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Algorithm for Experimental Researches in Gas Lift Wells

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Abstract

Mathematical models for approximation of dependency between the main parameters of gas-lift wells analysed. Requirements and frequency for active and passive experimental researches in gas-lift wells for identification of these models were determined. Sequence and flowchart for processing of experimental research data in gas-lift wells are developed.

Keywords

Gas-Lift Wells, Approximation, Identification, Experimental Researches, Active and Passive Experiments, Statistical Identification, Flowchart, Algorithm

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1. Introduction

It is known, that oil production processes commonly are non-stationary and it requires periodic researches for properly control of wells. As various disturbing factors are impacted to operate of gas lift wells for the identification of mathematical model approximately one times in quarter is conducted experimental researches. Main characteristics of the wells are both dependences between the oil production and working agent (gas or air) which injected into the wells and dependence between the oil production and bottom hole pressure of wells as well.

2. Formulation of Problem

Currently different mathematical models, formulas and algorithms for identification them and for calculating working regimes of gas lift wells are used. Besides, some active and passive research methods and sequences for this oil extraction method exist that require definition optimal sets of methods and algorithms for increasing efficiency of researches.

3. Solution

Gas-lift method available by deviated well bore production, multiple formation reservoir development, also when there are enough quantity of gas for injection. All these give high efficiency factor. Gas-lift production system consist of reservoir, production tube, collection pipeline from well to gathering station, separator, gas compressor, gas injection pipeline.

The advantages of gas-lift application are: high technical and economical efficiency, absence of lifting mechanism and friction elements, large period between repairs, and simplicity service of gas-lift wells and regulation of production regime, reliable surface equipment and so on.

The disadvantages of gas-lift application, which use compressor station, when pressure of gas very low are: low efficiency of all gas-lift system which includes compressor station, gas pipeline and wells, high expenditure for service of compressor station.

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For the optimum performance of the wells their technical and technological parameters are calculated and adjusted during design process. Next step it is building of the wells according to design parameters, that allow obtain maximum oil at minimum flow of working agent (gas or air). However, when geological and mining data of the layer and the affluent liquid in the wells change, calculated optimal regime of the wells is changed as well. That is why it will come to necessary to change of the constructional dimensions of the lifting tube, as result a total efficiency of gas-lift oil production become lower. Besides, every wells operates not separately, they operates in relation with other wells: because, they get the oil (liquid) from common structure (layer), also working agent distributes in optimal volume, implementing criteria of maximum oil production in dependence from specific consumption of the working agent (volume of the working agent that used for extraction 1t oil), regarding its minimization and during the distributing process it is necessary providing of performance some limits regarding other wells. Thus, requirement of researches is necessary to find of wells optimal models and explains complexity to support the technical and technological optimum during the long time. Because, it take into account the some periodically correction to wells design and it is not effective. It decreases the oil extraction effectiveness and it measure requires verifying researches in wells.

Properly designing of experiments provides adequate measurements results and also allows to decrease the production losses via changing regimes of wells on large range of working regimes during the researches on wells group which operate according to production requirements modes.

To study the effectiveness of all operations and procedures carried out during experimental researches should be use simulating the model and to determine the necessary steps on processing of the modelling results.

As mentioned at many articles, essence of the first research method is keeping pressure constant and getting on the use of by changing working agent for obtaining dependency

$$Q = K\,(p_{lay}-p_{bh})^n.$$

The K - productivity rate of well, p_{lay} - layer pressure, p_{bh} - bottom hole pressure, n - power of formula, which shows how liquid filtration processes are going on.

Above mentioned method gives information about flow of oil or liquid to bottom of wells. Besides, this data helps to understanding the process that take place in different layers and to determine optimal extraction modes in wells.

Research the wells by second methods means keeping constant working agent pressure and changing its consumption and building dependency $Q = f(V)$. According with this dependency, it should be noted that to use a logarithmic-parabolic mathematical model for purpose of approximation of experimental research results is advisable due accuracy. This model describes the gas-lift oil production process with accuracy enough for optimal control of the wells. Therefore, let's use the following models:

$$Q = a_0 + a_1 lnV + a_2\,(lnV)^2$$

All measurement results obtained after the completion of researches can be used for identification of the mathematical models and determination of optimal modes gas lift wells and preparation of analytical reports and recommendations. Note that problem of distributing of the given volume of working agent between wells can be solved by dynamic programming and simplex method which allow to decrease required calculations.

Although active researches as mentioned above is effective in terms of accuracy, however, in some cases - in wells, which regime change in a wide range and in "capricious" wells with low sustainability reserves, is not recommended, as well as when there is not sufficient volume working agent - is impossible to conduct these researches. In such cases, passive experiments or identification of mathematical model based on the measurements results of normal operating of wells, named statistical identification, although less accuracy but allows to obtained approximate information about the wells characteristics ($Q = f(V)$ dependency).

Usually experimental research in gas-lift wells conduct 3-4 times at year and changing of the technological modes based on results of researches decreases the oil extraction not more than permitted value. However, for identification of the models need measuring on 4-5 regimes. In this case production losses will be bigger. Because, for measurements on every regimes need lot of time for restoration of sustainability or stability of production process depending from state of wells (from 3 hour to 1-2 days). The reason of it is pulsing oil or liquid on out of wells, that will come to losses of production. Besides, pulsing can be cause of failure of lifting and other pipe and equipment. That is why well's research should be conducted with take into according above mentioned features.

The sequences of research, data processing of measurements results and of recommendations is shown as following flowchart (Figure 1). So after the analysis of wells, which characteristics should be clarified, wells are selected. Once selected wells determined the possibility of an active investigates. If yes, the research method is determined, and experiments are carried out depending on selected method and measurements are conducted and recommendations are

prepared.

If to conduct active experiments in wells is impossible, carried out passive experiments and dependency $Q=f(V)$ is obtained by the statistical identification by using data of experiments that are measured in normal working regime. At the end of processing the approximately results of the working modes (optimum and maximum) is determined. These values allow to verification of the possibility of active clarifying research in wells. If conducting of active researches is possible; the measurement results are processed and set the parameters of the working regime wells is calculated.

With the development of science and technology can be applied new research methods, dependencies and mathematical models. As envisaged on conceptual model database for experimental researches of gas lift wells, to scheme is added a new module conducting experiments. The new algorithms and software included this module are prepared and presented by person who carried out implementation of new experiments.

At the same time all types experiments in gas lift wells uses to decrease of uncertainty of information, to increase of accuracy of the applied models. An uncertainty reduces nonlinearity and accuracy of transfer function of wells and adequacy of models.

So in this case problem consist of finding of such control signal or such change sequence of wells modes when transient process in well would be short, pulsation and also measurement noise would be low.

As calculation shows, that via reducing of the duration of transient process and decreasing pulsation in the well can be got additional oil extraction up to 5%. Using of the programmable logic controllers for solving above mentioned research task allows apply individual approach to control of gas-lift wells during research and take into account features of every wells and as results - solving of task is becoming much easier.

Accordingly with described procedures and with sequence of the research all changes of regimes in the wells during research implements on based properly verified information which is obtained after data processing. Clarification of information about next change is conducted after every step using of comparison with initial data or with intermediate results obtained on appropriated step. Besides, using of multifactor experiment instead of the single-factor experiment allows decrease the possible variation range of the parameters and improves data quality.

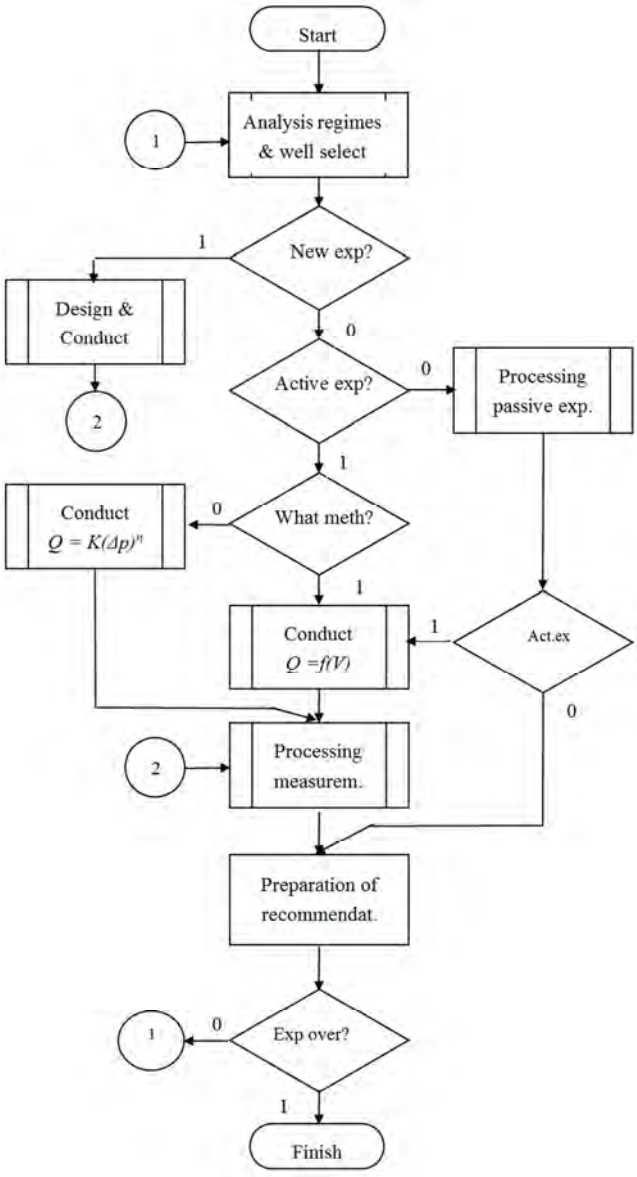

Figure 1. Flowchart of active and passive experiments.

4. Conclusion

Design of algorithms for passive and active experiments allows optimizing of research process with required volume of information to obtain reliability results with necessary accuracy that adequate to researched process.

This algorithm which will be part of control system for experimental researches on gas-lift wells will allow to implement of researches on this sequence and to increase efficiency of researches and to reduce possible losses through monitoring and automation control of these processes.

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