The diagram development for Computer Added Control and Monitoring system of drilling

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Abstract. The paper is concerned with the first stage of the extensive research aimed at developing design-automation system and well drilling process control. The proposed system is going to have some advantages over modern analogues, such as economic analysis at all levels, active engineering staff feedback, precedent-related principle for recommendations, etc. It will essentially reduce the risk of human errors and also optimize the well construction process from design to commissioning. The paper considers the results of the first design stage in a form of flow diagrams.

1. Introduction

Due to growing drilling volumes and development of new fields with hard-to-recover reserves, drilling reliable and less-consuming wells in shorten time are considered to be an urgent problem. However, many modern wells constructed with technological failures and characterized by reduced rate, require the use of expensive inflow intensification methods. The problem of reducing the time costs on service and insulation operations, well fishing services and unscheduled repair of drilling equipment is of particular importance. The well design stage errors or non-compliance with rules are the reasons for these problems [1].

The well design stage errors can be caused by various reasons. For example, they could be made by a design engineer while designing the draft template because of a lot of design documents (5 – 12 volumes) to be developed. Although the state expert review increases well design quality, it does not take into account technical and technological errors, since it only assesses the design compliance with the legal requirements. If such errors are made during the well drilling process, it can cause a severe accident.

As mentioned above, well design is made according to a draft template of existing wells for similar drilling conditions. This approach demonstrates its value, but it does not consider the field feedback (how “well-template” was drilled). Therefore, the design drilling well process is still not optimized.

These problems can be partly solved by using modeling methods and automatic control drilling system. The first attempts to develop such models were made in the 1960s, and the first successful results of their implementation were received in the 1970-1980’s. Nowadays, the demand for these automatic control systems is constantly increasing which is expressed in great number of researches

[2-7] and continuous introduction and improving applied developments by most international companies. The successful experience of automatic drilling system is available in different areas all over the world, including the Russian Federation (Western Siberia, Povolzhye), Kazakhstan; in offshore drilling. The latter is of particular demand due to high cost of well construction and high level of responsibility of offshore drilling. Drilling design process can be performed theoretical research, laboratory experiments and investigation of field data, as well as combination of theory and field data with further forecasting the model operation, etc. [2-7]

Presently, positive results of automatic system drilling have been achieved by foreign companies specialized in high-technology well construction, such as Sclumberger, Backer Hughes, Halliburton, Shell, etc. In Russia, this problem is being tackled by a number of service companies monitoring drilling, including telemetry. According to the field investigations results, the possibility to decrease the time of a standard well construction up to 15% and its cost estimate up to 5 – 10% has been proved.

Automatic well design systems, which are widely spread among design organizations, are also very important. This significance is confirmed by the fact that a well drilling project is the main document for the drilling crew and engineering staff. A wide range of well design systems with different levels of automation and application have been developed in national practice. Among them there are well design systems for cluster sites [8-10], including complicated geological factors and fields with reservoir management difficulties [11-13], automatic mining design systems (open pit and pit) [14-15], etc.

The given systems have a common disadvantage: that is the design of a separate stage of well construction, for example, well profile calculation and evaluation, or mine opening order, etc. Whereas oil industry requires the system which will measure the cycle of well construction and give valid engineering project out due to all the requirements and normative constraints, responding the given initial data by the operator.

On the other hand, drilling monitoring systems also have a serious disadvantage – the inactivity. In some cases, the systems only register the current process without analysis and management solutions. Therefore, the development of complex system for automatic or semiautomatic design, control and monitoring of drilling is of particular importance.

2. Development the diagram of well automatic design

Critical analysis of existing systems of automatic well design has been carried out. The list of requirements to be met by “the ideal” system has been formed:

- to provide an active feedback with an operator (the system must be in a constant connection with the operator (engineer); it is he who approves the final result and is responsible for the design quality;
- to use modern normative documents for system measurements, and to monitor constantly the legal and normative documents for updating the system data;
- to ensure active system memory: any completed project is saved in the system database and, in case of the next project, the database monitoring system proposes ready-made solutions for specific situations and conditions. Besides, the information about main indicators of the wells drilled efficiency with the option to evaluate the efficiency of adopted project solutions is added to the database;
- module-base organization – the option to do separate measurement;
- to make the module of cost-effectiveness analysis, where two parallel operations are carried out: the measure of specification time costs and well drilling construction cost, as well as the reference to database and making solutions on reducing costs and thereby increasing economic effect.

On the basis of the given list of requirements the diagram of automatic well design was made (figure 1). The system consists of 6 units and 2 databases which ensures the precedent-related

principle of its operation. The largest component of the system is an engineering measurement unit, so it was divided into modules for the convenient development and subsequent use.

For convenience, schemes, units and functional relations are shown in different colors. Design units are colored in green, purple means the output unit, while black – the input unit, facilities unit is colored in pink. Functional relations are indicated by solid lines, the color of which is determined by the relation source. For example, the information can be given to other units only from the input unit, while the output unit can both receive the information (green lines) and give the information out (purple lines). A model development of the given system with further integration and debugging by experimental measurements for the existing well is scheduled.

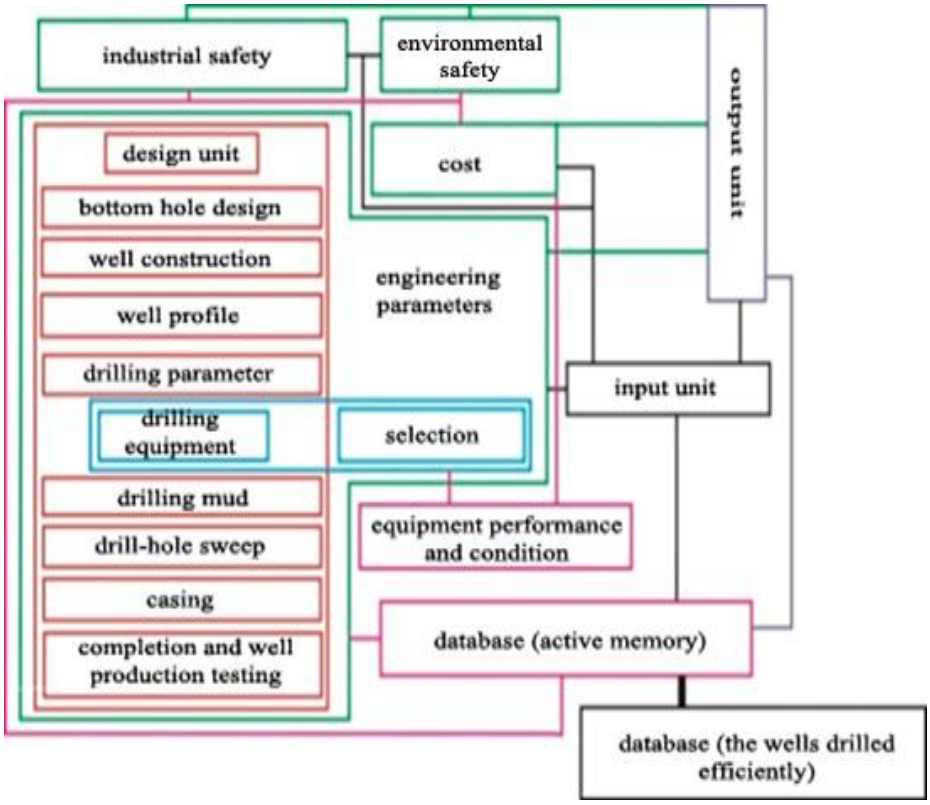

Figure 1. Automatic well design diagram.

3. Development of Computer Added control and monitoring system of drilling

The selection of national control and monitoring systems was made; KUB-2, Leuza-2, APK "Volga", KIBR – M1, SKUB-M1, MCU were included in this selection. It was analyzed according to GOST 14169-93 requirements "The systems of ground-control monitoring of drilling process of oil and gas drill-holes. General technical requirements and test methods" determining the minimum list of the parameters for the systems [17]. According to the analysis, GOST 14169-93 is proved to have lost its importance, because none of the systems met the standards, but they were actively used in drilling practice.

Therefore, the importance of modern Computer Added Control and Monitoring system of drilling is obvious. The diagram of the system has been decided to develop for modern drilling conditions satisfying the following requirements:

- database with option of "self-learning",
- precedent-related principle of operation,
- preparation of monitoring solutions for an operator in accordance with design and real drilling parameters;

- data recording system on media and server in Internet;
- monitoring technological parameters of drilling;
- drilling cost estimation;
- considering the feedback from drilling crew and engineers;
- control of drilling crew efficiency
- video surveillance of main components of drilling rig.

Therewith, the system itself should meet the standards: reliability, minimality (i.e. minimum of additional equipment and interference into a technological process), usability, quickness of analysis and solutions.

To identify the research problems correctly the diagram of a standard system of Computer Added Control and Monitoring system of drilling has been developed (figure 2). The prototype is made on a basis of the analytical comparison of national systems according to GOST 14169-93.

The diagram of the system includes mostly one-way communication. Measurement instruments fix technological parameters and transmit them to database which can either be stored on the media or used by an operator. In some cases, for example, in APK "Volga" diagram is complicated due to the analysis of obtained information by the system and suggestion of solution and recommendations (in figure 2 such version is shown by dashed lines). The given diagram emphasizes lack of using the information obtained in drilling, experience of a drilling crew and engineers.

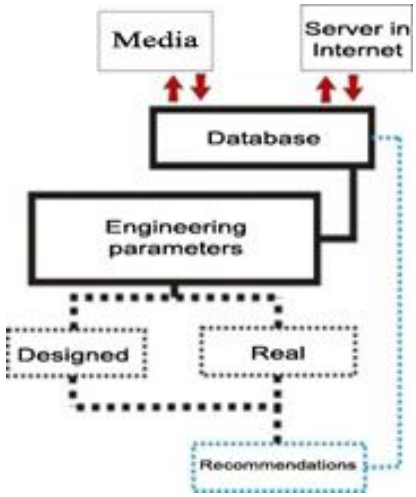

Figure 2. The diagram of a standard system of Computer Added Control and Monitoring system of drilling.

The alternative diagram of Computer Added Control and Monitoring system was further developed (figure 3). This system includes 4 functional units, such as: unit of engineering parameters registration, unit of technical conditions of drilling equipment evaluation, unit of feedback collection and estimation of drilling crew efficiency, unit of drilling cost assessment.

The unit of engineering parameters registration like its modern analogues gathers the information from measurement instruments in drilling operation. Then the data are processed and compared with those of the design data. After their comparison, taking into account the precedent-related operation principle of existing database (about already drilled wells), the system gives some option of monitoring solutions to an operator who, in turn, gives them to the engineers and drilling crew.

The unit of equipment performance and conditions gathers information for the analysis from the following sources: changes of technological parameters, with the other conditions being equal, operational video surveillance of main drilling rig components, the drilling crew feedback. The obtained information is analyzed according to the wear standards of drilling equipment, which are given as initial data. On the basis of the previous drilling experience the system also develops its recommendation which an operator transmits to the drilling crew and engineers in the form of possible solutions for the final approval.

The unit of collection feedback and estimation of drilling crew efficiency implies performing two tasks. The drilling crew can give useful information about the drilling equipment performance and drilling conditions to the system and an operator. The system operator, in turn, registers the information and interprets correctly.

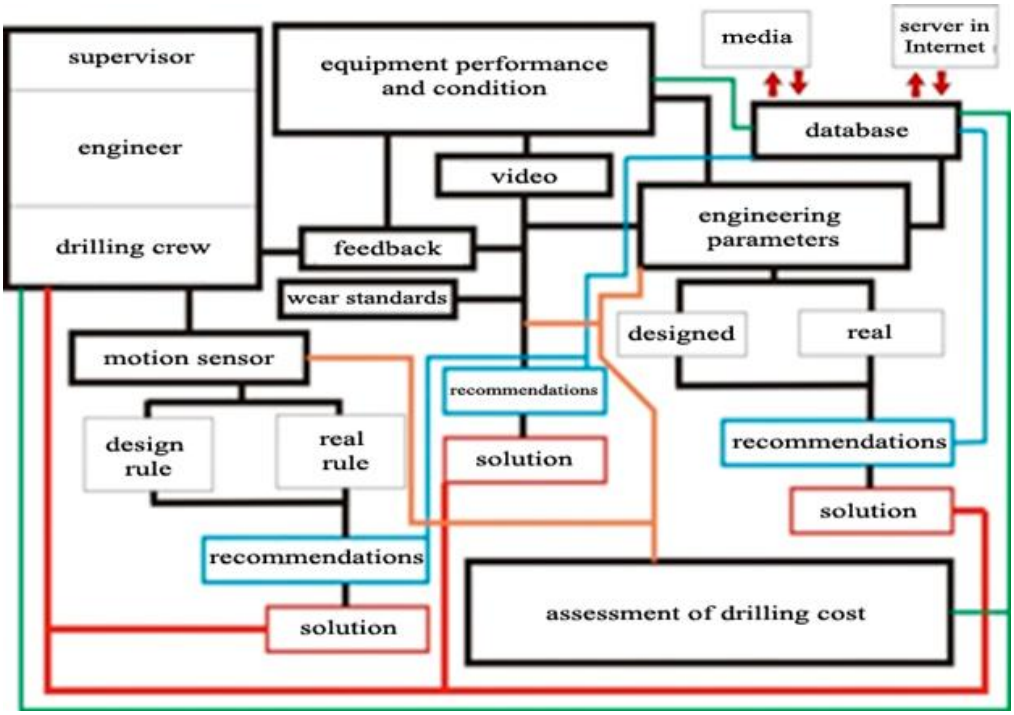

Figure 3. The developed diagram of Computer Added Control and Monitoring system of drilling.

Estimation of the drilling crew efficiency can be organized with the help of a motion sensor, for example, in each helmet. It will allow the system to analyze the efficiency of time management and improve working conditions. The unit of drilling cost assessment is to generalize and analyze the data from described above components of the system. The result of its operation is a real-time dynamic pattern of efficiency. The possibility of administrative decisions in the course of the given well project allows evaluating their influence on the well construction cost, and adjusting the drilling crew work, as well as control well project of the drilling process.

All the information is recorded in the database that operates according to the precedent-related principle and develops the recommendations for solutions. The data are stored on the server in the Internet with the possibility of receiving the report of the customers and additionally saved on the media within the range of the drilling site.

4. Conclusion

It should be noted that the suggested approach to well design is an alternative one. It allows optimizing the work of engineers of the design organization and decreasing the number of human errors. To be sure, it does not reduce the importance of engineer in design and drilling a well, but the system is going to improve the quality and the quantity of operations. The peculiarity of the system is that there is an active memory which allows the engineers to develop ideal technical solutions for the chosen areas and formulate the concept of “the model” for a well.

The suggested model of Computer Added Control and Monitoring system for drilling can increase the speed and quality of the well construction due to the recommendation system and application of successful experience of the drilled well constructions. This system is complicated at the design stage

and building the relations, revealing the trends in drilling. The next stage of the research is to specify the operating procedure for each unit and describe the character and the level of relations.

References

[1] Gutorov Yu A and Nikiforov A A 2012 Problems of well construction quality management based on performance assessment of wells as oil production objects *Oil and Gas Business* **5** 141–52
[2] Sitnikov N B 2000 Modelirovanie i optimizaciya processa bureniya geologorazvedochnyh skvazhin: avtoref. dis. ... doktora tehnicheskih nauk (Ekaterinburg) p 43
[3] Litvinov M A 2005 Sistema kompleksnogo modelirovaniya processov pri burenii neftyanyh i gazovyh skvazhin na osnove nechetkih mnozhestv: dis. … kand. tehn. nauk (Orenburg) p 156
[4] Cuprikov L A 2008 Razrabotka sistemy adaptivnogo upravleniya processom rotornogo bureniya neftyanyh i gazovyh skvazhin: dis. … kand. tehn. nauk (Krasnodar) p 193
[5] Primera A, Perez-Damas C, Kumar S and Rodriguez J E 2006 Simulation while drilling: Utopia or reality? *SPE Intelligent Energy Conference and Exhibition (Amsterdam, 6 April 2006)* **2** 460–70
[6] Zhou J and Nygaard G 2011 Automatic model-based control scheme for stabilizing pressure during dual-gradient drilling *Journal of Process Control* **21** 1138–47
[7] Breyholtz O and Nikolaou M 2012 Drilling automation: Presenting a framework for automated operations *SPE Drilling and Completion* **27** 118–26
[8] Bastrikov S N 2006 Proektirovanie i stroitelstvo skvazhin s kustovyh ploshadok na neftaynyh mestorozhdeniyah Zapadnoj Sibiri: avtoref. dis. … doktora. tehn. nauk (Tumen) p50
[9] Itkin V O 2004 Matematicheskie modeli prostranstvennyh traektorij pri proektirovanii kustovyh skvazhin: dis. … kand. tehn. nauk (Moscow) p 148
[10] Breyholtz Q and Nygaard G. 2009 Deep water drilling: Full pressure profile control in open hole section using model predictive control *Society of Petroleum Engineers – International Petroleum Technology Conference (Doha, 7-9 December 2009)* **1** 600–08
[11] Breyholtz Q, Nygaard G and Nikolaou M 2010 Automatic control of managed pressure drilling *Proceedings of the 2010 American Control Conference (Baltimore, 30 June – 2 July 2010)* Article number 5531008 442–7
[12] Harlamov A K 2007 Sovershenstvovanie metodiki proektirovaniya kustov i profilej skvazhin na mestorozhdeniyah so slozhnymi shemami razrabotki: dis. … doktora. tehn. nauk (Tumen) p 138
[13] Oppelt J and Reinicke K M 2015 Modeling, simulation and automation to optimize wellbore delivery *Oil Gas European Magazine* **41** 10–1
[14] Müller J, Jung S, Kruspe T, Herbel A and Jörns S H 2015 Measurement while drilling for directional drilling in deep geothermal reservoirs *Oil Gas European Magazine* **41** 34–5
[15] Korol G G and Lomako L S 2012 MINEGRAME System 5.0 *Credo-Dialogue* **1** 40-3
[16] Hauge E, Aamo O M, Godhavn J-M and Nygaard G 2013 A novel model-based scheme for kick and loss mitigation during drilling *Journal of Process Control* **23** 463–72
[17] GOST 14169-93 requirements “Systems ground-control monitoring of boring process oil and gas drill-holes. General technical requirements and test methods” *Support for GOST* URL: http://www.gosthelp.ru/text/GOST1416993Sistemynazemno.html