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Right-Time Decision of Artificial-Lift Management for Fast Loop Control

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Abstract

This paper describes the efforts of Petrobras to design control strategies for artificial lift optimization. The work relies on several challenges starting with a process variable identification for each artificial lift method up to the implementation of control algorithms on wellhead. The target achieved is an artificial lift closed loop management.

Onshore and offshore cases will be presented showing the different sensibilities and importance that the same variable can represent depending on the artificial lift method and the well type completion. It will also be discussed an option of high level language tool to translate the experience of petroleum engineers into field algorithms.

Petrobras elected three values as the main target for fast loop design:

- First, to develop tools to add operational flexibility and right time decision for the artificial lift methods. The objective is to assure the best economical production point for each well, even under flowrate change due to zone selectivity and secondary recovery management. Another focus is to enable real time analysis, fault diagnostic and permanent monitoring. Technologies behind these tools are based on heuristics and artificial intelligence.
- Second, to develop a methodology that facilitates the translation of knowledge from a senior petroleum well analyst into field strategies. A photography of the oil industry professionals shows an advanced age profile. The expertise of those engineers applied in real time is one of the milestones to reach the profits that the Smart field development allows.
- Third, field connectivity and data availability. The automation architecture is designed to be hardware and software independent. The objective is to assure data to reach the analyst with transparency of hardware and software implementation. Communication specifications represent the project data flow assurance. This communication directive is the key for integration between smart completion and artificial lift automation. The synchronized production data integrated with reservoir engineering analysis built Petrobras strategy for fast and slow loop management.

Introduction

The concept of *fast loop*, also known as *short term* comes from the strategy of Digital Integrated Production Management (Intelligent Field). Figure 1 depicts the Petrobras approach to this concept. The values behind this large step that oil companies worldwide are facing relies on the belief that more **integration** between exploitation activities (from reservoir management to production operations) coupled with a better **process perception**, powered by digital technology, will result on safer operations, OPEX reduction and profit gains.

The materialization of the desired smartness has strong relationship with the capability to perform right time decisions, which is related with process delay [1] and human resource availability to monitor production dynamics.

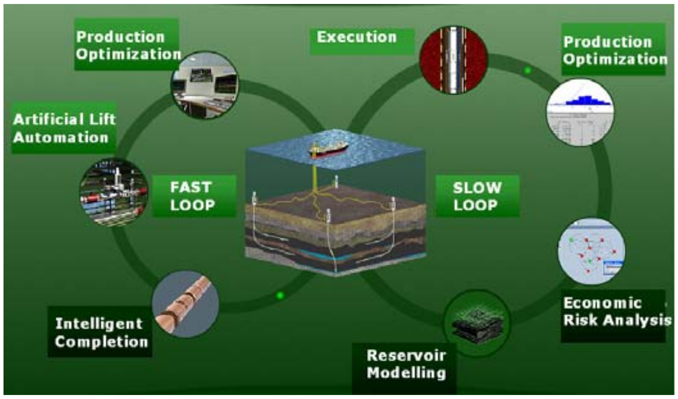

Figure 1 – Petrobras fast and slow loop integration model

Field production integration, shown in Figure 2, is a multidisciplinary task between petroleum, process and automation engineering. Interaction of control and monitoring will retrofit information to process model, while the intercession of monitoring and optimization enables data management to perform, cleansing and filtering of raw data to be manipulated. The production management is the result of expert analysis translated into optimization algorithms, powered by control techniques [2, 14, 15, 16].

Under a control engineering point of view, artificial lift management has less resistance to optimization and modeling than a slow loop process due to faster feedback response. The capability of right time decision is the influenced by:

- implementation of closed loop
- automation architecture
- process variable identification
- bilateral field knowledge transfer
- connectivity and data integration

Field plan development strategy influences daily production management and the fast loop algorithms design. It will restrict the sensibility of the variables, mainly the surface ones, due to the subsea arrangement. The choice of wet or dry completion, the use of manifold or satellite wells, the number of wells and their distance are driven mainly by economic analysis and flow assurance constraints. It seldom takes into account the impact of its decision for daily optimization production. So, the optimization work relies on an established scenario where the process identification is crucial to reach final results. The same set of variables used in one scenario for a feedback control strategy can be a wrong approach for another, depending on the local environment, even for the same artificial lift method. Generalization of strategies must be careful analyzed considering the algorithm application envelope.

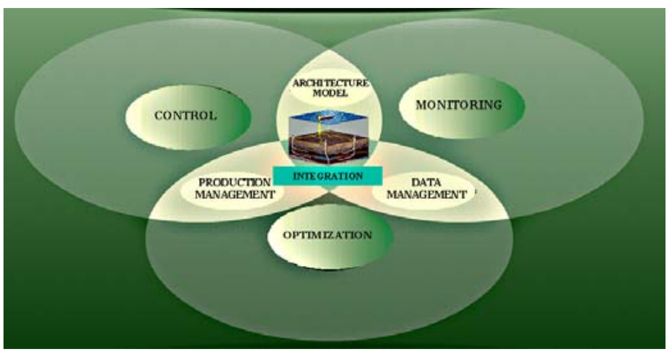

Figure 2 – Knowledge intercession involved on field integration

Closed Loop vs Open Loop

Open loops are advisable for systems in which the inputs are known ahead of the time and in which there are no disturbances. That's not the case of artificial lift management. The advantage of using a closed loop control approach applied to multiphase flow artificial lift process is the fact that the use of feedback makes the system response relatively insensitive to external disturbance. On the other hand, great care must be taken with the stability, due to the risk of overcorrecting errors and, thereby, causing oscillations [3].

Traditionally, artificial lift production management is done through an open loop approach. The most important reasons for that is the difficulty of individual phase flowrate measurement inr multiphase flows. Multiphase metering technology is available but its high cost and maintenance still hinders the widespread application in individual wells. There is no doubt about the value of direct measurements of produced oil flowrate for well optimization; it is the desirable controlled variable for any artificial lift process. Gas injected flowrate and pump speed rotation are classical manipulated variable depending on the lift method. Another fact that contributed for the predominance of open-loop systems in well management for decades was the assumption that well flows in a steady state condition. Consequently, checks on well productivity were performed just periodically (weeks or even months). However many internal and external disturbances influence the production and must be corrected at the right time. The production losses associated of a non-optimized well management contribute to decrease the final recovery factor of the field.

Nowadays, the increase of control engineering application in upstream together with artificial intelligence techniques is addressing new questions: How accurate must be oil flow rate measurements in order to optimize production? Is it possible to perform optimization with estimated variables? Which variable or set of variables can indirectly give the information of oil production in a constant base for a closed-loop control?

Right Time Decision and Real Time

Smart field implementations are strongly associated with Real Time Operations. The meaning for RT is a discussion that doesn´t have a consensus, but some convergence can be highlighted. The SPE TIG RTOptimization [4] group describes Real Time as a process of measure-calculate and control cycle at a frequency, considering the time constant constraint of the system in order to reach and maintain the optimum operation. The IEEE concept supplied by Locke [5] names a real time as a system whose correcteness includes its response time as well as it functional correctness. RT systems are also classified as Hard or Soft Real Time depending on the consequence of a missing deadline. Schiesser and Mc Guire[6] define Hard Real Time as an application that has real, serious, non-negotiable deadlines. For these systems worst-case timing is critical, and missing a deadline is a failure. An example is a computer-controlled car braking system. Soft Real Time has the characteristic that missing a deadline degrades the quality but, is not a failure. Most of the systems are in this classification.

Regarding upstream petroleum process control a good definition merges Real Time and Closed Loop operation[7]. It is called a real time operation if the combined reaction and operation-time of a task is shorter than the maximum delay that is allowed, in view of circumstances outside the operation. The task must also occurs before the system to be controlled becomes unstable. A real-time operation is not necessarily fast, as slow systems can allow slow real-time operations. This applies to all type of dynamically changing systems. The polar opposite of a real-time operation is a batch job. The consensus of all concepts is that value of Right Time Decision of Artificial Lift Management for fast loop control has full dependence of process response delay identification. Dynamics on lift process for an artificial lift method happens in seconds, minutes and hours. A full time closed-loop control system is necessary, mainly not because of short delay of seconds but to avoid production losses. When operational conditions changes the system has to react and find again the best operational point on a self manner

For Petrobras, embeded decision is the ability of adding to a process the flexibility that, considering the uncertainty and preferences, choose just one action among several possibilities. It results in a system capable of self adaptation under new situations, understanding relations between facts, discovering meanings, recognizing strategies and learning based on experience[8].

Process Variable Sensibility Analysis

Deep water offshore well optimization management is highly dependent on well completion decisions during field development. The instrumentation location along the well bottomhole, xmas-tree, flowline, riser and production unit will define if the available monitored variable is sensitive enough to compose a continuous diagnostic and optimization system. Sensibility variable analysis are required to excite both steady-state and dynamics of a process. The next step is process model identification from input-output data. To prepare for a formal plant test, a pre-test is usually necessary for three reasons:

- step each manipullated variable and adjust existing instruments and PID controllers;

- obtain the time to steady state for each Controlled Variable

- obtain data for initial identification.

Temperature

The constraints of each production system needs to be identified and analysed. Regarding investigation of temperature on production unit on offshore wells, many internal and external disturbances, like gas expansion, ocean currents, reservoir temperature, pipeline insulatoin efficiency will influence on heat transfer and the coupling with prodution rate.

Petrobras performed a study on a offshore production unit with the objective to find a low cost maintenance strategy with surface variables, to avoid dependence on subsea intervention. The first approach was to investigate the behaviour of temperature in the platform production header. The well chosen was from Campus Basin, on Marimbá Field, and its characteristics are shown in table 1.

Well Informations
Water Depth: 480m
API: 27
Completion: wet x-tree, Satellite well
Artificial lift method: Gas lift
Flowline length including riser: 2280m
BSW: 0 %

Table 1 – Information of the well for temperature investigation

The test was performed by changing gas lift rate and investigating the correlation of production rate, measured on test separator circuit, and the temperature profile. The objetive was to identify the sensibility of a possible control pair of manipulated and controlled variables to model the process. Figure 3 shows the well manipulation on steady-state steps of gas injection.

Field results demonstrates that the temperature on the platform production header and oil flow rate performed a proportional behaviour explained by the canonic theory of mass conservation and heat tranfer, without being dominated by external season disturbance, as depicted on Figures 4 and 5. Althoug this satisfatory behaviour was percieved, a good sensibility window for control optimization purpose was not achieved. Even with production variation of 5 m^3/h, the amplitude of the temperature reached no more then 1,5 °C as depicted in Figure 6.

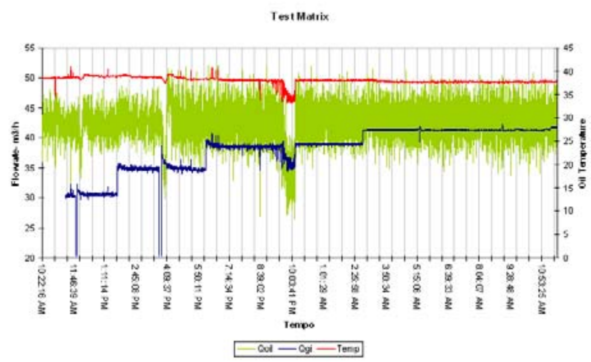

Figure 3 – Matrix test with stability steps for temperature, flow rate and gas injection correlation

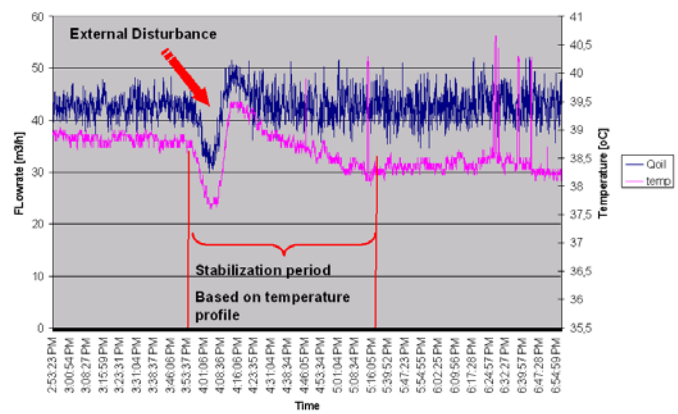

Figure 4 – Stability period diagnostic performed by temperature after dynamics of the system.

In spite of the fact that results of temperature sensibility were not satisfactory for optimization, the variable shown good performance for diagnose purposes. On Figure 4, is depicted a stability period definition based on the temperature profile after a controlled external excitation performed by the operator. This information helps to define the maximum time necessary for a well test procedure, optimizing well test period per well.

It's clear that each production scenario will define the greater or smaller functionality for an individual variable. Lementayer et. al [12] from TotalFinaElf, show that temperature was used with good performance on a dry completion gas lifted field. The tubing head temperature was high enough on the production unit, allowing good sensibility. Field experience demonstrates that temperatures reaching the surface with less then 45° C is much susceptible to external disturbances on offshore satellite arrangements, decoupling the temperature information from liquid flowrate. Boisard et al [13], in another paper of TotalFinaElf, tried first a surface temperature approach, but sensibility results led the group to use bottom hole pressure as the controlled variable. The use of

DTS (Distribute Temperature Sensing) on horizontal section is other good example of temperature analysis from production diagnostic. The Joule-Thompson effect due to gas expansion can be monitored delivering information of horizontal section length efficiency. In this case, very few changes on temperature, in magnitude of decimals, are relevant and can be associated with production inflow, as the environment of measurement has a stable geothermal profile.

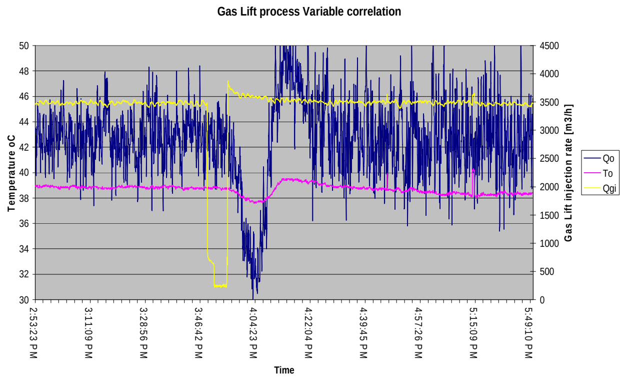

Figure 5 – Temperature and flow rate dynamics due to gas lift manipulation.

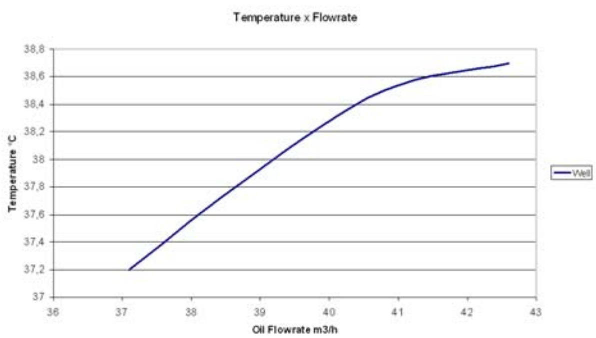

Figure 6 – Temperature x oil flow rate sensibility

Differential Pressure (DP)

Petrobras has a production facility in the Amazon, the Urucu field, a high GOR and light oil production scenario. Amazon forest is a great gift of nature in the planet, and therefore, a very sensible and alive ecosystem. In this environment, one of the challenges for the human-forest relation is logistics, mainly on the raining season. This scenario led Petrobras professionals to understand that remote operations and continuous monitoring of well variables, including oil flowrate, were key values for a safety and fast response operation. Regarding flow rate, the first idea was the installation of multiphase meters, but at that time measured uncertainties were high and costs were prohibitive.

In 1995, an in-house metering system composed of two orifice plates located on upstream and downstream of the production wellhead choke, plus temperature sensors was designed and installed to estimate multiphase flow rate. The idea of the assembly was make the most use of pressure drop and flow stabilization that wellhead choke produce, due to high tubing head pressure and GOR.

The sensibility of the differential pressure signal and its relation with flow rate were very satisfactory, as depicted on Figure 7. The red trend is the liquid flow rate on the test separator, its oscillations were very well tracked by the downstream differential pressure signal, seen as a yellow trend. So, the sensibility results permitted the design of a continuous monitoring system for individual wells, with an algorithm correlating the surface variables. The diagnostics of GOR breakthrough, the well testing identification and its duration are some of the profits of the system. Nowadays, a neural network was programmed to generate a universal equation for the algorithm to be extended for all wells, minimizing calibrating necessities for each scenario.

A temperature sensibility test was performed in a gas lift well in urucu field, in order to get a comparasion with the studies done in the offshore scenario. The results demonstrate that increasing the gas lift rate, a decrease of temperature in wellhead is observed, because the liquid was cooled due to the gas expansion and flow velocity rise. It's possible that natural flow wells perform a different manner, but this was not part of the scope of the study. The motivation of it was to find a pair of controlled and manipulated variables for artificial lift closed loop control.

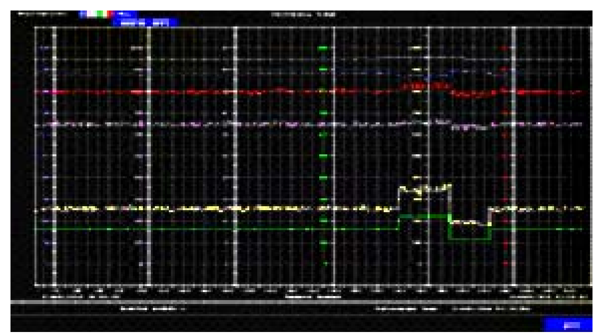

Figure 7 – Sensibility of the DP on a flow rate oscillation

The frontier of the DP approach application is a question that needs to be clarified. In order to find answers, tests where performed on a multiphase loop circuit. This loop is a Petrobras research (R&D) facility, where different flow arrangements can be generated. An intermediate scenario with 25 API oil, 54 cp and low pressure drop was investigated. The results, depicted on figure 8, shows that for this composition the DP still presents good sensibility. It's expected that this will not be true for much heavier oils.

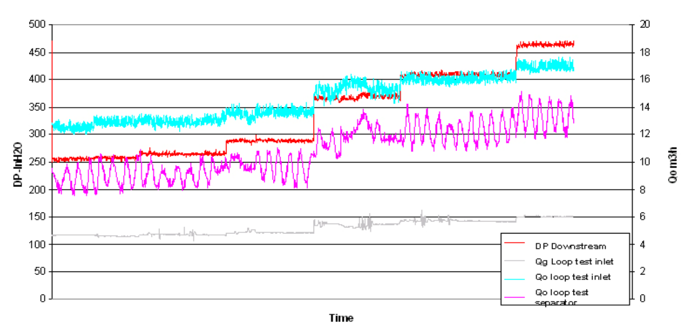

Figure 8 – DP sensibility test on multiphase loop circuit

Closed Loop Artificial Lift Systems in Petrobras

Petrobras helds a decentralized R&D process in some of their assets, involving local artificial lift experts and local universities. The goal is to put the engineering expertise at the well site, using customized PLC's. On of them resulted in a five year project development with a state university, programmed a firmware that allows the engineer expertise to get close to the well site, for sucker rod pumping and intermittent gas lift applications. This firmwares allow the engineer to specify the shape pattern for the dynagraph cards or the casing/tubing pressure records and write an algorithm to be executed at the PLC which define the well behavior, acting over the artificial lift hardware available at the well site, such as the electric motor, the variable speed drive or the motor valve, depending the artificial lift method installed.

Rod Pump

In the rod pump system the downhole dynamometer card, or dynagraph, can be used as the controlled variable and the pumping unit strokes per minute as the manipulated variable. As a matter of fact the dynagraph shape is the monitored variable. Pattern recognition based on artificial intelligence concepts is used to match a set of dynagraph patterns with the dynagraph calculated for each beam stroke. The main idea is to allow the field team to generate patterns based on their own experience supported by an intelligent algorithm, designed to perform graphical analysis of the card shape.

The oil well automation is nowadays a tool widely used to monitor, control and improve oil well performance. Artificial intelligence concepts and techniques are used to help the oil field team to not only manage the wells but also to code their own expertise in a knowledge database to be used by a PLC to control the well at the very well site. In this matter the downhole dynamometer card pattern recognition plays an important hole, due to the high level of empiricism that is still used in practical cases.

Eight hundred wells, located in the Northeast Brazil, operate under a system that depicts the concepts above. Besides the matching process the system allows the engineer to implement an algorithm in a friendly user language. The matching process together with the algorithm, allow the implementation of the expert reasoning about the well behavior thus depicting an autonomous and intelligent monitoring/controlling system operating in a small Programmable Logic Controller (PLC) at the very well site, with a satisfactory performance[15].

So, the Rod Pump optimization decision begins at the wellhead performed by a PLC firmware, known as SCUB, where the pump dynagraph card is classified based in a set of pre-designed card patterns that represents situations such as, normal operation, pump-off, traveling valve leak, as depicted on Figure 9.

An algorithm written by the local artificial lift champion is then executed by the PLC to analyze the well conditions based in that classification and to perform actions, like stopping the well operation or send a warning to the central office.

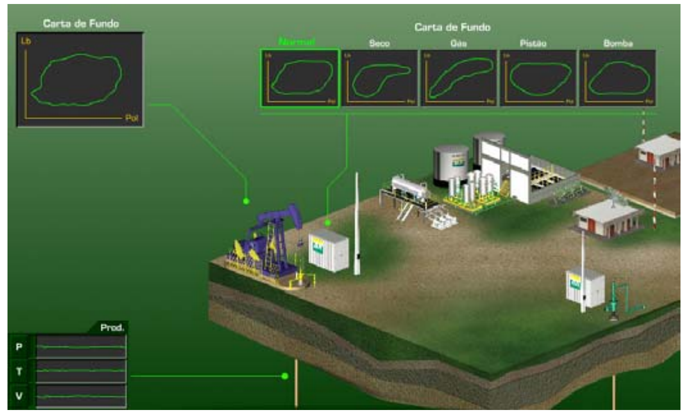

Figure 9 – Rod Pump Control based on pattern recognition

All the well data generated by the SCUB firmware are sent to the central office in a non-stop sequential pooling, and stored in an access type data base, to be merged to the well servicing and production data for overall oil field analysis.

Intermittent Gas Lift

Intermittent gas lift is widely used in the Petrobras onshore petroleum fields. The intermittent gas injection in the annulus between the tubing and casing causes a gas lift valve to open. This gas lift valve is a pressure driven valve installed in the lower part of the tubing and controls the amount of gas injected at the bottom of a liquid column held inside the tubing. The injected gas becomes a big gas bubble that carries the liquid column up to the surface. The intermittent cycles are obtained by a motor-valve installed at the surface opening and closing at fixed time intervals (Time cycle - Tc) and remaining open during a fixed amount of time (Time injection – Ti). A firmware for the PLC was especially designed to optimize both Tc and Ti. Based on the tubing and casing pressure continuously acquired by a pair of electronic pressure transmitters (PT) and on artificial intelligence (AI) concepts such as neural nets and fuzzy logic, this firmware performs the pattern recognition of the casing and tubing pressure behavior, executes an algorithm implemented by the user and gives a diagnostic about the performance of the system[16]. With the diagnostic and changing the values of Ti and Tc, the electronic device improves the system performance, reducing the gas consumption and increasing the liquid production. In an analogous way as the Rod Pump firmware above referred, this firmware, named "SGLi", allows the engineer to implement an algorithm to define the proper behavior of the well. For the sake of standardization, the same hardware is used for both artificial lift methods. On Figure 10, an algorithm example is presented. This algorithm performs adjustments to the time injection based on the slug time travel, and represents a simple example of what can be implemented.

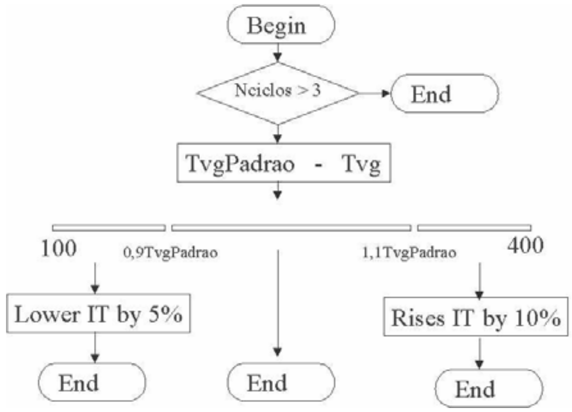

Figure 10 – Control Algorithm for intermittent gas lift optimization

Continuous Gas Lift

The artificial lift distribution in Petrobras shows that Continuous Gas lift is the most important artificial lift method in the company, providing 60% of the oil recovery. The reason of this is the robustness of pneumatic lifting, as the main production scenario is offshore and workovers must be avoided. On the other hand, it opens a gap for optimization, as gas lift the efficiency is worst when compared with other methods like ESPs (Electric Submersible Pumps) or subsea multiphase pumps for a scenario analysis where these methods are applicable.

Closed loop gas lift management has the objective to increase the methods performance, helping to counterbalance its low efficiency, maintaining the production in optimal operation state in a 24/7 period. The objective of the algorithm is to maximize the oil recovery with the smaller gas injected flowrate possible.

A strategy based on the downhole pressure as the controlled variable and the casing pressure as the manipulated variable, with PID acting in a control valve installed on the injection line was implemented in the Riacho da Forquilha field, an onshore mature field of Rio Grande do Norte business unit. The system is remotely operated with a radio link. An optimization algorithm was embedded in a PLC on the wellhead to enable right time decision operation. The set of variables identified for this application is depicted on Figure 11 [14].

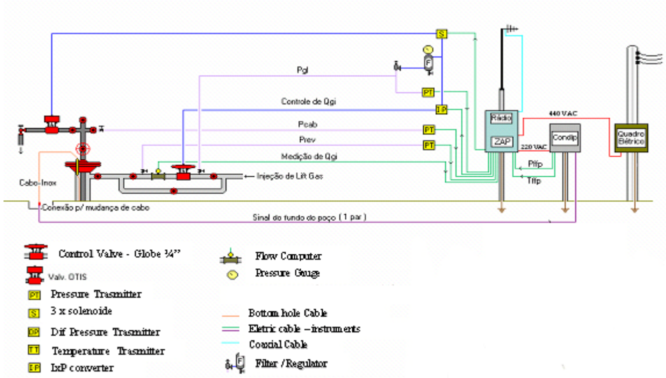

Figure 11 –Field automation architecture for GL Closed-loop

The methodology is efficient to find a new gas lift injection rate due to changes on well production related to GOR, BSW, flow assurance or external constraints like compressor instability. Without a continuous monitoring system with a closed loop control, these disturbances would be corrected only with a well testing batch job. Mature fields have multiple wells to be tested, and losses associated with wrong time decision on artificial lift management are significant.

The wells are monitored with a dedicated SCADA system. A well analyst from Natal, distant 250km, can verify the well behavior and how the control is operating on closed loop manner. If modifications on the algorithm are needed, a new strategy can be downloaded remotely. Figure 12 is depicts the data flowchart of the system. Besides optimization operations, the algorithm performs decisions under the need of reactivation, kick-off or shut-down due to any event related to the production.

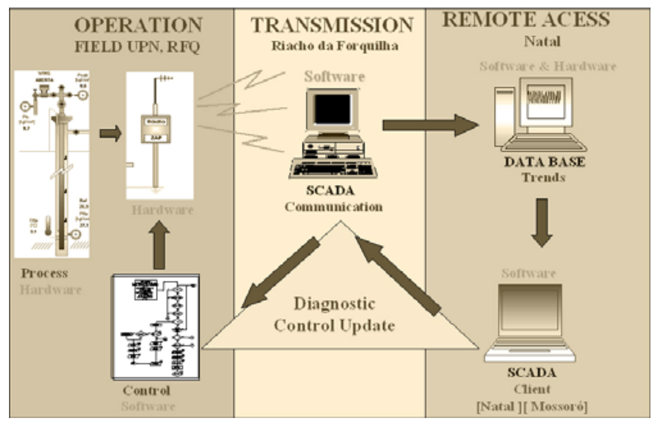

Figure 12 – Data flowchart of field with knowledge feedback of well analyst

The end user can choose how the well optimization strategy will run, as to reach a stable production with minimum gas lift injection or a more dynamic operation, querying the well in a small time constant, looking for the best operation point. Figure 13 is depicts a cycle of searching, in which a better operational point was reached when gas lift rate was increased.


Figure 13 – Well optimization with decrease of Pwf (dark green).

Bilateral Field Knowledge Transfer

The best knowledge of well behaviour is on the brain and blood of senior petroleum professionals. When they retire this know-how goes together with them, and this is not different in Petrobras. Another fact is that most of the technologies available for "Smart Field Projects" are focused on bringing the data to well analyst desktop, but just that doesn't assure the transformation of data to information. In fact, they are just IT tools. One of the solutions is bring the petroleum engineer closer to the lift process implementation, in order to allow him to embed his/her knowledge in an optimization algorithm format that runs at the wellhead. We already mentioned in this paper that closed loop artificial lift management is a multidisciplinary task. Usual methodology implementation from automation arena is a specialized tool for automation professionals and request a considerable learning time. The interface between automation and artificial lift petroleum process is a green region. This scenario led professionals to think how to fulfill this gap. The main goal is to build a methodology that enables:

- continuous enhancement of algorithm strategy by the well analyst. They are the owners of the wells and best source of feedback.
- a "fit for workflow organization" solution that helps accelerate technology absorption by assets.
- an easy tool to be used on petroleum engineering training courses, since the beginning of professional formation inside company.
- a dynamic structure capable to evolution
- fit for onshore and offshore automation architecture

The initial base platform chosen for this development was the MPA-LUA system. The acronym means Automation Procedure Module and LUA is the language behind the application. This system was designed inhouse, with help of an university, to increase the efficiency of offshore platform start-up and daily operations, automating the procedures with the objective of minimize production losses.[9]

Basically the MPA-LUA system is composed of an execution server and a configuration/management tool. It's interface language with end user is a flowchart running as client application for design and monitoring purposes. The server runs the flowchart as a process of the operational system of the production unit.[10]. One of the keys for choosing this platform is because it fits the organization workflow for artificial lift management. MPA is composed of three modules, as depicted on Figure 14: the Pre-Setup, based on LUA language, the Configuration and the Execution module. The first is where the engineer will program, in a high level language, all the equipments needed for the expert system, plus auxiliary functions (alarms, clock…) and methods like, reading pressure of aspecific equipment. This is responsibility of the Technical Support team of the asset. On the configuration module is build the application plant and programming the control strategy for the application. This phase is a co-responsibility of end users and Technical Support. The execution module is the one which makes possible to start, stop and monitor a flowchart that is running. It is of operational responsibility.

The continuous use of this system combined with an advanced programming of Pre-Setup will result on a universal library of equipments and methods that will allow the end users to select the functionality for a desired new algorithm.
As yet, only total heuristic procedures were implemented but artificial intelligence and PID control modules are available to be used.

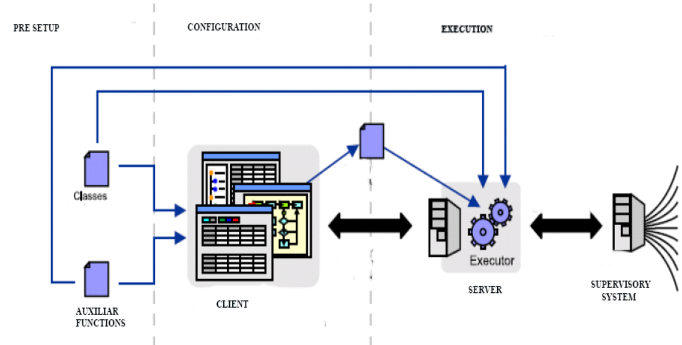

Figure 14 – MPA-LUA module composition

This methodology assures a bilateral field knowledge transfer on the configuration and execution level, with an interaction supported by a high-level language interface between developers and end users. Many wells have some particular behavior and installed equipment. This approach will enable the well analyst monitor the data and feedback it with small modifications, as depicted on Figure 15. The focus is always strength the right time decision for the process. A natural consequence is the enrolment of each professional that helps on implementation phase.

A multidisciplinary team composed by Petrobras staff and Brazilian universities is working on a project to identify new functionalities and requests to adapt a high-level language system for artificial lift management, plus to extend the applications for small controllers to fit onshore architecture. Regarding PLC programming languages MPA efforts can not be taken as a variant of the IEC 61131-3 standard, which is a valorous initiative. It defines a set of language interfaces and format definition that the PLC vendor has to follow. The mais advantage of the standard is to help PLC programmers, that need to work with different PLC suppliers. Nevertheless, it still does not help to bring near multidisciplinary areas as the MPA-LUA initiative.

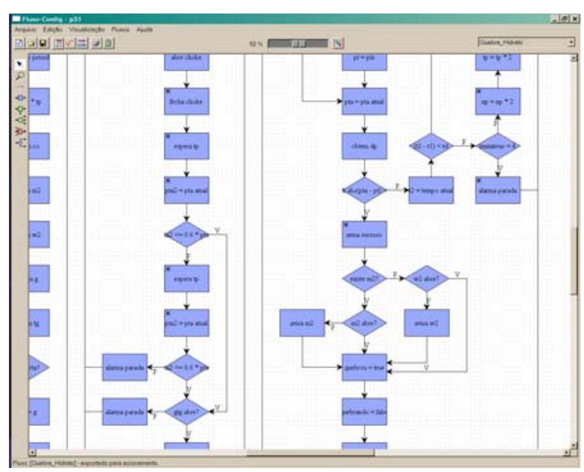

Figure 15 – MPA Typical Flowchart

Connectivity and Data Integration

Integration of artificial lift automation with smart well equipments can result in a babylon of devices with several protocols and electrical communication interfaces. On a onshore architecture, the stand alone artificial lift PLC needs to be integrated with smart well Hydraulic Pressure Unit - HPU, permanent downhole pressure and temperature gauges (optic or electric), speed drivers for pumping wells and all other wellhead transmitters. Enhance the connectivity of devices and avoiding proprietary protocols is a market strategic differential consideration for champion engineers responsible for intelligent field implementations. Reinforcing this scenario come the right practice of using just one radio to link the field and the control room.

The state of art control panel designed for artificial lift and smart well integration is the one with less communication bridges or auxiliary PLCs. It means that each component of the panel has connectivity flexibility to communicate with an internal concentrator unit that will manage the communication with supervisory system.

Nowadays, for mature field implementation it is still difficult to reach the state of art criteria because many low cost systems needed to be used in order to balance the project cost does not permit high connectivity. So, more than one protocol needs to be implemented with communication bridges to integrate all devices into the control panel.

Automation Architecture

The main drivers for automation architecture are to be hardware and software independent and to be able to embed intelligent algorithms designed by well analysts, as was described before. The standard objective is to assure the data to reach each level of decision makers[11].

Inside the control room or at office desktop the end user doesn't need to know the brand of the PLC, or VSD of a particular well. The SCADA system is prepared to communicate in a pre-established format and the field devices needs to meet with this specification. Onshore fields with multiple artificial lift methods use to have one supervisory system for each artificial lift system. It brings multiple software tools to monitor the field, what increase the delay of analysis and consequently the decision in all levels. The best practice for a field operation with large number of wells is concentrating the information in fewer screens as possible to help operator to manage information alarms.

Offshore and onshore applications have different field realities. The algorithm that will help to reach the right time decision based on field process variable must be located at the wellhead for onshore installations. It's a decentralized control strategy because the action in the process can not be dependent on radio link efficiency. Offshore reality has all well information concentrated in the control room linked by wire; this reality is already changing for wireless. An expert system can be designed to acquire data from SCADA supervisory system, the delays of the lift process permit this architecture, as was demonstrated in MPA-LUA application on Figure 14. Nevertheless, this is not the mandatory architecture for offshore installations. Decentralize the control in a net of small systems for each wellhead brings maintenance independence from critical routines that runs in the central production unit PLC. The choice is done based on how maintenance organization is defined for a specific field. If in the permanent staff of an offshore platform there is not a person in charge of the modifications on control loops of the main PLC, it's better to decentralize the control in small PLCs per well, allowing maintenance responsibility for instrumentation professionals.

Closed loop management means significant care on instrumentation reliability and data treatment. Strategies of on-line self diagnosis and calibration of instrumentation must be available to assure the quality of raw data coming from the field. The use of smart instruments and bus technology is recommended.

Conclusion

- Real Time Operation - RTO is not sufficient to assure the results expected for smart field projects. Right time decision tools, based on process identification and time constant are necessary to compose the intelligence that will run in real time.

- Closed loop control is the right strategy for artificial lift management. The variables available in each well will define the complexity of the solution. Artificial intelligence helps on scenarios with lack of sensible variables. It's strongly advisable that Green field development projects enhance the instrumentation of individual wells on surface and subsurface. It will avoid time waste with intervention to install the equipments necessary for feedback strategies.

- Technology implementation is considered succeeded when the approach is absorbed by daily operation. Usually, this phase happens to be one of the hardest steps. There is a gap between automation and petroleum engineering that, when fulfilled, will help the technology absorption and continuous feedback.

- On smart field implementations, the zone selectivity using smart completion brings the need of flexibility and self decision quality for artificial lift management.

- Intelligent Energy on production management means enterprise efforts to enhance integration, better perception of reservoir, well, artificial lift, fluid processing and logistics, providing an operational mentality change. It's an irreversible pattern for oil industry, which the main challenge is to apply smart solutions, since the field plan development assures the right infrastructure for daily optimization. Smart field is much more from just technology implementation approach.

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