**ИНСТИТУТ НЕФТИ И ГАЗА ИМ. М. С. ГУЦЕРИЕВА**

***Кривилев Григорий Михайлович, Удмуртский государственный университет, grigoriy.krivilev@gmail.com***

***Научный руководитель — Бобков Даниил Олегович, Отдел разработки месторождений ООО «УДС нефть»***

**ПРИМЕНЕНИЕ ИСКУССТВЕННЫХ НЕЙРОННЫХ СЕТЕЙ
НА НЕФТЯНЫХ МЕСТОРОЖДЕНИЯХ**

**THE APPLICATION OF ARTIFICIAL NEURAL NETWORKS ON OIL FIELDS**

**Аннотация.** Рост популярности искусственных нейронных сетей (ИНС) привел к тому, что их начали использовать для решения любых проблем. Целью данной работы является критический анализ особенностей нейронных сетей и выявление области их наиболее эффективного применения на месторождении. В итоге можно сказать, что способ применения зависит от возраста месторождения: на новых месторождениях ИНС следует применять для адаптации математических моделей, а на старых месторождениях — для предсказания эффекта от проведения ГТМ или прогнозирования неисправностей.

**Abstract.** The growth of popularity of artificial neural networks (ANN) has led to the fact that engineers started to use them everywhere. The goal of this work was to critically analyze the unique features of neural networks and determine the most effective ways of application on oil fields. In the end, the method of ANN application depends on the age of the oil field: on new fields neural networks should be used for model adaptation, however on the old oil fields it should be primarily used for failure prediction and technical actions efficiency analysis.

***Ключевые слова***: искусственные нейронные сети, нефтяное месторождение, статистические методы.

***Keywords***: artificial neural networks, oil field, statistical methods.

An intelligent oilfield is the oilfield, where the highest efficiency available at the current level of technological development due to full use of information. A big part of any intelligent oilfield is connected with neural networks and machine learning. Even though almost everybody has heard of these terms, it is difficult to understand how neural networks should be implemented in the structure of forthcoming or existing oilfields. The goal of this work is to critically analyze and understand what the role of neural networks in modern and forthcoming oilfields is and how it should be implemented towards the most effective usage.

An artificial neural network (ANN) is a data analysis system, which consists of a node aggregate interconnected in a special manner. Each ANN has an input and output layers and can have multiple hidden layers. The quantity of hidden layers and nodes in them depends on the problems that the ANN will have to solve. The working principle of ANN are relatively easy to understand and have already been described in a number of works [1].

Now one should specify a few moments. First, it is necessary to understand that neural networks belong to a family of existing statistical analysis statistical approaches. There are also many other methods, including extrapolation forecasting methods, spectral correlation data analysis with period and seasonality search, models with statistical intervention parameters, harmonic models and many others [2].

The main advantages of ANN in comparison with other statistical methods are as follows [3].

1. Possibility to work with non-informative noise input signals and polytypic information.
2. A neural network has fewer requirements for the qualification of its user compared to complicated statistical models capable of obtaining similar results.
3. Neural networks can adapt easily to new data during the whole process of field development and do a much better job in systems with many interconnected factors.

However, they also have some disadvantages connected with their working principles.

1. Neural networks can be overtrained or they can have too complex structures. This results in excellent training accuracy but the accuracy of actual predictions will be relatively low [4].
2. In deterministic models with a small number of input parameters the error of neural networks is usually higher than the error of more specific statistical methods.
3. Most neural networks do not have the ability to separate inaccurate data. This fact may lead to lower quality of prediction.

Now there are many mathematical models to predict and analyze almost every technological, geological or hydro dynamical process on the field. However, all of them consider only some particular factors. Therefore, every model has to be adapted to the level of adequate accuracy. The more factors are implemented in the model, the better it is.

New oilfields do not have established models. In addition, they tend to be smaller and smaller in the future. Therefore, it will be too expensive to employ a team of experts on the regular basis to correct the models and monitor the field. Therefore, the main task of neural networks on new fields will mainly be connected to model building, optimization and decision support systems.

However, this is not the case for old oil fields. The age of the field results in the fact that the information flow on this oilfield is already established and has all the interconnections that it needs. The geological and hydrodynamic models are accurate and have been already adapted for this field. The planning process is based on the already existing models and takes into account many aspects that have proven to be important during the years of its development. So the two main areas in this field suitable for ANN implementation are connected with forecasting:

1. Pipeline and equipment failure prediction. Most of the pipelines and equipment are old (as well as the field itself) and the chemical composition of the oil is mostly aggressive to the equipment (H2S and water content) [5].
2. Prediction of geological and technical actions efficiency as they require the consideration of multiple factors and their interconnections.

These aspects are valid to majority of old oilfields. Their infrastructure and models have already been developed and the best way to implement neural networks is to use them for prediction in narrow areas such as failure prediction or efficiency evaluation.

Another part of the work was connected with the fact that McKinsey Global institute analysis pointed out in one of their researches that less than 1 % of the data gathered on the oilfield is used for decision-making [6]. Therefore, we have tried to design an information flow diagram on an existing oilfield with the purpose to analyze it and determine the best ways of neural network applications. However, during the work we have found out that this represents not data loss but effective data generalization necessary for fast decision-making.

In this work we have critically analyzed the actual advantages and differences compared with other systems of statistical analysis and made the following conclusions.

* Artificial neural networks have the advantage over other methods of statistical analysis in systems with a large number of parameters that are interconnected. In deterministic models with a small number of variables other methods should be used as their accuracy is much better.
* On oilfields with an already developed infrastructure and established information flows the most efficient application of neural networks is to be connected with failure prediction and efficiency analysis. On new oil fields neural networks should be used for development of the applied informational models and for their adaption to the local conditions.
* The fact that only a small amount of information is used for decision-making is connected mainly with the generalization of data during its flow in the information system.

**References**

1. Sun L. et al. Application of BP neural network in oil field production prediction // 2010 Second WRI World Congress on Software Engineering. DOI 10.1109/WCSE.2010.101.
2. Korovin I. et al. Modern Decision Support Systems in Oil Industry: Types, Approaches and Applications // International Conference on Test, Measurement and Computational Method (TMCM 2015).
3. Bukharov O. E., Bogolyubov D. P. Development of a decision support system based on neural networks and a genetic algorithm // Expert Systems with Applications, 2015.
4. Malvic T. et al. Neural networks in petroleum geology as interpretation tools // Central European Geology. 2010. Vol. 53/1. P. 97–115. DOI: 10.1556/CEuGeol.53.2010.1.6.
5. Layouni M. et al. A Survey on the Application of Neural Networks In the Safety Assessment of Oil and Gas Pipelines.
6. The age of analytics: competing in a data-driven world // McKinsey global institute, December 2016.

***Курамшин Максим Дмитриевич,*** Удмуртский государственный университет

Научный руководитель — Губанов Александр Михайлович, Удмуртский государственный университет

**ТЕХНОЛОГИЯ КОНЦЕВОГО ЭКРАНИРОВАНИЯ**

**THE SCREENOUT FRACTURING TECHNIQUE**

**Аннотация.** На сегодняшний день большинство компаний ведет разработку трудноизвлекаемых запасов, что требует значительных финансовых инвестиций и внедрений инноваций в процесс добычи, таких как технология концевого экранирования. В статье представлены сущность данного метода и его особенности.

**Abstract.** Nowadays a lot of companies develop hard-to-recover reserves which require significant financial investment and introduction of innovations in the production process, such as Screenout Fracturing Technique. The main idea and features of this technique are discussed in this article.

***Ключевые слова:*** гидроразрыв пласта (ГРП), технология концевого экранирования, проппант, проводимость, трещины, перемычки, вдавливание.

***Keywords:*** fracturing, screenout fracturing technique (TSO), proppant, conductivity, fractures, brattice, embedment.

**Preface**

To understand the nature of TSO it should be mentioned that TSO is a fracturing modification.

The main point of fracturing is opening of artificial or forming of natural fractures occurring in the reservoir by pumping liquid under high pressure and its further dislodgment by pumping frac sand or acid without sacrificing its high permeability after finishing the process and excess pressure relief.

The following problems are solved during fracturing:

* creation of fractures by pumping special matched fracturing liquid;
* fracture retention in open condition by addition proppant with grains of any size and solidity to fracturing liquid;
* removing of fracturing liquid to restore filtration characteristics of the hole-bottom zone;
* enhancing the formation productivity.

**Screenout Fracturing Technique**

To enhance formation productivity the method of creating short and wide fractures penetrating outward pollution bubble in highly-permeable interlayer is used. This method is called screenout fracturing technique (TSO). TSO is a modification of fracturing when short 30 mm wide fractures are created (a few tens of meters). It occurs due to controlled spread of fractures to planned length and their further consolidation by proppant pumped with fracturing liquid.

Proppant concentration increases pumping front because of filtration leakage of fracturing liquid through fracture surface. Then it results in the formation of proppant plugs near the end of fracture which prevent its further spreading. Proppant pumping continued after crack arrest allows increasing the pressure inside fracture thereby increasing its opening. Thanks to this fracturing modification activity costs reduce by decreasing of pumped liquid volumes and proppant volumes and cutting time of operations.

Opening increase of consolidated fracture results in increase of its conductivity. Dimensionless parameter value of *hydraulic conductivity* ***C*** allows estimating well productivity after fracturing by substitution method of efficient well radius instead real radius in Dupuis formula. Efficient well radius is proportional to fracture length multiplied by function of *fracture hydraulic conductivity.*

**C** = (**W** \* **kprop**) / (**x** \* **kform**),

**W** — fracture opening, **kprop** — proppant pack permeability, **x** — fracture half-length, **kform** — reservoir permeability.

For West Siberia oilfields fracture dimensionless conductivity ***C*** ranges 0,5–1,5.

There are some Particularities of screenout fracturing technique (TSO):

* Prevention of fracture adverse spread after pumping is stopped (when using traditional fracturing techniques great spacer fluid volume usually remains before fracturing liquid with proppant after killing a well; thus, fracture can continue to spread that can decrease fracture conductivity).
* Prevention possibility of proppant backflow by achieving more equable spread of exertion throughout proppant pack (fractures created using traditional methods close longer allowing some amount of proppant to settle at the bottom; it creates higher concentration of proppant on the fracture bottom).
* *Proppant embedment* is a complicating factor in this process (term *proppant embedment* describes influence when adjoining to fracture surface proppant grains penetrate into it, thereby decreasing efficient fracture opening; this process occurs in soft rocks).

**Conclusion**

TSO in which filtration seepages of fracturing liquid are concealed for creation of high proppant concentration of pumping front provides quicker fractured closure and allow minimizing proppant backflow. Brattice creation and raised proppant pack process in fracture end can be used successfully for creation of short and wide fractures in high-permeable reservoirs.

**References**

1. Губский ст. А. Технология концевого экранирования на месторождениях Западной Сибири // Нефтегазовое обозрение. 2000. C. 4–9.

2. Экономидис М., Олайни Р., Валько П. Унифицированный дизайн гидроазрыва пласта. Алвин, Техас: Орса Пресс, 2004. (Economides M., Oligney R., Valko P. Unified Fracture Design. Alvin, Texas: Orsa Press, 2004.)