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Alto do Rodrigues GeDIg Pilot—Case Study for Continuous Steam Injection Recovery Combined with Real-Time Operation

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Abstract

Alto do Rodrigues (ARG) is an onshore heavy oil brownfield with continuous steam injection recovery located in the Rio Grande do Norte and Ceara Business Unit in the Northeast of Brazil and it was chosen as a pilot in Petrobras corporative program for Digital Integrated Field Management - GeDIg.

The ARG pilot consists of on-line monitoring of bullhead temperature of producers and injector of five spot networks connected with steam facilities measurements such as pressure and steam quality. The real time operation is combined with two collaborative environments integrated with SOLAR, an in-house development collaboration software.

Reservoir heterogenerity analysis like steam channeling is provided when steam generators parameters, well instrumentation, and historical data are combined in new workflow processes of steam analysis. Change management associated to process mapping guided the pilot implementation to minimize the side-effects of new process absorption.

The objective of this paper is to present the methodology and results from Digital Integrated Field Management in the onshore heavy oil brownfield of Alto do Rodrigues.

Introduction

Petrobras defined a corporate strategy for implementing the company’s vision os Digital Oil Fields. This program is called GeDIg – Digital Integrated Field Management [1].

Alto do Rodrigues is one of the project pilots chosen in this program to persue ultimate recovery augmentation, oil production optmization, and operational cost reduction through the digital integrated management of oil and gas fields. Specific goals of GEDIG activities are: train people, apply information, automation, simulation and modeling technologies.

Alto do Rodrigues (ARG) is an onshore heavy oil brownfield with continuous steam injection recovery located in the Rio Grande do Norte and Ceara Business Unit in the Northeast of Brazil (Figure 1)

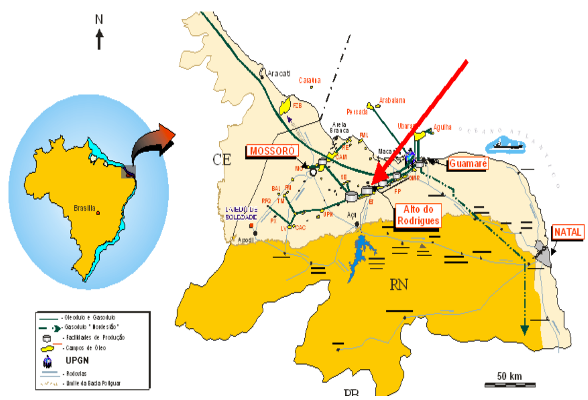

Figure 1 – location of Alto do Rodrigues Asset

This paper focuses on the analysis of continous steam injection recovery over a single five spot network, which represents a cell of the field draining network that is under development as part of a major steam pipeline project the will cover all the Alto do Rodrigues asset. It describes many aspects concerning people, processes, and technology involved in the implementation of the project.

Business Case

The Alto do Rodrigues asset produces oil and gas from 12 onshore fields and from 1 offshore field. There are more than 2300 wells in a 80 km2 area, producing oil by Sucker Rod Pumping Units (95%) and Progressive Cavity Pump (3%) as major artificial lift methods.

In addition, water and steam (continuous and cycling) are used as Improved Oil Recovery (IOR) methods. Steam is produced by 21 steam generators installed in 7 steam stations.

The main goal of this pilot is improve the ultimate reservoir recovery with real time continuous steam injection system management, including reservoir, steam generation facilities, and injection and production well control.

The most important considerations are:

- Better reservoir management provided by real time monitoring of the bullhead temperature, leading to predictive anomaly detection, such as steam chanelling and production zone connectivity problems due to cementing casing degradation;
- Improved steam generator planned and executed injection parameters comparison (temperature, pressure, steam quality;
- Equipment condition monitoring with real time data visualization and analysis;
- Optimized articial lift method for operational cost reduction with sucker rod pump and progressive cavity pump analysis
- Downtime reduction by detailed action monitoring and production deviation early detection.

Typical challenges associated with this kind of project are the distance between the operation facilities and headquarters and change management implementation.

Project Methodology

The project strategy is based on business process mapping, collaborative environment design, and a change management plan.

Process Mapping

In order to increase the potential use of information provided by automation equipment and GeDIg collaboration rooms (CGeDIg rooms), it was necessary to model, examine, and propose new ways of working in Alto do Rodrigues (ARG) (Magdaleno et al., 2007). Since information from sensors installed in each well makes it possible to evaluate oil and gas production on real time, some objectives of this work were the identification of which data must be shared and how this information should be presented by applications, in order to improve decision making. To have this work done, some business processes needed to be reviewed and/or introduced, which required business process modeling (BPM).

Models comprise characteristics of particular interest of the real world, or those characteristics that are aligned with project goals. Therefore, process modeling in the GeDIg project had three main objectives, stipulated by its mentor team: (i) to define the best way of using the automated information obtained by sensors; (ii) to identify data integration problems in databases and documents used in the production process; (iii) to search opportunities for collaboration among people during process execution and maximize these opportunities through the use of technologies available in the CGeDIg rooms.

The BPM approach was applied based on the idea of that it is only possible to improve what is known. Process modeling is an excellent chance to translate tacit knowledge into explicit knowledge. The improvement comes from the combination of explicit knowledge and the discussion about current (AS-IS) process models with all involved participants. The new (TO-BE) processes must be planned and explicitly defined to become part of people work (Hawryszkiewycz, 2007).

Furthermore, to develop Information Technology (IT) applications accessing integrated production information it was necessary to be aware of where and how this information comes from, and by whom they are consumed and produced during the work processes. Business processes modeling activities can be used as the starting point for the identification of business requirements, business rules and information. In the GeDIg project, a series of IT applications and information were identified and must be organized to compose the ideal IT architecture to support decision-making, through collaboration in the CgeDIg rooms. The BPM methodology used in the GEDIG project was composed of four phases detailed in Figure 2.

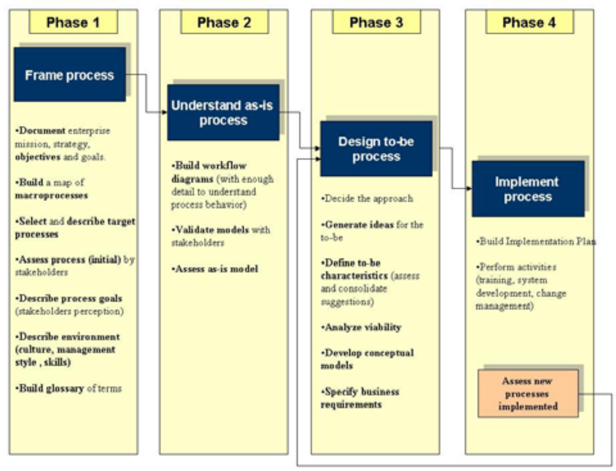

Figure 2. BPM methodology used in the ARG asset based on [4],

In first phase, an initial survey to identify the macro-processes was conducted based on the asset structure. From this survey results and each macro-process objectives, the processes were prioritized, in conjunction with its managers and executors, and also in accordance with the original objectives of the GeDIg project.

In second phase, the prioritized macro-processes were understood and detailed. In this phase some diagrams were constructed representing the details and sequences of activities of each process. After the validation against the process participants, it was possible to evaluate the important aspects concerned with the project.

In third phase, meetings were carried out with the managers and the end users responsible for the processes, to extend and discuss which characteristics and improvements should be planned for each process (designing TO-BE process models). In this phase, business requirements and conceptual data models were delineated.

Fourth phase was the last stage of this project. In this phase, the improvements designed in the previous phase are implemented. Change management must be conducted by the processes champions with support of the modeling teams.

After the implementation of each new process, an evaluation must be made and new changes as necessary were proposed. In this case, the methodology returns to phase 3 to propose a new TO-BE process. The evaluation and design of the TO-BE processes are carried out until the desired final result of the project is reached as a whole. This way, the TO-BE process is implemented in stages. This situation is depicted in Figure 3.

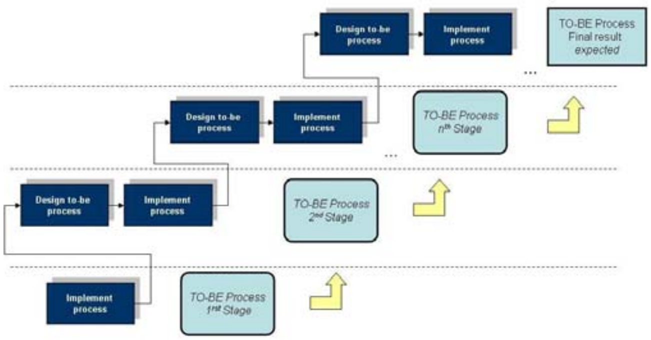

Figure 3. TO-BE Process Evolution according to the Methodology

Collaboration facilities

To implement the project GEDIG, softwares were developed and hardwares acquired. 2 (two) collaborative rooms were built: one in Alto do Rodrigues (Figure 4) and the other in the city of Natal, where the Business Unit head office is located and is far from Alto do Rodrigues about 200 km. An Integration Software called SOLAR was developed to integrate all the suites used by operators, engineers and managers.

The IT aspects concerning the project involve the design of the collaboration facilities, the definition of the IT architecture reference model, and the development of the collaboration software.

Figure 4. Alto do Rodrigues Colaborative enviroment.

Colaborative tool

The collaborative solution can be used as an effective tool for interactive collaboration in multidisciplinary production decision meetings as well as for storing and sharing information among members of asset teams in the organization. It integrates all information in the production chain, from operational data that comes from the fields to the KPIs and other indicators used by managers to measure the progress of the asset as a whole. This approach takes the insight in the decision process to a new level. The followed modules are under development in SOLAR:

- Continuous steam injection network management Sucker rod pump optimizer;
- Production downtime diagnosis;
- Real time production monitoring;
- Downtime management;
- KPIs monitoring and analysis tool;

Implementation

Among a variety of processes that were modeled, continuous steam injection received a special attention because it represents the most important secondary recovery used in Alto do Rodrigues Asset. The modeling was done based on an initial proposal made by reservoir engineeres of monitoring bulkhead temperatures of the wells from the Estreito field that use cyclic steam injection. The Estreito field has been choosed because all wells are automated. The proposal for intelligent field for this project is based on:

- Well automation;
- Acquisition and data treatment;
- Use of SOLAR software to analyze the temperature variables and their conformity with established known standards.

The SOLAR software, in addition, must be able to generate alarms and events on line and in real time when the temperature variables exceeded the set points, advising operators and engineers to, in case of a non-conformity, reduce or halt the flow rate of wells that violate the set points.

Data are acquired from a variety of softwares and tools developed either by PETROBRAS or by third parts. These softwares were integrated and implemented into SOLAR. The directives applied to the Steam Injection Process were:

1. as input data:
   a. The bulkhead temperature;
   b. The gross production;
   c. The temperature gradient relating to the gross flow rate, furnished by the field reservoir engineer;
   d. The level of temperature homogeneity required for the wells, in terms of the maximum allowable difference, furnished by the field reservoir engineer;
   e. The maximum allowable temperature established by the operating engineer.

2. as a tool for the management:
   a. Temperature differences among all wells;
   b. Verification of conformity of the temperature differences with the set points;

c. The reduction of the flow rate for those wells that violated the temperature set points, in order to return the temperature to values compatible to the established limits.

3. as a tool of visualization:
   a. Well locating map;
   b. Wells temperature;
   c. Gross flow rate;
   d. Wells BSW;
   e. The temperature gradient relating to the gross flow rate;
   f. Trends.

The steam injection process is started when the measurement of the wells bulkhead temperatures are is out of range. Once identified those wells, the Reservoir Engineer responsible for the area, ask for a meeting to discuss the issue. In this meeting, the actions required to turn the wells to the optimal status are distribuited to all envolved personell. Typical meeting and tools used are:

- RTP (Well Technical Meeting) Meeting, via Collaborative room and SOLAR software;
- Tools
  - Proprietary and third part sofwares;
  - oil production trends, steam injection trends, bulkhead wells temperatures and gross production trends.

Results

Information Quality: After the GEDIG's implementation, we got integrate a variety of information relating to the steam injection process that, before the GEDIG project, were dispersed on the technician's mind and in various systems. In addition, with the use of the automation, it is now possible monitor the wells temperature, helping Engineers to take decision more precise.

Make decision agility: Use of the Collaborative Rooms have reduced time and money spent with the meetings, since the personell located in Natal does not need to move to Alto do Rodrigues.

- Increased cross discipline collaboration in general, leading to better and faster decisions

Future Work

New additional modules is planned to be implemented into SOLAR by the final of 2008. These modules intends to optimize the production analyses:

- Daily production diagnostic;
- Economic and additional SOR estimatives for thermic processes;

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