PLUNGER LIFT PERFORMANCE OPTIMIZED BY FLOW AND PRESSURE OPERATED CONTROL SYSTEMS IN A TURNKEY INSTALLATION

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ABSTRACT

Fluctuating line pressures and liquid loading are a bad combination and in the Moxa Arch field in Southwestern Wyoming they presented the operator and Weatherford Artificial Lift Systems with a perplexing problem. Can conventional plunger lift be effective in an area with severe line pressure fluctuations? Can it provide for efficient removal of accumulated fluids while reducing or eliminating the need to vent the well and minimizing the time that the lease operator has to spend at the well location? Finally, can this be accomplished with limited resources of field personnel who are unfamiliar with the workings of plunger lift?

This paper will discuss a 90 well plunger lift project in the Moxa Arch field that was successful in positively answering all these questions. It will describe the field history, the well candidate selection process, the initial pilot project and the total turnkey installation of plunger lift into 90 wells in a *3* month period of time. It will discuss the advantages of using an Integrated Solution Team approach to the project which provided for fixed installation costs and increased stabilized production, without placing additional burdens on the limited field personnel pool available.

FIELD HISTORY

Weatherford Artificial Lift Systems began to research what type of plunger lift installations had been installed in this field in the past and why had they been unsuccessful. For some time, the Moxa Arch field had been running a combination of time cycle and self-adjusting plunger lift controllers, which had been generally unsuccessful. While these controllers have proven to be successful in liquid removal in normal production situations with mild line pressure fluctuations, they proved to be unsuitable in this field where the line pressure can jump 100 psi in 60 minutes. This sudden increase in line pressure presents a problem for standard time cycle and self-adjusting controllers and wells still have to be blown to atmosphere so that optimization is very time consuming for the operators.

The use of "B" valve or atmosphere valve had proved **to** be viable alternative. The sudden increases in line pressure would slow or stall the plunger arrival and if the plunger failed to surface during the normal "on" time, the controller would open a controlled tank valve to give the well additional differential to try *to* surface the plunger. Upon plunger arrival, the controller then closed the "B" valve and moved into a sales delay mode or shut in for plunger fall time. Although this method appeared to help normalize production and did reduce the operator's time on location, gas was being vented to atmosphere, a practice that had to be reduced or preferably eliminated due to environmental considerations. In addition, as prices for natural gas increased so significant revenues were being lost due to this practice.

Fluctuating line pressure was not the only reason that plunger lift had been unsuccessful, as economic restraints became tighter and more responsibility was placed on fewer field employees, the amount of time required to optimize a plunger lift installation was simply not available. In addition to reduced personnel resources, adequate training on the existing plunger lift controllers was not provided, resulting in the wells being neglected and production suffering accordingly, eventually leading to the plunger lift equipment being removed from the well all together. In other instances proper plunger maintenance and inspection was not being performed, leading to the plunger failing to arrive and literally falling apart in the well.

PILOT PROJECT

After reviewing the various alternatives to enhance artificially the production on the Moxa Arch Field and summarizing the benefits and problems associated with each, it was decided that plunger lift was still the most logical and economical choice regardless of past experiences. Based upon this decision, the operator began to research various plunger lift controllers and plunger lift companies that had experience in dealing with extreme line pressure fluctuations such as in the Moxa Arch Field. The two most commonly used types of controllers for this application are the self-adjusting controller and the Differential Flow type controller. To effectively demonstrate the abilities of both self-adjusting and

differential controllers a pilot program consisting of 10 wells was installed. The ten wells, split evenly between two types of controllers (vendors), were picked based on similar characteristics including depth, formations, tubulars, line pressures and production. The two types of controller chosen were:

Self-Adjusting/ Auto Adjusting Controllers - these controllers monitor plunger arrival times and automatically make adjustments in the off and sales times for the next cycle based on the plunger arrival speed of the current cycle. This type of controller is reactive to fluctuations in line pressure.

Differential Pressure and Flow Controllers - these controllers monitor casing, tubing and line pressures of the current cycle to determine when the well is ready to come on under existing wellhead conditions. This type of controller can also monitor flow rates or meter differential inches during the sales or after flow time to determine when to initiate the off cycle. This type of controller is pro-active to fluctuations in line pressure.

Historical production graphs for each of the ten wells were obtained for a period of one year prior to the original plunger lift installations and a baseline production average was established for each well. For the plunger lift installation to be considered a success with acceptable payout periods a 10% increase in production over the established baseline was needed.

PILOT PROJECT RESULTS

Review of 45 days of new production data on the 10 pilot wells indicated that production increases of 10-45% had been realized with both types of controller. With sustained production increases on all ten pilot wells it became apparent that this pilot project should be expanded to a full field level on acceptable plunger lift candidates. After reviewing gas liquid ratios, tubing and casing pressure differentials and wells that were being blown to atmosphere 150 potential plunger lift candidates were identified. The current gas prices made it very attractive to move rapidly on the plunger lift installations so as to increase field revenues. However the field personnel infrastructure could not handle the additional burden of managing a project of this potential size and pace, and so a Turnkey approach was indicated.

THE TURNKEY INSTALLATIONS

In order to facilitate the rapid implementation of the plunger lift installations an agreement was reached between the Operator and Weatherford Artificial Lift Systems to an Integrated Solution Team approach. Weatherford would perform complete turnkey installation of the plunger lift systems and would provide a project manager that would be responsible for all aspects of the plunger lift installations. This would include candidate selection, slickline installation services, welding and roustabout services, trenching, initial line out and optimization of the wells and training of the operator personnel.

CANDIDATE SELECTION

It was decided that the plungers would be installed thirty wells at a time but, before work could begin on the first thirty wells, the candidates selected, based on differentials and GLRs, were further reviewed to ensure that they were also acceptable candidates with respect to downhole configuration. Then all the relevant well file data required for a plunger lift installation was placed in separate project binders grouped by geographical proximity. This would allow for all installation services to be performed with minimal travel around the field and the most efficient flow of services from well to well.

The binders allowed for quick reference to review any well's history or current stage of installation with out risk of misplacing the actual well file. They included well bore diagrams, tubing tallies, perforation depths, work-over history reports, copies of any recent wire-line or slick line reports and production data. Each well had a standard cover page that allowed for quick access to pertinent well information. Once this data had been obtained and the candidate list finalized on the first thirty wells, arrangements to start the turnkey project were made.

PROJECT COORDINATION

Before any work could begin, all of the various third party services were gathered for a pre-project meeting to discuss the work to be performed and to conduct Health, Safety and Environmental planning. A detailed description of each phase of the project was presented and each service company's installation and safety responsibilities were outlined and documented. In order to expedite the installations and ensure fast and efficient resource utilization, installation instructions and completion check sheets were generated.

At the beginning of the project, each service provider would be given installation instructions and completion checklists that included all relevant well information and pointed out any special circumstances that each well may present. Upon

completion of the tasks listed, a completion log was to be filled out and turned in to indicate that this well was ready for the next phase of installation. After reviewing the completion checklist for that phase of the installation, new installation instructions were issued for the next service provider to move on that well. The services provided were as follows:

Slickline Services

The primary responsibilities of the slickline service provider were:

To test the integrity and ID of the bottom master valve and call upon roustabout services to replace it if needed.
To gauge and drift the tubing to check for consistent ID.
To install the bumper spring assembly.
To complete and submit a completion of work log.

Roustabout and Welding Services

After reviewing the slick line completion log and verifying that the well was ready for the next phase of the installation, the Roustabout and Welding services provider was called in with the following main responsibilities:

To lower the wellhead to one master valve to improve flow characteristics and restrictions.
To prefabricate and install the new dual outlet lubricator.
To reconfigure the wellhead flow line and verify its integrity with a pressure test.
To check the integrity of the surface production equipment – separator and heater-treater.
To remove any avoidable surface flow restrictions.
To install the orifice union assembly.
To complete and submit a completion of work log.

Trenching Services

After reviewing the roustabout and welding completion log and verifying that the well was ready for the next phase of the installation, the Trenching services provider was called in with the following main responsibilities:

Contact Wyoming One Call to ensure adequate marking of all flow and pipe lines and thus secure a "right to dig" approval prior to work commencement.
Bury all PE-39 direct burial cables from the wellhead to the production unit to a depth at least **IS"** as required by Operator regulations.
To complete and file a completion of work log.

Controller Installation Services

After reviewing the roustabout and welding completion log and verifying that the controller installation could begin, the installation instructions and well name were given to the Weatherford Artificial Lift Systems Plunger Lift Technician whose primary responsibilities were:

To perform final wellsite inspection, evaluation and integrity tests.
To check the methanol tanks and start injection of the chemical to help reduce the incidence of freezing in the tubing due to the higher pressures expected and to the winter timing of the installations.
To drop the plunger.
To hook up and calibrate all necessary wellhead electronics, controller, sensors and pressure transducers.
To perform a complete controller inspection.
To surface the plunger if necessary, depending on the amount of fluid in the hole and the available pressure, and set the controller conservatively to allow for overnight clean up.

Initial Line Out and Optimization

As part of the turnkey agreement, Weatherford Artificial Lift Systems took full responsibility for the operation of the plunger lift equipment for 30 days after the installation, while the well cleaned up and the controller was optimized for current field conditions. This period was also used to begin to train the lease operators on the use of the controller and basic optimization and troubleshooting.

The primary responsibilities of the Plunger Lift Technician during this initial line out phase were:

To review daily production.
To optimize the well to current field conditions, including ensuring that the plunger was the most suitable for the particular well characteristics – pad-by-pad, brush or spiral type.
To monitor pressures, flow rates and plunger arrival times.

To begin to train the lease operators on the use, optimization and troubleshooting of the control ler.

Training the Operators

One of the main reasons plunger lift had not worked satisfactorily in the Moxa Arch Field was that the operators were not comfortable with the plunger lift controllers being used and had little basic understanding of plunger lift mechanics. In this training program the operators first sat through a basic plunger lift "how-to" seminar and a "hands-on" training session with the controller in a classroom setting, before being introduced to the controller on a well head. The familiarity with the controller that was gained in the classroom was invaluable once the operator was moved into the field. The primary purposes of the operator training were:

To achieve full operator familiarity with the controller.
To teach a basic understanding of plunger lift mechanics and practices.
To teach optimization techniques, troubleshooting and general plunger lift maintenance.
To teach plunger lift safety and blowdown procedures in conditions of ice plug potential.

BENEFITS OF THE TURNKEY INSTALLATION

Numerous benefits can be obtained through utilizing the turnkey approach for installation of plunger lift systems, particularly where an operator has limited manpower to devote to new projects. Some of these benefits are as follows:

Utilization of service companies to select and coordinate all contractors and services. This relieves the operator of the workload associated with identifying and selecting service providers.
Supervision of all contractors and installation of the equipment is done by the project manager.
Fixed costs for the complete installation eliminates cost overruns and the necessity for supplemental AFE's.
Risks, such as problems encountered with wireline operations and other unanticipated problems, normally assumed by the operator are passed on to the service company.
Installation of equipment can be expedited by relying upon service company resources for coordination and supervision. **As** previously discussed, plunger lift systems were installed and operational on ninety wells within three months.
Optimization of the wells production can be accomplished by using experienced and knowledgeable technicians to start up operation of the equipment and make required adjustments. The costs associated with this are included in the turnkey price.
Reduced administrative work for the operator as the result of single source invoicing. Operator receives one invoice for each well or groups of wells instead of invoices from each contractor and service provider.

CONCLUSIONS

The automatic controlling of a plunger lift system, in an environment of severe line pressure fluctuations, is both achievable and effective, with the right degree of planning and transfer of expertise to field personnel. As field resources continue to become scarcer and as more responsibility continues to be spread over a reduced personnel field resources, the use of a turnkey installation on a project of this size is not only efficient but also highly cost effective and can lead to major future economical advantage. The levels of production increase seen in the pilot project wells was continued through the 90 wells of the turnkey project.