) from a single location, the settings for all the plunger applications are available in the same unit (the operator on has to make one stop to control the entire site).

b. Lower cost and speed of installation. It requires only the physical installation of one RTU and associated peripheral equipment, although the I/O wiring is a little more complex.

c. Lower cost to maintain. It requires only one battery power system with a single solar system. Less equipment equals fewer failure points.

d. Easier to configure. All data is available in a single unit, therefore, all configuration occurs in one place.
e. Fewer communications issues since the 485 buss is not necessary and cuts down tremendously on the Modbus communications.

f. Advanced site controls and optimization routines for the plunger wells to intelligently and safely operate the facility.

g. Additional system processing capacity available for continued advancement of facility and plunger lift controls.

Disadvantages:

a. Single point of failure at the RTU. This can shut down the entire facility.

b. Some amount of complexity in the configuration due to the amount of information contained within the system.

As mentioned earlier, today’s solution has raised new concerns as a by-product of the current systems capabilities.
TOMORROW’S SOLUTION

The goal of tomorrow’s solution is to further increase the number of advantages and decrease the number of disadvantages of using a highly scalable controller in this type application. To accomplish this task, several areas have been identified as needing improvement, enhancement, and redundancy.

This obvious issue with a single unit have the ability to control a more vast system, is the loss of the system during a failure and the time it takes to restore the system to an operational state. Two philosophies have been derived from IT type technologies, one is a short term solution, the other longer and more robust, but also more costly.

1. Short Term Solution: Live “Hot” configuration backup being kept on-site: This solution can be accomplished with a feature that would allow the operator to either set a typical back-up window (usually some time in hours), and give the host system the ability to invoke an on demand back-up of the system. This solution minimizes the downtime of the system to the time it takes to get a service technician to the site with equipment and replace the failed unit in the enclosure. By utilizing a schedule back-up of the system, this means when a unit failure occurs, the facility can be brought back on-line is the state that was present at the time of the last site back-up. This becomes especially important when tuning and optimizing advanced plunger lift algorithms.

2. Robust Solution: Parallel System: This solution is optimum in that it would be a truly redundant system, yet requires considerable development and capital to employ. The parallel system could be
equipped to take over the real-time operation of the site if a failure of the primary system is sensed. Only when there is a level of risk or financial exposure to downtime does this option become viable for further development. Considerable resources would be required to implement this option.

Continue to refine the user interface into the system. Traditionally, instrumentation equipment has not had the most user friendly interfaces & has somewhat lagged behind the current technologies. The immediate need is for simplified, intuitive interface (HMI or GUI) into the complexities of the system, especially when working with certain advance plunger operations. Possible solutions could employ popular technologies such as XML or Java driven web browser interfaces utilizing TCP/IP protocols which lend themselves to being highly customizable for site and operator specific needs. Additional local communications mediums such as USB, Bluetooth, Wireless Access Points, WiFi, and Ethernet may further the development of this type solution. A possible benefit of this enhancement would be reduced operating training and learning curves due to intuitive interfaces.

Define and implement role based access to the device. As with many companies, more than one division of the company will need access to the same device for information, yet one division many not need access to certain parts of the system and could possibly cause harm if the were to make a mistake in the wrong part of the unit. Role based access could limit certain types of users to certain to the areas of the device that they need access to, yet protect other users of the device by protecting their data from being accidently making changes.

Continue the exploration and development of more intelligent control algorithms.
1. Expand and enhance individual plunger algorithms.

2. Further refine and automate site and facility control algorithms.

RESULTS AND BENEFITS

***** I'll need some additional input from Anadarko for this section. *****

* Reduction of the facility’s carbon footprint.

* Health & Safety Advantages from not venting loaded wells to atmosphere due to operating wells on pressure and rates versus operating them on time.

* Operator time scheduling/saving/efficiency.

FUTURE REQUIREMENTS

***** I'll need some additional input from Anadarko for this section. *****