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UTILIZATION OF SMART FIELD CONCEPT IN MATURE GAS FIELD REHABILITATION

1. INTRODUCTION

In the past the gas industry focused its interest and major investments mainly on the early life of the reservoir and on the development and constant maintenance of production. But times change and currently mature gas reservoirs defined as reservoirs in an advanced stage of decline of reservoir energy and production should be considered as potential additional energy sources. In principle there could be countless options to maximize production of mature gas reservoirs, although both technical feasibility and cost of each alternative should be analyzed carefully before making a decision. Expertise in various domains and knowledge accumulated by production and service companies should be well integrated in order to design a successful operations considering the high risk associated to every intervention in the reservoirs where reserves are already depleted. Mature fields rehabilitation should start by identifying the main production issues, which once acknowledged could be corrected. Such correction measures are usually applied in order to increase well productivity.

During the last 7 years were introduced new technologies and ways of working to many Romgaz fields ensuring that there are technical solutions for each asset in essence to integrate people, processes and technologies.

Assets which are part of the Smart Field program have shown increased production, time delivery, faster and superior decisions making, improve cooperation, detecting errors and increase ultimate recovery while reducing costs.

The philosophy of a smart field is based on the following scheme:

“to measure – to simulate – to take a decision – to follow – to control” [4].

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The field management is executed in real time at four main levels:

1. ***Instrumental***, getting data in real time to improve the daily management and installation of remote sensors on the underground and surface equipment for data collection in real time.
2. ***Information***, it is an automatic verification of the data and their analysis and the installation of the appropriate software for data management and visualization, the transition from "data" to "information".
3. ***Operational***, which involves the integration and optimization of the production processes, automated forecasting of emergency situations, the integrated control of the processes taking place underground and on the surface.
4. ***Management***, it consists of the transformation of operational processes, innovative technologies, new production processes and virtual teams.

Smart field includes two control lines:

1. ***The operating line*** provides control over the effectiveness of management processes in field operations (production, control and management modes and condition of the equipment, support processes etc.).
2. ***The simulating line*** provides a dynamic development management model under varying external (context) and internal (content) conditions.

This paper discusses the integration of smart sensory and control devices within the company's gas fields, seeking the optimal production strategy. We present a unique case study detailing real-time field and well performance monitoring, management and production optimization. Monitoring with real-time capabilities helps engineers across the company to understand the behavior of the field, which leads to better analysis and real data.

2. CASE STUDY

2.1. Technologies deployed in Romgaz fields

Smart Fields is an asset which can be optimized 24 h per day, 7 days per week. The underlying philosophy is that the total value we can get from fields depend of how accurate we can locate hydrocarbons in the ground, how can we optimize the production and the wells facilities and overall production through the field cycle life of a field, from second to life cycle.

To improve production, increase ultimate recovery factor we must understand better the reservoir. First step is surveillance which can be limitless. We talk about reservoir, surface facilities, production or operations surveillance.

Technologies deployed in the fields:

- 3 D seismic – to improve the actual reservoir geological model by a better understanding of the lithology;
- availability of state-of-the art technologies, tools and software's (for well integrity – Analysis behind casing, Ultrasonic Imager, for reservoir saturation RST, for services snubbing or FLO-THRU, softs like PETREL, PIPESIM or OFM);

– a functional network which collects all the production data in real time (pressure and temperature – wellhead sensors, flowrate – multistream flowmeters) and transmits it to the engineering department for reservoir management (changing in real time the soaping programs) and active reservoir surveillance to optimize reservoir performance;
– automatic soaping equipment's – automatic soap – sticks launchers (trough tubing) or continuous liquid – foam injection (trough casing) for helping the wells to lift the bottom hole water;
– field compressor;
– a project management team capable to take the best real-time decisions.

The application of "smart" and integrated technologies allows production engineers and reservoir engineers to exchange the knowledge more effectively, which finds its reflection in the productivity of the operations and makes it possible to take considered and accurate decisions ensuring the largest profits. All of these tasks must be performed in the most efficient management of the company, and it is in real time. To provide the maximum gas recovery of each well and the reservoir, the production optimization is required (Fig. 1). The optimization requires a careful analysis in real-time a greater volume of the prospecting data, integrated with the data from other fields, such as geology, geophysics and reservoir engineering [4].

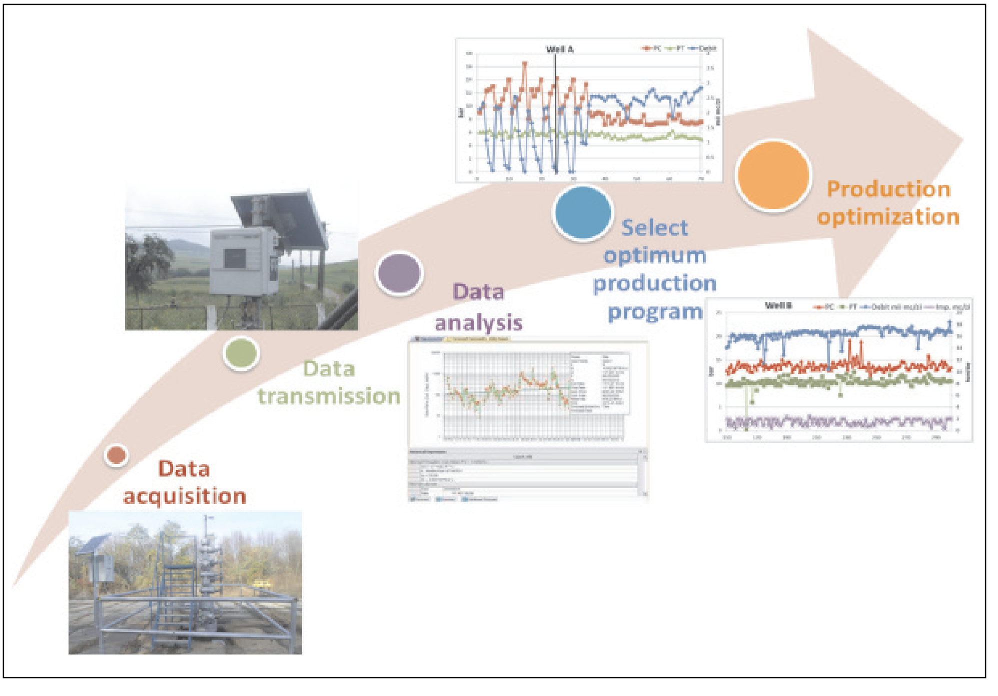

Fig. 1. Data acquisition, analyzing and production optimization

2.2. Well and reservoir performance indicators

Romgaz has started since 2003 a field rehabilitation and project management campaign. The main challenges for these projects were how to combine and integrate older systems into a newer one.

The first step was to implement real time flow rate monitoring. So we installed flow-computers in the groups with a sensor for each well and the data collected by these devices is sent to the production department hourly or by demand of the production engineer (Fig. 2).

The monitoring of technological flux must be delivered in real – time from the process to the survey room, to show the exactly moment and time when malfunctions appear and to ensure at any moment of time a historical for each interrogated parameter [2].

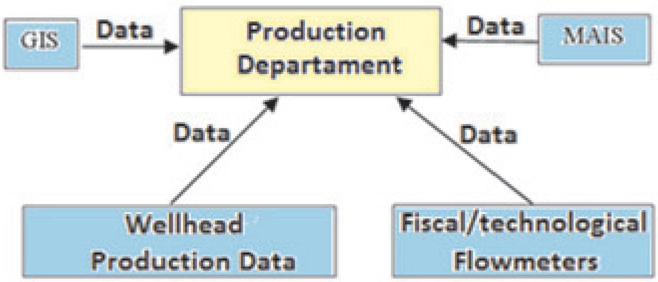

Fig. 2. Data monitoring at the production department

The engineers (production and reservoir engineers) are interested to know and track parameters and information's regarding the gas wells, groups, valve positions, drying stations, wellhead or field compressors, other equipment's or devices from field and the transmission gas pipeline working parameters.

The monitoring well parameters are: tubing pressure, casing pressure, flow rate, gas temperature and liquid quantities.

Knowing evolution of flow rate through time we can intervene if it is necessary for liquid unloading.

When we observed that the production of some wells is decreasing by hours because of liquid loading issue we decided to set up for each wellhead pressure and temperature sensors to generate proper soaping programs. The data measured by these sensors it is sent every hour to the production department for production monitoring. The software has some alarms to alert the engineers if something is wrong with the measurements.

The real time parameters monitoring in the natural gas production process has to be a continuous operation during the entire exploitation process (Figs 3 and 4). This activity begins with well head, groups, well head and field compressors, drying stations and finishing with the technological or fiscal measurement panels.

Romgaz implemented since 2006 the energy unit measurement (real time gas chromatography) to fiscal panels. These measurement points are equipped with electronic devices which can deliver data in real time to production department to be analyzed [2].

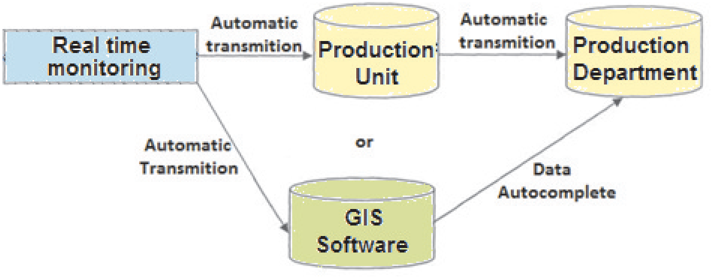

Fig. 3. Data acquisition diagram

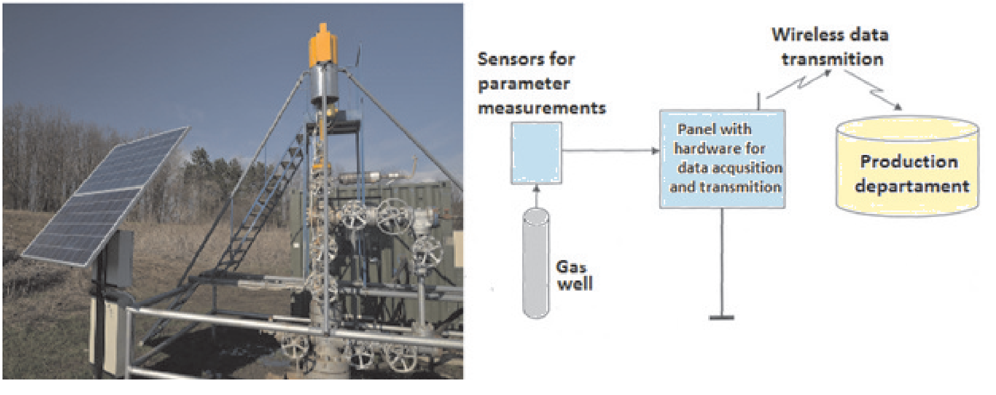

Fig. 4. Data acquisition from wells

We installed at the well head tubing / casing pressure and temperature sensors (see Fig. 5). The scope of these sensors is to get real-time measurements of these parameters (pressure and temperature), which helps the production engineers to plan proper liquid unloading programs, and to obtain stabile flow rates.

After a period of time of monitoring the fluctuations of these parameters we have redesigned the whole soaping programs for the wells in these fields. We observed that some of these wells need more than one soaping operation per day so we have decided to by automatic soap stick – launchers and continues foam injection units.

In the same time we observed that some high production wells are high pressure sensitive. So to avoid production fluctuations by these wells we have installed wellhead compressors.

The gathered data is integrated in the simulation software's to help us to do on demand a more effective workover or stimulation candidate selection.

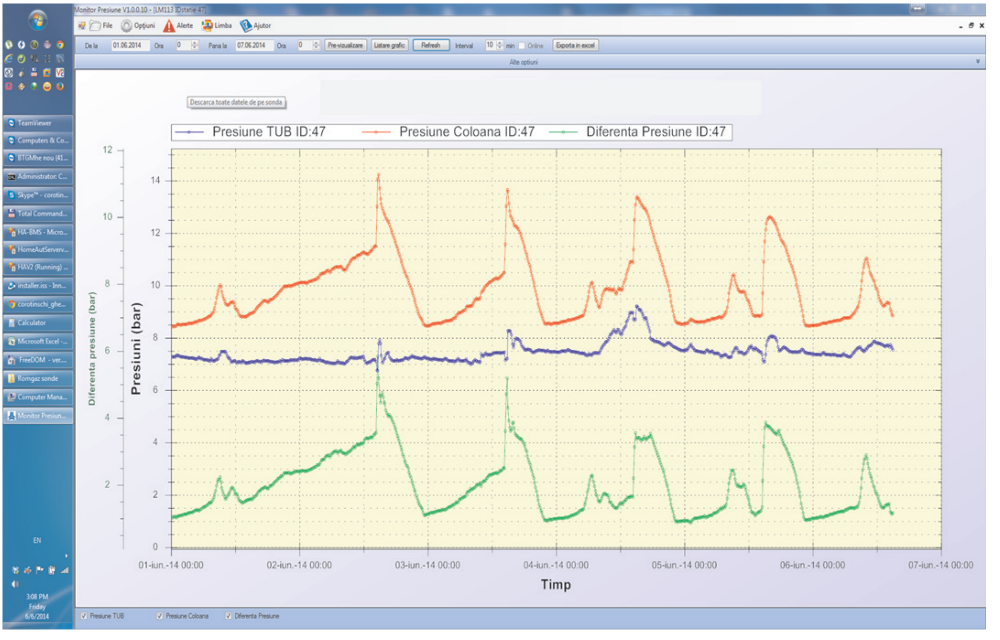

Fig. 5. Tubing and casing pressure report chart for one well

2.3. Field performances (Benefits – Production optimization)

In this section we resume how Romgaz has integrate knowledge and science in intelligent fields, for optimizing field production.

At wells that have liquid loading issues (where it is possible) we had to monitor in real time how the tubing – casing pressure varies. A pressure variation of 1 bar between tubing and casing means an increase of 10 m hydrostatical pressure in wells. So, for wells with a 5 1/2 in casing and 2 7/8 in tubing that's approximately 10 l/m of water in the well.

In the Figure 6 is represented the tubing and the casing pressure and the flowrate of one of these real time monitoring wells were we decided to implement continuous foam injection (Fig. 7).

We monitored the following parameters p_t, p_c, *Q and liquid impurities* (Fig. 8). We observed that this well stopped at every 3 days. So, we decided to set up a foam injection unit which to inject continuously a small quantity of mixture water + soap foam (25 l/day). In the previous program the foam was introduced once at 4 days.

After setting up the continuous foam injection unit to this well we got a stabilized flowrate which has variations just with the change of the pipeline pressure.

In the Figure 9 is represented the tubing and the casing pressure, gas and water flowrate of one of these real time monitored wells were we decided to implement the automatic soap stick launcher.

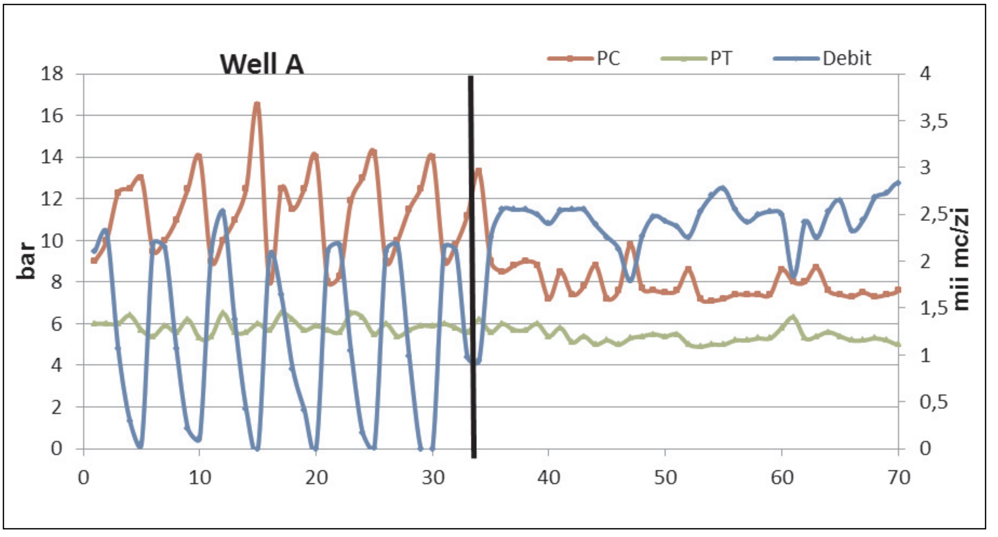

Fig. 6. Well A pressures and flowrate behavior in time

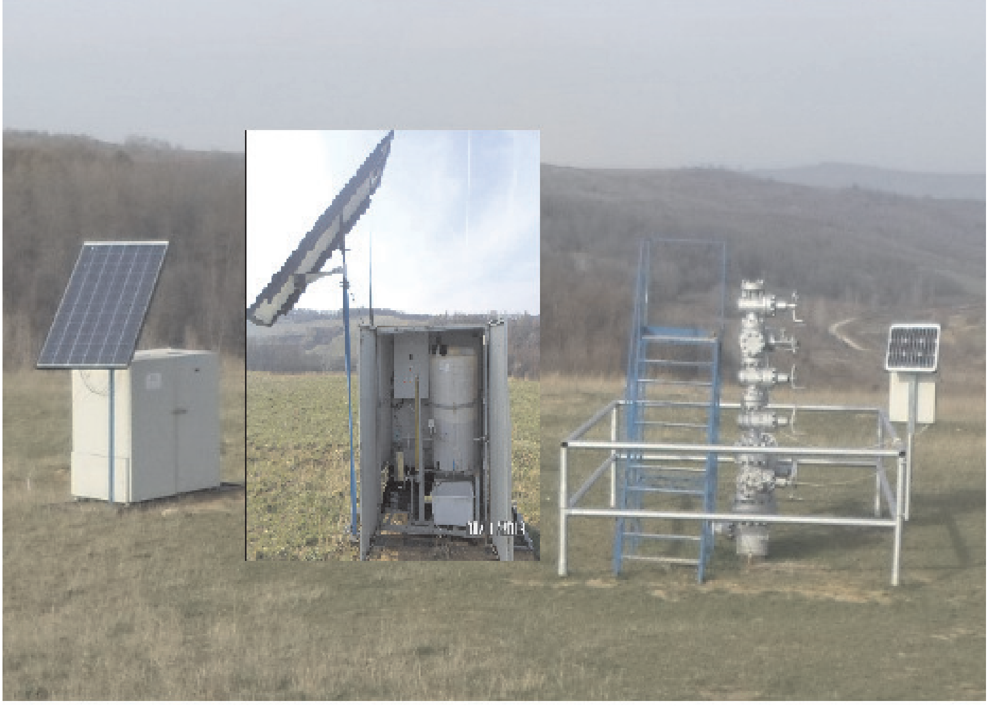

Fig. 7. Continuous foam injection unit

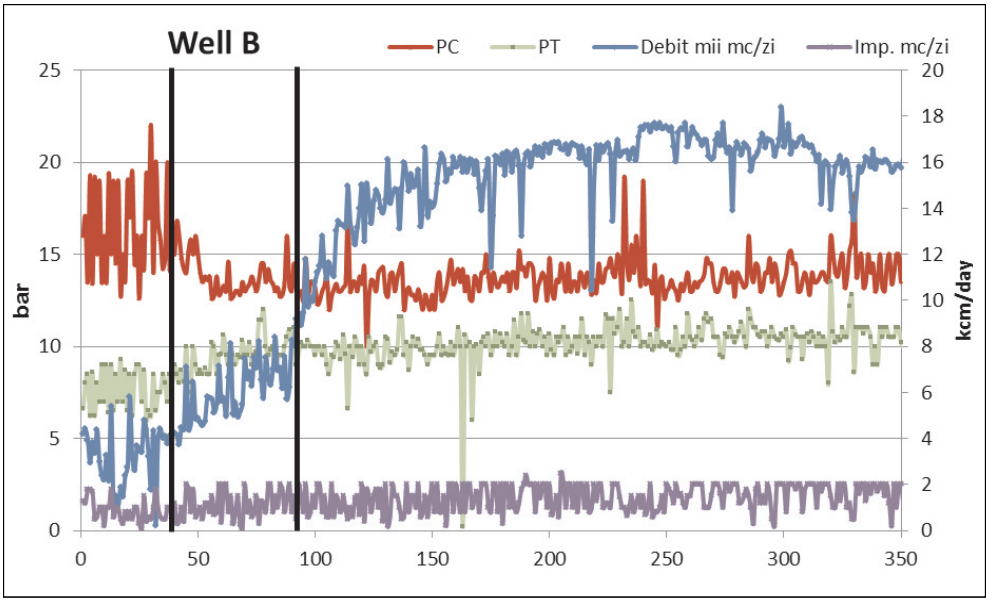

Fig. 8. Well B behavior in time

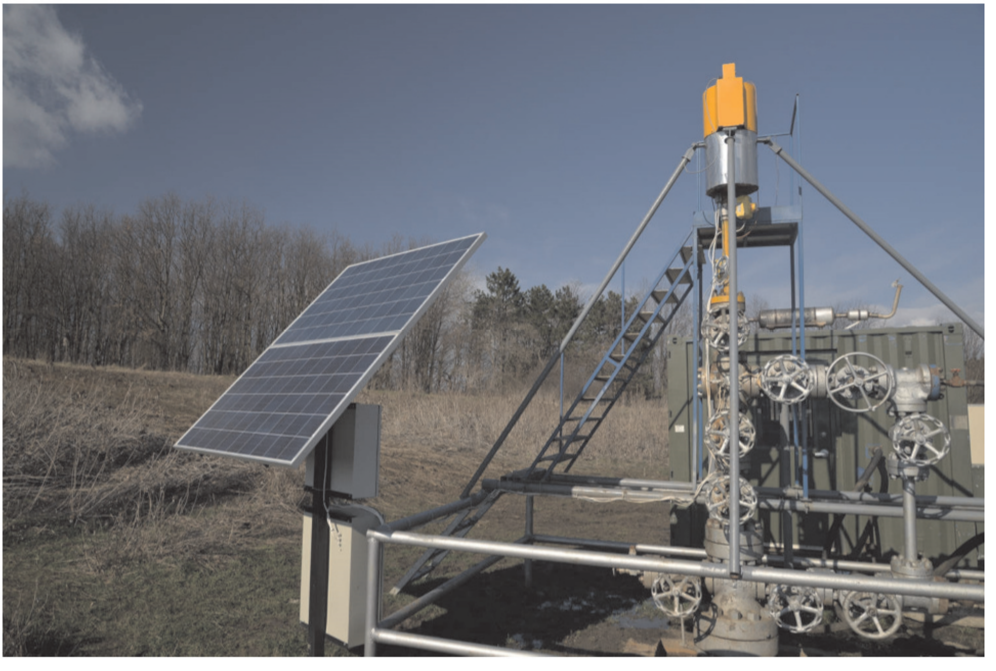

Fig. 9. Automatic soap sticks – launcher

After implementing the launcher we have done a second optimization by increasing the number of soap sticks launched in this well.

Soap sticks selections are made accordingly with well completion:

– for wells with the tubing fixed over the perforated zone we use especially light density soaps or a mixture of light and normal density soap sticks in case of a well with more than 100 m perforations;
– for wells with the tubing fixed in the middle of the perforated zone we use liquid soap or a mixture of light and normal density soap sticks in case of a well with more than 100 m perforations;
– for wells with the tubing fixed at the bottom of the perforated zone it is recommended to use liquid soap for annulus liquid unloading and for the wells which are producing a lot of water we can use also a mixture of light and normal density soap sticks.

Another example of improving the production was the observation of some wells which are pressure sensitive so we decided to set up some wellhead compressors to get a stabilized production (Figs 10 and 11).

We install well head compressors for sensitive pressure wells to prevent water flooding or perforation blocking at high pressure which involve expensive interventions.

In the example presented, for the well C, we can see that the field "loss" daily 10–15 kcm/day. By implementing well head compressors we eliminate all the production drops.

Fig. 10. Wellhead compressor

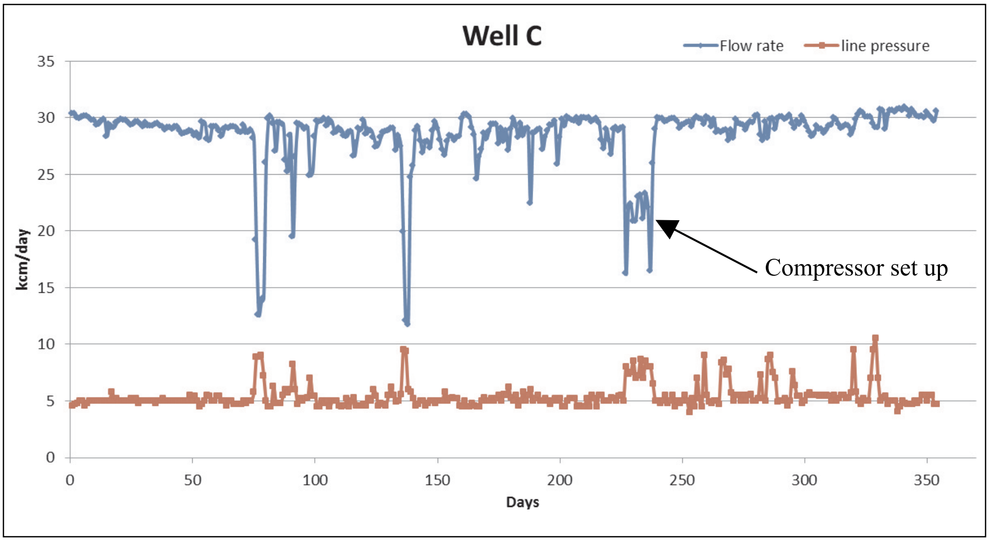

Fig. 11. Well C behavior

During 2008–2009 by implementing Smart Field concept it was obtained a better management of water impurities and productivity (Fig. 12). It is easier to determine pressure drops and to eliminate them. The benefits of smart completions and intelligent fields are indicated by the sustained productivity and minimizing production interruptions.

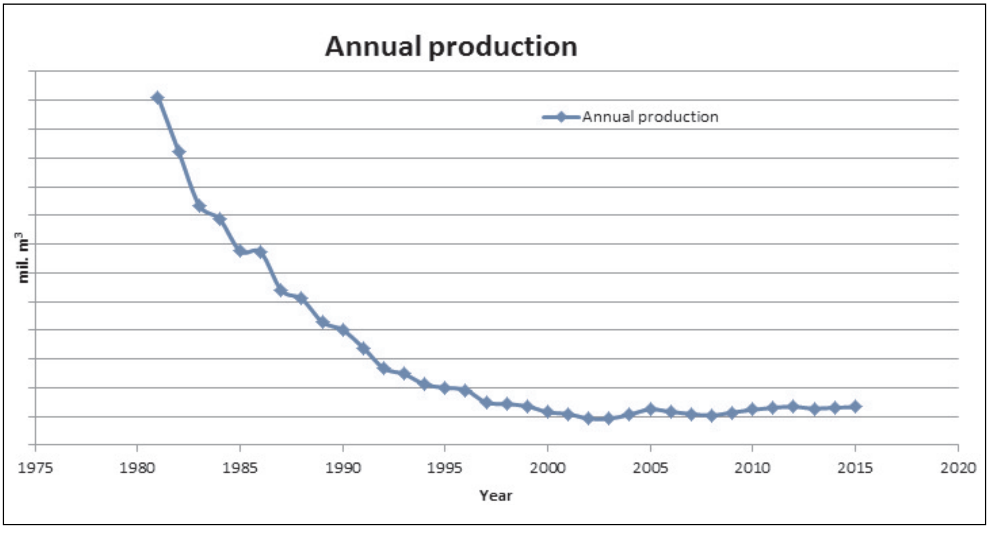

Fig. 12. Annual productions for one field

3. CONCLUSIONS

One challenge of our company is the development of the mature fields into smart fields for real time well behavior surveillance. The main advantages are: a rapid assessment of the development scenarios and the production cases, the integration of the technology cycles, the reduction of costs through the real-time operations, further enhancing the performance of technological operations

The field rehabilitation, supervisory control and data acquisition system at the producer is a strategical measure imposed by a competitive gas market.

Implementing a modern SCADA system help to identify and track various problems, reduce the operational and maintenance costs which will reflect in gas price.

This system provides a quick access to information for the company and help to make a decision accordingly at the appropriate time, which leads to production optimization. Applying all these technologies for these fields helped us to maintain the annual decline rate close to 0 or to have an anti-decline.

Smart Field project implementation helps us to increase recovery gas resources by 10%.

During this period we:

- monitor day-to-day production;
- enabling the wells with problems to be addressed as soon as possible;
- ensure data integrity;
- help fast decision making so enhancing the lifecycle of field;
- assure gas quality, pressure, physical and energy unit measurements which are priority conditions for a demand gas market and can't be supervised and optimized without a modern SCADA system;
- optimize water management;
- optimize production;
- optimize technological process;
- increase safety operations;
- reduced gas leaks;
- protect the environment.

Using intelligent field help us sustain field production, prolonged the life of wells and control wells optimum production, even increasing field final recovery factor [5].

The experience from this field has provided unique knowledge and better understanding how these technologies could be used further more to other fields up to next level.

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