Continuous Gas-Lift Optimization: Offshore Gulf of Mexico

March 16, 2005
Executive Summary

Problem

Continuous gas-lift is the most common artificial lift method employed in offshore operations (5). The major problem most operators encounter with continuous gas-lift is maintaining an optimum gas injection rate into each well. Since injection gas is limited in offshore facilities, each well cannot use its optimum gas injection rate. In the past, this optimum gas injection rate was assigned to the well that would yield the maximum oil production.

Ship Shoal 208 is a primarily gas-lifted field located 50 miles offshore the coast of Louisiana. The field has about 50 oil wells, 45 of which are on gas lift, located on twelve platforms, four of which have compressors to inject gas. The four compressors supply 30,000 MCF (1,000 standard cubic feet) to the 45 gas-lifted wells, which is only 60% of the optimum supply. A standard adjustable choke controls the gas injection rate at each individual well. The injection rate often varies because of fluctuations in the gas-lift supply pressure. Therefore, field operators go to each well and manually adjust the gas-lift rate on a trial-and-error basis (6). This approach to stabilizing injection gas requires increased manpower and results in production loss.

Solution

In order to efficiently stabilize gas injection rates in a multiple-well field, a gas-lift optimization system must be installed and implemented. The optimization system monitors gas-lift supply pressure, total gas available, and other variables and accordingly adjusts injection rates to yield maximum production rates (1). The system achieves the final goal by using four tools: maintain a constant gas lift injection rate, real time
wellhead surveillance, optimization well test, and data to desktop. Not only does the field production increase, but the production engineers gain valuable information for field analysis through the data archive program.

The central component of the optimization system is a Programmable Logic Controller installed in the control room with Control-Net communication to the field panels. Human Machine Interface software is used on the main computer to view data gathered by the field panels (3). Data is gathered by field panels through pressure, temperature, and flow transmitters installed on each individual wellhead, gas lift headers, and test separators. Field operators can also set gas injection rates in the software to be executed by the Programmable Logic Controller. All operators will also be fully trained to use and troubleshoot the optimization system.

**Conclusion**

The total cost of the entire project, including training, would be $860,000 (3). With the expected production increase of 350 BOEPD, the project pays itself off in 62 days if the average price of oil is $40 per barrel. The Ship Shoal 208 field would also save on field costs, like transporting operators to each platform after major upsets in production facilities. With the optimization system, all production is monitored and adjusted automatically after facility malfunctions. A similar field, operated by BP, in the Gulf of Mexico that has recently installed an optimization system saw a 450 BOEPD, which equated to a 7% production increase (3). BP’s production engineers no longer waste time gathering and sorting raw field data. They now use that time to execute plans to improve field performance.
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Introduction

Continuous gas-lift is the most common artificial lift method employed in offshore operations (5). The major problem most operators encounter with continuous gas-lift is maintaining an optimum gas injection rate into each well. Since injection gas is limited in offshore facilities, each well cannot use its optimum gas injection rate. In the past, this optimum gas injection rate was assigned to the well that would yield the maximum oil production. Today, a unique point on a gas lift performance curve, as seen on Graph 1 labeled “Optimum Gas Injection Rate”, has been recognized where the cost of the additional injection gas is greater than the additional profit that will be made from increased oil production (1).

Graph 1: Gas Lift Performance Curve

In a typical continuous gas-lift installation, a standard adjustable choke controls the gas injection rate at each individual well. The injection rate often varies because of fluctuations in the gas-lift supply pressure. Supply pressure fluctuates due to compressor down-time, equipment maintenance, and increases in other wells’ injection rates (1).
Historically, these fluctuations were stabilized by adjusting operating conditions such as gas injection choke, on a trial-and-error basis (6). This approach to stabilizing injection gas requires increased manpower and results in production loss.

In order to efficiently stabilize gas injection rates in a multiple-well field, a gas-lift optimization system must be installed and implemented. The optimization system monitors gas-lift supply pressure, total gas available, and other variables and accordingly adjusts injection rates to yield maximum production rates (1). The Amberjack oil field located in the Gulf of Mexico Mississippi Canyon block increased production 600 BOEPD after gas-lift optimization, representing a 7% production increase (3).

The Ship Shoal 208 field located about 40 miles southwest of the Amberjack field has the same characteristics of Amberjack before it installed a gas-lift optimization system. Ship Shoal 208 has about 50 oil wells, 45 of which are on gas lift, located on twelve platforms, four of which have compressors to inject gas. The four compressors supply 30,000 MCF (1,000 standard cubic feet) to the 45 gas-lifted wells, which is only 60% of the optimum supply. Currently, Ship Shoal 208 produces 3000 BOEPD but with the optimization system the production would increase by about 350 BOEPD (4).

To facilitate implementation of a gas-lift optimization program, two factors must be considered before purchasing or upgrading automation systems and gas-lift equipment. First, there are certain field criteria that must be met in order to implement such a program. Second, the anticipated production increase must financially justify the cost of optimization. The following pages will also provide a detailed description of the automation system, the method of implementing it, and qualifications to support the proposal of gas-lift optimization.
The information presented in this proposal came from multiple Society of Petroleum Engineers (SPE) Technical Papers and Presentations. SPE Papers contain the most accurate information and recent technology and are also peer-reviewed. These papers provide specific case studies of Gulf of Mexico fields that have implemented a gas-lift optimization program in the past five years. The *Journal of Petroleum Technology* was also consulted for the history of continuous gas-lift.

**Specialized Acronyms**

- HMI—Human Machine Interface
- MVT—Multivariable Transmitter
- PID—Proportional Integral Derivative
- PLC—Programmable Logic Controller
- RTD—Resistance Temperature Detection
- SSV—Surface Safety Valve
Technical Description

The primary goal of the gas-lift optimization system is to inject less gas to the less productive wells but continue to inject the optimum rate to the most productive wells when supply gas becomes limited (1). In order to accomplish this goal, the optimization system must also allow engineers to observe live data from the field. Then, the engineers can understand how to improve well performances in the field. The optimization system has four main tools that work together to provide the overall benefit (3):

1. **Constant Gas-Lift Injection Rate**—The computer constantly measures gas lift rates and adjusts the injection choke according to the set point. This prevents tubing head pressure fluctuations from affecting the injection rate. Maintaining a constant injection rate decreases the amount of slugging in wells and therefore, decreases instability in production processes.

2. **Real Time Wellhead Surveillance**—This tool allows the engineer to see temperature and pressure data from individual wells. This replaces two-pen chart recorders that are read manually by field operators.

3. **Optimization Well Tests**—In order to determine the optimum gas lift injection rate on each well, an optimization well test must be run on each well. The computer runs the test and plots fluid flow versus gas lift rate.

4. **Data to Desktop**—The last tool transmits all the automation data back to the office and stores it in a database. The engineers can access this data and customize the interface to display any information from the optimization system.
**Field Criteria**

Any oil field that produces on continuous gas-lift is a potential candidate for gas-lift optimization. The field’s wells must be equipped properly with tubing, flow line, gas lift mandrels, valves, and spacing. If the wells meet industry standards in gas lift equipment, then the wells will have the greatest economic efficiency at optimum gas lift injection rates (2).

More specifically, fields that lack equipment to measure flow-line pressure, temperature, and production casing pressure are candidates for gas-lift optimization (3). Currently, Ship Shoal 208 measures tubing and casing pressure by portable two-pen chart recorders. Each well is monitored for three days and then the chart recorders are moved to another well. Two-pen chart recorders also measure the instantaneous gas lift rate through a shared test loop. Field operators must adjust the gas lift rate by turning a manual choke and constantly look at the chart recorder to check the rate. The gas-lift optimization for each well is useless due to manual data gathering and analysis. The manually gathered data is affected by (3):

- Accuracy and calibration of the two-pen chart recorders.
- Operators accurately labeling the chart.
- Facility upsets, line pressure fluctuations, and compressor down-time.
- Operator time, experience, and diligence.

The last criterion for gas-lift optimization is the need to decrease operating costs. Gas-lift optimization systems provide optimum gas lift injection rates with minimal manpower (2). Operators at Ship Shoal 208 are transported from platform to platform to readjust injection rates for major supply disturbances and daily variations.
Method

In order to acquire the necessary data for gas-lift optimization, new hardware must be installed at each individual wellhead, gas lift headers, and test separators.

*Table 1* below shows the required equipment for the three locations (3):

<table>
<thead>
<tr>
<th>Wellhead</th>
<th>Gas Lift Header</th>
<th>Test Separator</th>
</tr>
</thead>
<tbody>
<tr>
<td>♦ Pressure transmitters to the flowline and production casing.</td>
<td>♦ Two inch stem and seat throttling globe valve with a 6 to 30 psi actuator, throttled by the gas lift control panel for each well.</td>
<td>♦ RTD temperature probe and pressure transmitter.</td>
</tr>
<tr>
<td>♦ RTD temperature transmitters to each flowline.</td>
<td>♦ Flange type orifice meter upstream of the control valve with a MVT to continuously measure the gas lift injection for each well.</td>
<td>♦ MVT across an orifice meter to measure the gas rate.</td>
</tr>
<tr>
<td>♦ Discrete pressure switches to the pneumatic SSV to detect a shut-in well and count the resulting down-time.</td>
<td>♦ Gas lift control panel that receives the gas lift rate from the MVT and controls the gas lift rate thru the control valve.</td>
<td>♦ Turbine meter counters on oil and water dump lines.</td>
</tr>
</tbody>
</table>

*Figure 1* (3) illustrates a typical wellhead equipped with pressure, temperature, and flow transmitters; pressure switch; and control valve. Each individual well at Ship Shoal 208, regardless of whether it is gas-lifted or not, must be properly equipped in order to maximize potential of the optimization system.

*Figure 1: Individual Wellhead Schematic*
The central component of the optimization system is a PLC installed in the control room with Control-Net communication to the field panels. After receiving data from the field panels, the PLC performs PID loop control of the gas lift rate to maintain the optimum rate through the control choke. HMI software package gathers data from the PLC and displays it for platform operators (3). The HMI software also works in reverse. Gas lift injection rates are entered into the HMI and then sent to the PLC for execution. All the data gathered by the system is also archived in a database onshore at the office headquarters. At the main office, production engineers can access data from the database to analyze the field performance.

Figure 2 (3) below shows the entire optimization system schematic. It maps out the path of data from wellheads and gas lift headers, to the field panels, to the PLC, and finally to the HMI where operators can see graphical data. The other path of data from the PLC goes to the archive system at the office headquarters onshore.

![Figure 2: Optimization System Schematic](image)
Costs

After installation of the computer system and required equipment, the offshore employees must be trained to use the optimization system to its fullest potential. The offshore personnel will attend a week long course focusing on the specific equipment that was installed. They will also learn how to troubleshoot each transmitter, valve, and field panel. In addition, offshore operators will become familiar with the PLC and HMI software so they can communicate effectively with the production engineers in the office.

The cost of the entire gas-lift optimization system, including installation and training, is $860,000 (3). The estimated production increase from 3000 BOEPD to 3350 BOEPD justifies the cost of this project in approximately two months; if the average price of oil is $40 per barrel. The estimated income increase from production is 350 BOEPD multiplied by $40/BOE, or $14,000 per day. In 62 days, the total income from the production increase is $14,000/day multiplied by 62 days, or $868,000. In Appendix A, increased revenue from varying production rate increases was plotted against time (in months). A horizontal line was drawn at the project cost to illustrate how many months it would take to justify the cost of the project if the production increase was lower or higher than the expected 350 BOEPD. The last point at twelve months represents the increased revenue during one year of gas-lift optimization at varying production increases.
Qualifications

In the first three years at Marietta College, I (Matthew Peloquin) have gained valuable knowledge in many aspects of petroleum engineering. Most recently I have completed courses in Drilling Engineering, Reservoir Engineering, Production Engineering, Formation Evaluation, and Petroleum Geology. These courses have provided me with an extensive background in petroleum engineering that can be applied to the specifics of gas-lift optimization.

Additionally, this past summer I worked for UNOCAL at Ship Shoal 208 offshore in the Gulf of Mexico. While at Ship Shoal 208, I worked on a summer-long project manually optimizing each gas lift well. By doing so, I learned how tedious and inefficient the process of manually optimizing gas lift wells can be. From this experience at Ship Shoal 208, it is with great confidence I propose a gas lift optimization system for the field. My (Matthew Peloquin) resume is attached in Appendix B.
Conclusion

In order to produce a well at its greatest potential, the optimum conditions must be maintained in the wellbore and at the wellhead. For a gas-lifted well, these optimum conditions mean optimum gas injection rate from a limited-supply compressor. Today, in the petroleum industry, the only way to meet this need is through a fully automated gas-lift optimization system. The system proposed for Ship Shoal 208 will not only increase daily production but it will provide the production engineers with real-time data that can be used to troubleshoot and enhance the performance of production facilities.

Similar fields in the Gulf of Mexico have had success with gas-lift optimization systems, like the one proposed for Ship Shoal 208. BP’s Amberjack Field in the Mississippi Canyon Blocks installed one such system and increased production 600 BOEPD, while the anticipated increase was only 450 BOEPD (3). The “production wedge” that the optimization system provided for the Amberjack Field is clearly shown in Figure 3 below (3). Shortly after the optimization system was installed, production rate increased steadily from about May 2002 until the end of testing in December 2002.

![Figure 3: Increased Production at Amberjack Field](image_url)
Another success of optimization was Texaco’s Lake Barre Field located in Terrebonne Bay, Louisiana, approximately 18 miles north of the Amberjack Field. Appendix C shows well tests measuring the gas injection rate and gross oil production without the optimization system (1). The tests show that constant fluctuations in supply pressure cause gas lift rate instability along with production variation. When the gas rate increased above the optimum rate the production decreased, which is an inefficient and ineffective use of injection gas. Once the optimization system was implemented, the gas lift rate and gross production of the well tests stabilized, as shown in Appendix D (1). The injection gas was held around the optimum rate and not wasted as production was maintained.

Other than increased production, the optimization system at Amberjack allowed the production engineers to focus their time on improving well performance. Before the system was installed, engineers spent 80% of their time gathering, sorting, and filtering data and only 20% analyzing that data (3). Now, engineers still spend the same amount of time analyzing data but 80% of their time is spent creating and executing plans to improve field performance (3).

The most important factor to remember when installing such a system is that it cannot do everything by itself. There must be human intervention with the gas-lift optimization system everyday in order for it to achieve maximum potential. Production engineers must consistently use the system to access and analyze field data and make the necessary changes to increase production.
Works Cited


Appendix B

<table>
<thead>
<tr>
<th>Present Address</th>
<th>Permanent Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marietta College</td>
<td>205 Franklin Avenue</td>
</tr>
<tr>
<td>215 Fifth Street</td>
<td>South Plainfield, NJ 07080</td>
</tr>
<tr>
<td>Box 1365</td>
<td>(908) 756-3170</td>
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<tr>
<td>Marietta, OH 45750</td>
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</tr>
</tbody>
</table>

### OBJECTIVE:
To obtain a permanent position in the petroleum industry based on my experience in drilling, reservoir, and production engineering.

### EDUCATION
- **2002-2006**
  - Marietta College, Marietta, OH
  - Major: Petroleum Engineering (Accredited by the EAC of ABET)
  - Bachelor of Science in Petroleum Engineering, May 2006
  - Cumulative GPA 3.88/4.00
  - Petroleum Engineering GPA 4.00/4.00

- **1998-2002**
  - South Plainfield High School, South Plainfield, NJ
- Diploma, Graduated number 9 out of 250, GPA 4.25 (4.0 scale)

### EXPERIENCE:
- **UNOCAL** (Engr. Intern II - Offshore GOM) Ship Shoal 209
  - May 2004-August 2004
  - Executed well tests and mudoutab work
  - Optimized gas lift wells
  - Observed drilling rig and wire line operations
  - Performed weekly and monthly platform safety inspections
- **Anadarko Petroleum Corporation** (Engr. Intern II - Onshore) Tx, TX
  - May 2003-August 2003
  - Relief pumped and mudoutab work
  - Designed new Excel spreadsheet to capture and display Step-Rate Tests
  - Performed Step-Rate Tests in order to analyze water flood
  - Determined a solution to create more water on-hand to inject
  - Observed liner, acid perforation, fracture, and other general well services
- **Marietta College** (Athletic Department) Marietta, OH
  - August 2002-May 2004
  - Organized sporting events
  - Assisted in event setup
  - Managed statistics
- **Outback Steakhouse** (Busboy/Host) Greenbrook, NJ
  - November 2000-August 2002
  - Minimized waiting time for customers
  - Excelled in customer service
  - Provided a lasting impression
- **Number One Maintenance** (Landscaper) South Plainfield, NJ
  - June 1999-August 2002
  - Operated the business
  - Maintained a healthy lawn for customers

### HONORS:
- Chevron Texaco Scholarship, Kappa MU Epsilon National Mathematics Honor, UNOCAL Scholarship, Alpha Lambda Delta National Scholarships Honor, Robert L. Bruce Petroleum Engineering Scholarship, Trustees' Scholarship, Adele de Leeuw Scholarship

### COMPUTER KNOWLEDGE:
Extensive experience with Microsoft Windows and Office XP
Proficient at installing internal and external hardware

### LEADERSHIP:
- Lambda Chi Alpha Fraternity (Social Chair, 2005; Vice President, 2004), Society of Petroleum Engineers Treasurer, Recreation Basketball Coach

### VOLUNTEER EXPERIENCE:
- North American Food Drive, Humane Society, Campus Clean-Up, Recreation Basketball Coach