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Real Time Optimisation Approach for 15,000 ESP Wells

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Abstract

In Rosneft Oil Company 90% of production is provided by 15 000 ESP wells. That is why monitoring and efficiency increasing of those wells are of current importance. Up to recent time, analysis and optimisation were done regularly on monthly basis, while real time monitoring systems were oriented mainly to keep books of oil production.

In our opinion implementation of real time monitoring and control systems and reducing analysis and optimisation cycle to days may increase production by the means of rate increase and downtime reduction.

Research in this area started in Rosneft in late 2006 in the framework of New Technologies System. Currently there are solutions for data gathering and proceeding, worked out information use in business processes, has practice in production increase and well downtime reduction, started company-wide application of system.

Paper includes cases of well regime analysis done with the described system.

An important question of quantative evaluation of system applicability for certain conditions was examined. This paper may help to take decision on application of this type of systems for other companies.

Introduction

In Rosneft Oil Company 90% of oil production is provided by 15 000 ESP wells. That is why monitoring and efficiency increasing of those wells are of current importance. Up to recent time, analysis and optimisation were done regularly on monthly basis, while real time monitoring systems were oriented mainly to keep books of oil production.

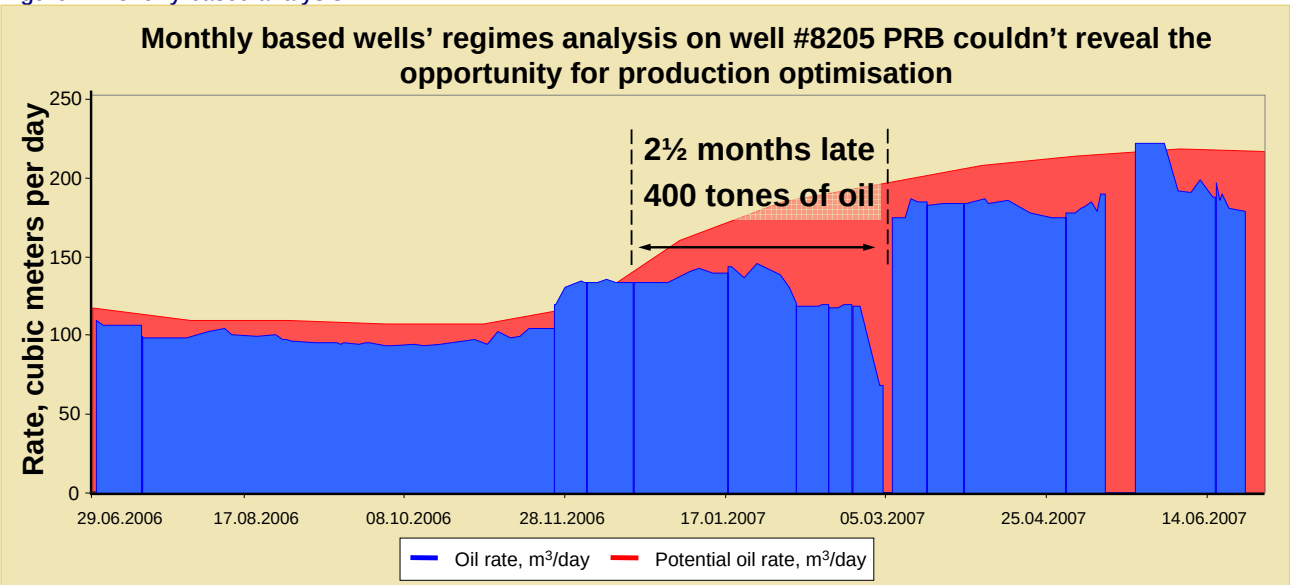
Monthly efficiency calculations include estimation of production potential – maximum possible oil rate for that well that could be provided by lowering down bottomhole pressure (frequency increase or bigger pump installation) or increasing well productivity (fracturing) and comparing it with the current oil rate. This “simple» comparison is based on large amount of data collected (liquid rate, water cut, annulus pressure, fluid level, GOR, …) and engineering calculations for bottomhole pressure calculation, estimation of current well productivity, etc. [1]

Analysis of current wells’ regime efficiency shows that there is a potential of increasing oil production (in terms of oil rate increase and well downtime reduction) by the means of introducing monitoring and control systems and processes and shortening up analysis loop to days (see example – “Figure 1. Monthly based analysis”).

Experience of real time ESP monitoring and control systems application in other companies shows that there might be an effect of production increase by 2-10% and cost reduction by 5-25% [2].

Research in this area started in Rosneft in late 2006 in the framework of New Technologies System to define the value of those systems application, to check its applicability and plan company-wide application.

Figure 1. Monthly based analysis



Work Scope and Field Tests

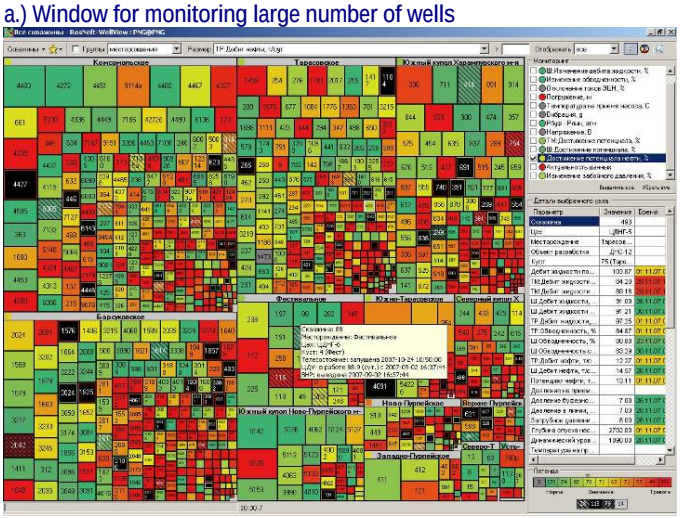
While building ESP monitoring and control system 3 pads of wells were connected to the system, provided process of data acquisition from VSDs, switchboards and down hole sensors, provided an ability of remote control.

Project included software (Figure 2) development for ESP monitoring and control system with the following functionality:

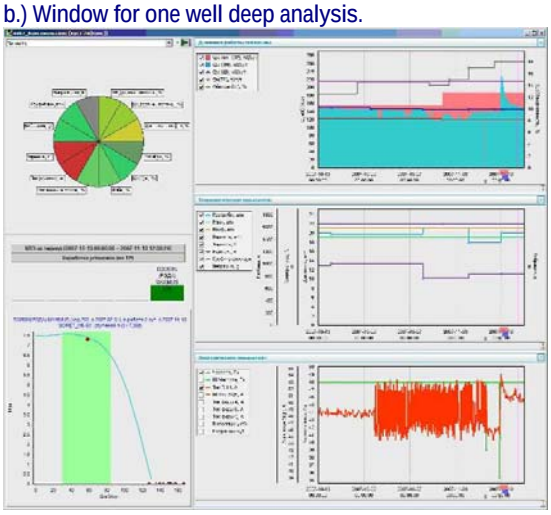
- analysis of current well regime and equipment, including pump head performance curve, NODAL analysis, flowing bottomhole pressure and production potential estimation;
- alarms on abnormal behavior of well of equipment parameters;
- graphing of well and ESP parameters for an arbitrary time interval;
- remote control of ESP (start/stop pump motor, settings change).

Figure 2. Software for monitoring ESP wells.

a.) Window for monitoring large number of wells



b.) Window for one well deep analysis.



To test the system created and to define the efficiency of its application, project team carried out field tests. The goal was to uncover the possibility of oil production increase and lowering risks of equipment failure.

The work was done on revealing the wells that have oil production increase potential and interventions were planned to reach the goal production, analysis of pump regime was done to resolve technology problems and solutions were suggested. Some case studies are presented in "Figure 3", "Figure 4", "Figure 5" and "Figure 6".

Figure 3. Pump set point (bottom left) moves to the left operating zone due to rate decrease (top right)

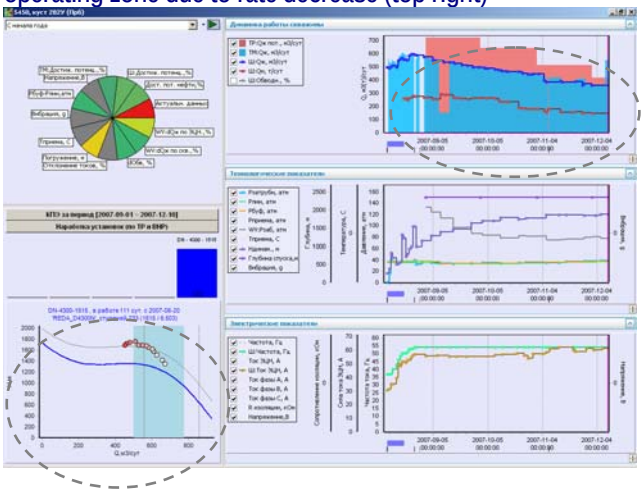
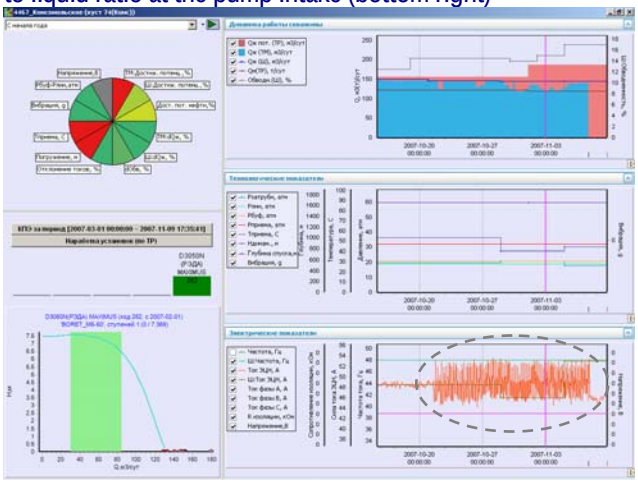


Figure 4. Unstable current due to influence of the high gas to liquid ratio at the pump intake (bottom right)



As the result of actions taken we've got an effect of 7% increase in production of wells with interventions. But taking into consideration that the object of monitoring process was a pad of wells and we had examined all the wells in test pads, average increase of production per pad is 3% and reduction of "unachieved potential" (the gap between potential oil production and current oil rate) is 10%.

Figure 5. Pump cable isolation resistance fall (bottom right) resulting in a pump stop

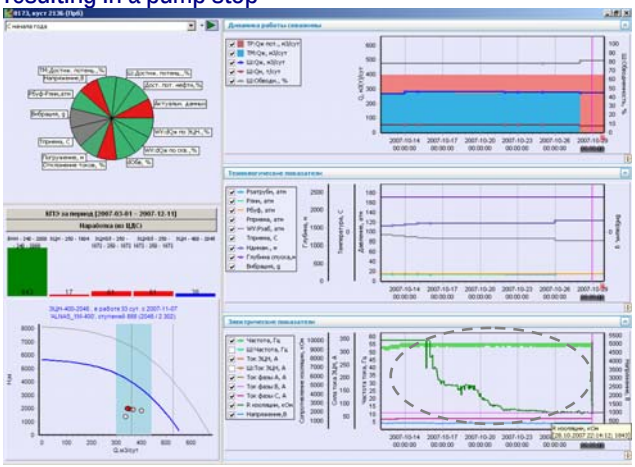
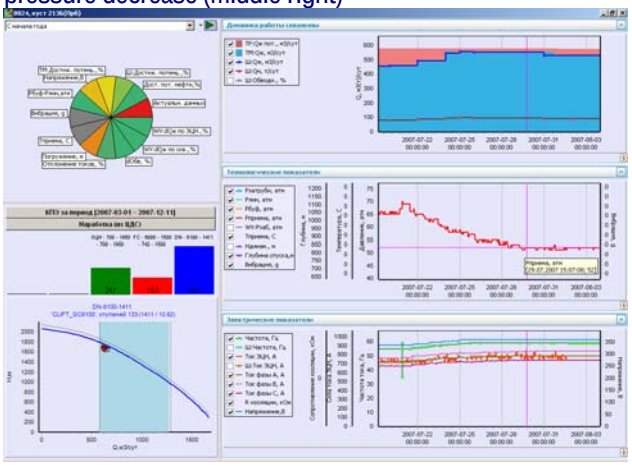


Figure 6. Pump motor frequency increase (bottom right) and corresponding rate increase (top right) and pump intake pressure decrease (middle right)

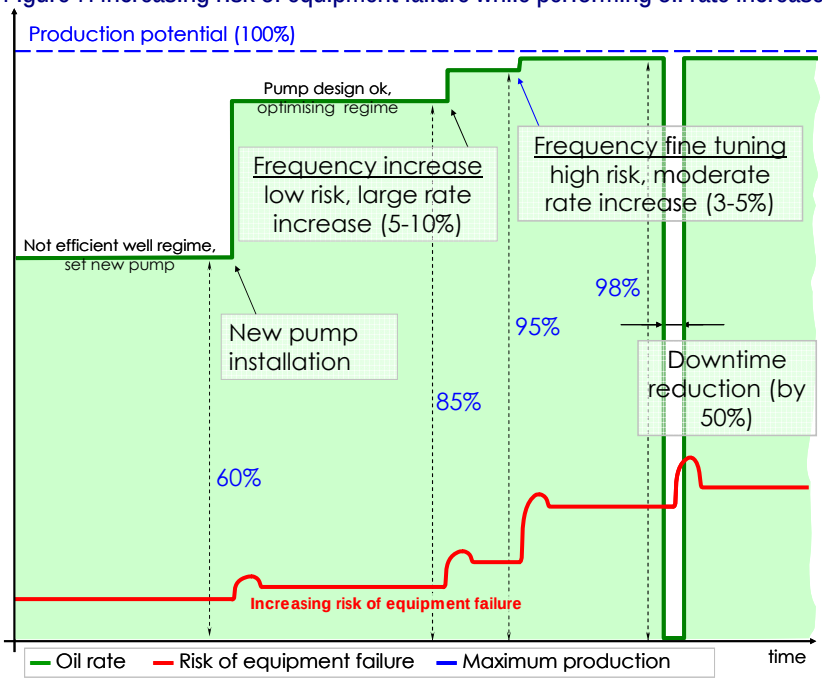


During the process of revealing wells for optimisation it was determined that production potential achievement operations on a well also increase risk of pump failure (Figure 7). As a result, monitoring well regimes after optimisation routines is even more important.

While the field trials of the "Rosneft-Wellview" system emergency power cut happened and wells in one of our test pads were stopped. This gave us a chance to test functionality and efficiency of the remote control option to start ESP motor. Experiment shows that software remote start of ESPs allowed us to do it 56% faster than the technician have done. Thus it could be stated that it is possible to decrease oil production loss twice while emergency power cuts.

Summing up the results, the correct way to measure effect of the monitoring and control systems is in the terms of "reduction of unachieved potential", but not in the terms of "oil rate increase". On a well with the current production close to maximum possible one, the effect from the system application in terms of "oil rate increase" is impossible to attain and use of the system can only be proved by sustaining current rate, but not increasing it. However if there is a gap between oil production potential and current oil production, the system might contribute to oil production increase. Based on this project results, the guaranteed effect of ESP monitoring and control system implementing is 10% reduction of unachieved potential.

Figure 7. Increasing risk of equipment failure while performing oil rate increase

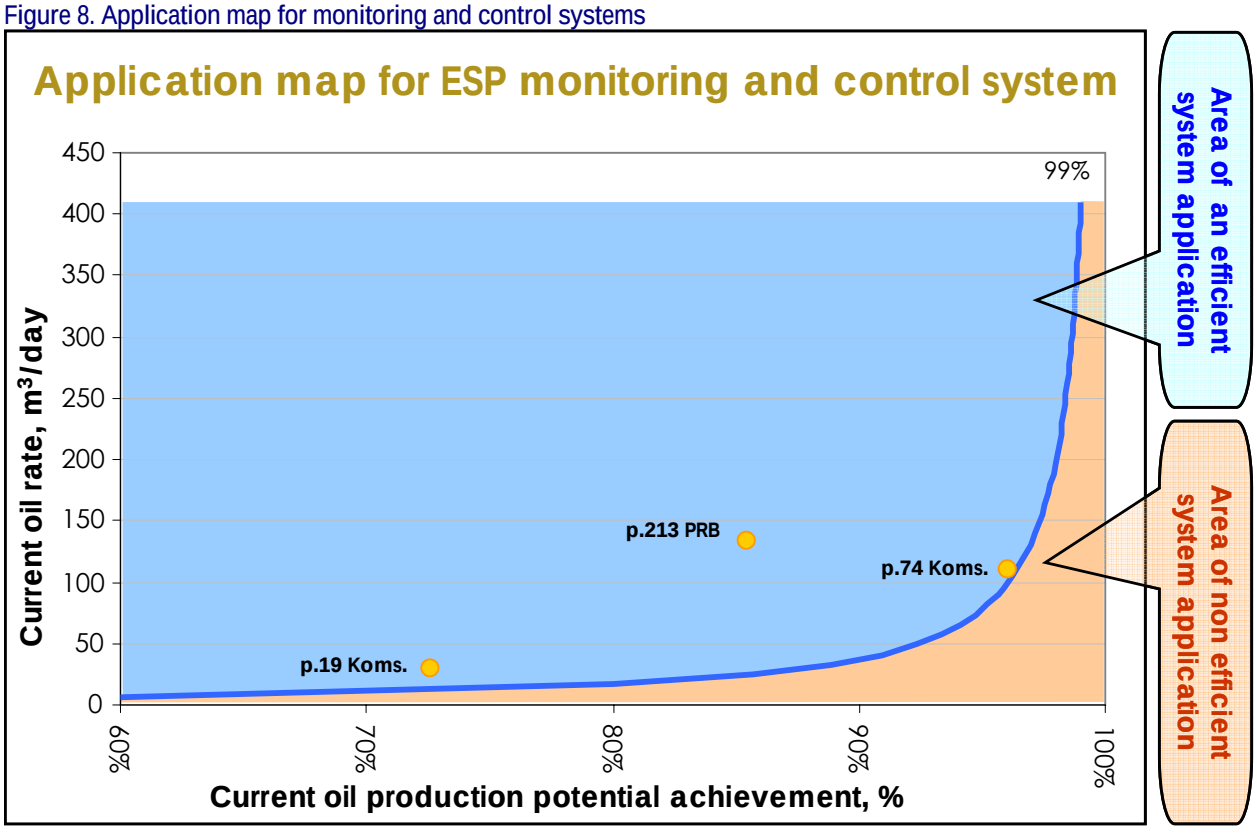


Defining applicability criterion

Based on revealed effect of ESP monitoring and control systems application of 10% reduction of unachieved potential, the criterion to define whether it is rational to introduce these systems for some specific pad could be created.

For a well in pad we can estimate costs for system implementation, additional sensors and VSDs' costs. Assuming the pay-off period of 180 days and current level of oil prices it turns out that every well must provide additional 2.6 barrels per day.

Figure 8. Application map for monitoring and control systems



So we need that 10% reduction of unachieved potential on each well will provide not less than 2.6 additional barrels per day. I.e. there is a condition for a pad where system application will be efficient:

$$\left(q_{oil} \cdot \frac{100\%}{N} - q_{oil}\right) \cdot 10\% \geq 2.6 \text{ barrels per day, where:}$$

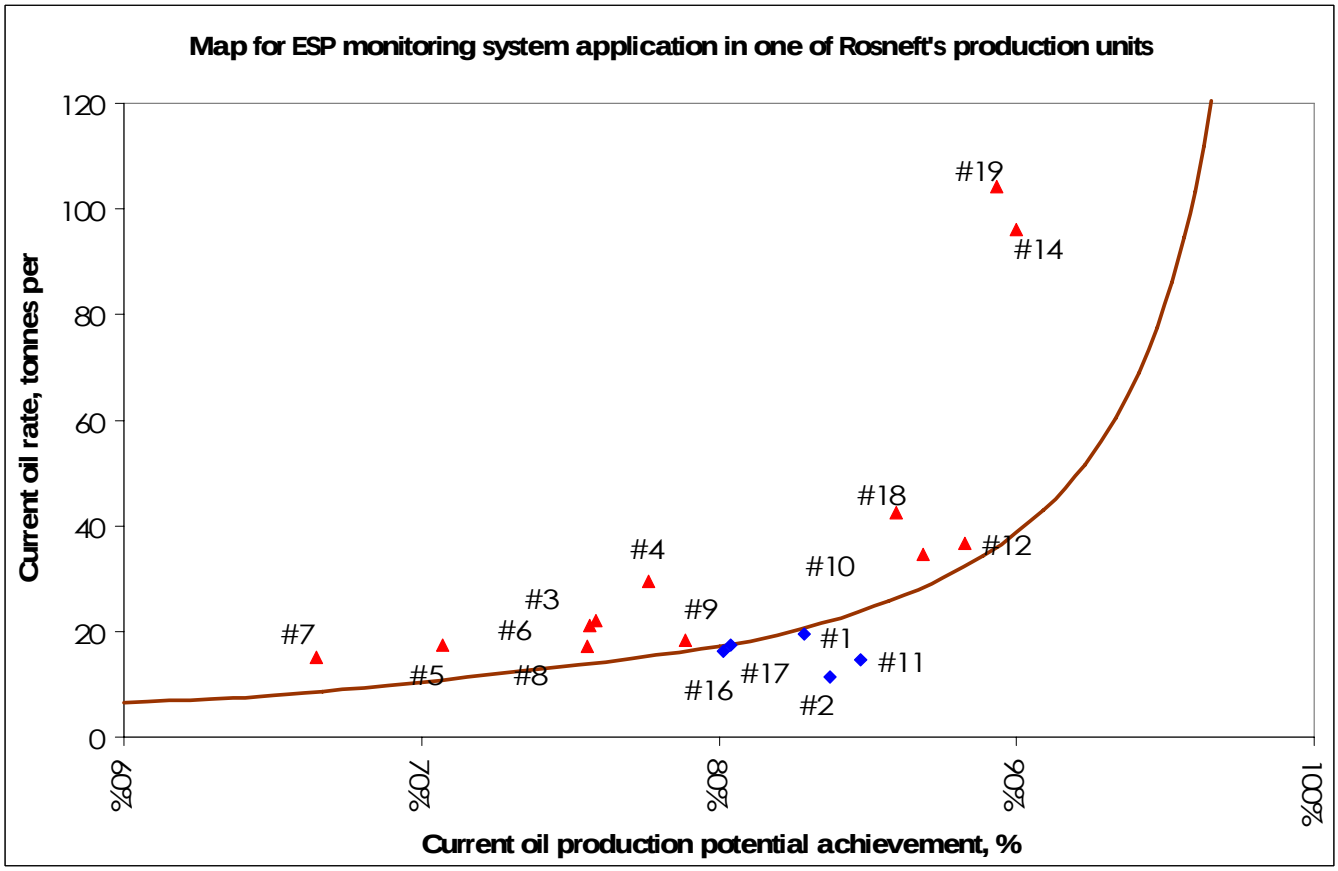
q_{oil} – current oil rate, bbls/day;
N – current potential attainment (ratio of current oil rate to potential oil rate) of a pad, %;
10% – reduction of unachieved potential stated from a system application;
2.6 – daily oil rate increase necessary to prove system efficiency, bbls/day.

Described condition is showed graphically in "Figure 8". That plot contains points that correspond to our 3 pilot pads. It could be concluded that the implementation of "Rosneft-Wellview" system on those pads was rational and efficient.

In compliance with the described criterion all the pads in all production units of Rosneft Company were tested to select those production workshops that were efficient to have the system implemented. In this case we've selected production workshop as a unit of automation because all the wells in a workshop are treated by the some specific persons and should be treated in the same way.

An example of the calculation is presented in "Figure 9. Defining efficiency of monitoring systems application" below.

Figure 9. Defining efficiency of monitoring systems application



It shows that 5 out of 18 workshops did not match the criterion of efficiency. But the rest 13 workshops with about 4000 wells do match criterion and the effect of monitoring system application there is estimated on $38 000 000 (see Table 1 below).

Table 1. System application efficiency for one of Rosneft's production units

	System is effective	System is not effective
Number of workshops	13	5
Number of wells	5 276	318
Cumulative oil rate increase, bbl/day	20 893	497
Additional cumulative oil production for 180 days, bbls	3 760 611	89 333
System implementation costs, $	33 723 211	2 032 587
Earnings from additional oil production, $	72 463 982	1 721 333
Net profit, $	38 740 812	-311 254

Conclusion

During the pilot project of ESP monitoring and control system creation and testing to reveal an effect of its application to define the criterion for applicability for Company's fields, all planned arrangements of hardware and software creation, field trials and performance analysis were fulfilled.

Project resulted in definition of the ESP monitoring and control system application – 10% reduction of unachieved potential. Also applicability criterion defined for different fields – see "Figure 8".

The monitoring and control system "Rosneft-Wellview" is recommended for company-wide implementation in Rosneft Oil Company. Calculations showed economical efficiency of system implementation on 7 451 wells out of over 11 000 working ESP wells, with the possible annual oil production increase of 11 million bbls.

Further system development is planned in the direction of analytical software and monitoring processes improving.

Results achieved certify that the technology of the ESP remote monitoring and control is very promising.

References

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