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The Mathematical Models and Function Algorithms of Automatic Control System of Dynamic Treatment Process on Underground Massive

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Математические модели и алгоритмы функционирования системы автоматизированного управления процессом динамического воздействия на подземные массивы

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Математичні моделі та алгоритми функціонування системи автоматизованого керування процесом динамічної дії на підземні масиви

The mathematical models of technological process of pneumatic and hydrodynamic treatment on anisotropic underground rock massive, saturated with useful minerals, is considered. The treatment applies as a way of directed changing of massive status for intensification of mineral extraction and its effectiveness depends of quality of parameters control. The structure of the automatic control system and the algorithm of its parameters selection is proposed.
Keywords: process, mathematical model, control, massive, system.

Рассматриваются математические модели технологического процесса пневматического и гидродинамического воздействия на анизотропные подземные породные массивы, насыщенные полезным минеральным сырьем. Воздействие осуществляется как способ направленного изменения состояния массива с целью интенсификации извлечения сырья. Предложена структура системы автоматизированного управления и алгоритмы контроля ее параметров.
Ключевые слова: процесс, математическая модель, управление, массив, система.

Розглянуто математичні моделі технологічного процесу пневматичної та гідродинамічної дії на анізотропні підземні породні масиви, насичені корисною мінеральною сировиною. Дія здійснюється як спосіб спрямованої зміни стану масиву з метою інтенсифікації вилучення сировини. Запропоновано структуру системи автоматизованого керування та алгоритми контролю її параметрів.
Ключові слова: процес, математична модель, керування, масив, система.

Introduction

The exclusive feature of formation of underground rock massive, containing useful minerals, in particular oil and gas arrays, is anisotropy. There comes a time when lightly extracted part of the product ends and significant reserves remain sequestered within the array, resulting in reduced production volumes. In this case becomes important problem of increasing the intensity of extraction of useful product. One of the ways is a purposeful change in the properties of the array by external treatment, particularly pneumatic and hydraulic dynamical processing, while negative effect anisotropy array. Quality implementation exposure provided by automatic process control, which allows you to quickly react to put out of negative influence of anisotropy and ensure the stability of technological parameters.

Technological base of process

Pneumohydrodynamic saturated groundwater treatment is carried out by high-pressure arrays aerated fluid injection through wells drilled from the surface on the horizon is to change its status to intensify the yield of usable product. In addition, hydrodynamic impact on the producing formation is carried out in order to alter the balance of his status as a method of pre-selection activation of hydrocarbons [1], [2].

Essence pneumohydrodynamic impact is compulsory introduction mixture of air and liquid in the array developed under high pressure with subsequent discharge (Fig. 1).

Integrated pneumohydrodynamic impact is complex multifactorial process, and it is necessary to apply the rational organization of automated control. Virtually all applicable Geotechnology reduced to the well producing hydrocarbons and consist of:

– Drilling from the surface to the producing formation with its opening;

– The impact of different kinds of wells in the reservoir to increase its natural gas permeability;

– Pumping up filtering [3].

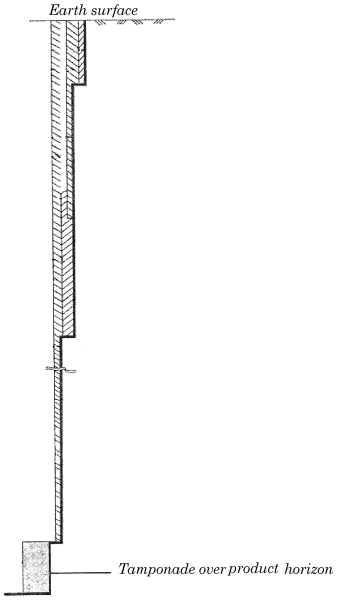

Figure 1 – Vertical section of the well

The pneumohydrodynamical effects of rising pressure in the annular space of a well and pump-compressor pipes by forcing air compressor, and the collapse-the opening of the well through a management device.

This approach is commonly referred to as «traditional».

Differences «alternative» approach to a «traditional» Truce in the second paragraph and theoretical assumptions [4]. For «alternative» approach to the second point can be formulated as «the creation of conditions for self-hills on well (exposure of the array into the well) to initiate (start) out of hydrocarbons». The basic idea of an alternative approach, except for changing the direction of the stimulation on the opposite, the assumption is that the permeability of the reservoir and discharge sources are shown simultaneously and technogenic origin.

If we consider a system of «productive layer – production (well)» in terms of synergy, the traditional scientific knowledge of saturated arrays undergo significant changes. For example, a well-known fact that from a certain depth of exploitation array acquires the ability to self-destruct with the formation of spin zone is interpreted as the formation of an ordered tree of man-made cracks – «dissipative structures». These and other kinds of dissipative structures, consisting of man-made cracks in the vicinity of the exposed surface, usually referred to as «tree» system of cracks [5].

Theoretical base of investigation

Known techniques to stimulate extraction through the wells drilled from the surface, for example, hydraulic fracturing directed hydrodismemberment layers, etc. are used when drilling the resulting «tree» system cracks around technological injection well in which the working fluid or other agent in order to further their disclosure. When designing technology schemes of pumping of liquid agent must make a preliminary calculation of the basic parameters, such as injection pressure, flow rate (tempo), and others.

To solve the problem, a linearized model of fluid flow in fractured porous media is applied [3]:

$$\frac{\partial P}{\partial t} = \frac{\partial}{\partial x}\left(K(x)\frac{\partial P}{\partial x} \right).$$

The equations of the same type are obtained to describe the process of movement of air, or gas-liquid mix.

The automatic control system was effective for the treatment of an array, you must use the model in real time, and on the other hand, the filtration characteristics of the reservoir are actually random variables whose values are initially based on average data exploration. In the circumstances, the following approach adopted.

The system of using two models:

– the original model of the rock massive with its characteristics of geological data;

– a forecast model, reflecting the expected state at the moment, on the basis of the information on the results of the effects in real time.

This approach allows you to escape from the identification procedure object parameters (filtration coefficient, the coefficient of the anisotropy of the effective porosity, etc.).

The simulation of the one-dimensional flow does not provide sufficient information for the theoretical understanding of the nature of the process. To solve the problem of mathematical modeling of hydraulic impact to an array with a two-dimensional (planar) formulation technique of longitudinal-transverse direction (Douglas). The equation is of the form: $\frac{\partial p}{\partial t} = \frac{\partial}{\partial x}\left[k(p)\frac{\partial p}{\partial x} \right] + \frac{\partial}{\partial y}\left[k(p)\frac{\partial p}{\partial y} \right]$

Task selection and effects that improve the quality of treatment in spite of the unfavourable structure of the array. In other words, it is also necessary to improve technology to processing to compensate for unfavourable characteristics of the building of the reservoir. One possible way is the way of the hydraulic impact through the cascade of wells (way to cascade moisturizing treatment). Studies of fluid discharge in coal seam through the cascade wells led to the conclusion that the use of this method to improve the uniformity of processing array.

The approach to system construction

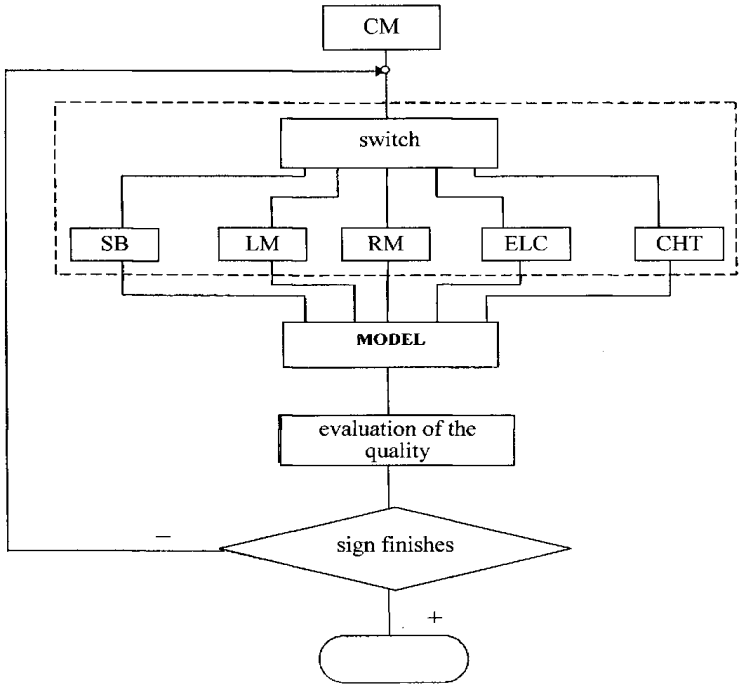

Figure 2 – Structural-functional diagram

When you build a system of control of an important component is the unit software, designed to simulate the condition and operational definition of current results.

As stated above, the purpose of automation-stabilization technology options.

The system includes the technological schemes of all interventions, coordinating the work carries out central module (CM). The generalized structure of the system is shown in Figure 2. Here SB – a single borehole, LM – local method, RM –regional method, ELC – effects on a layer in the complex, CHT – cascade Hydro-treating.

The switch selects the specified flow chart and sets the direction of further operation.

The mathematical models form the basis of a software management system. The main feature of the process is the impact that the object (mountain range) "closed" from direct observation, and a mathematical model to simulate the process of impact, based on information about the "reaction" to the impact of the object.

Comparing the data, the system fulfills team correction controlled parameters. Fig. 3 shows the functional- logical structure of automated control system (ACS).

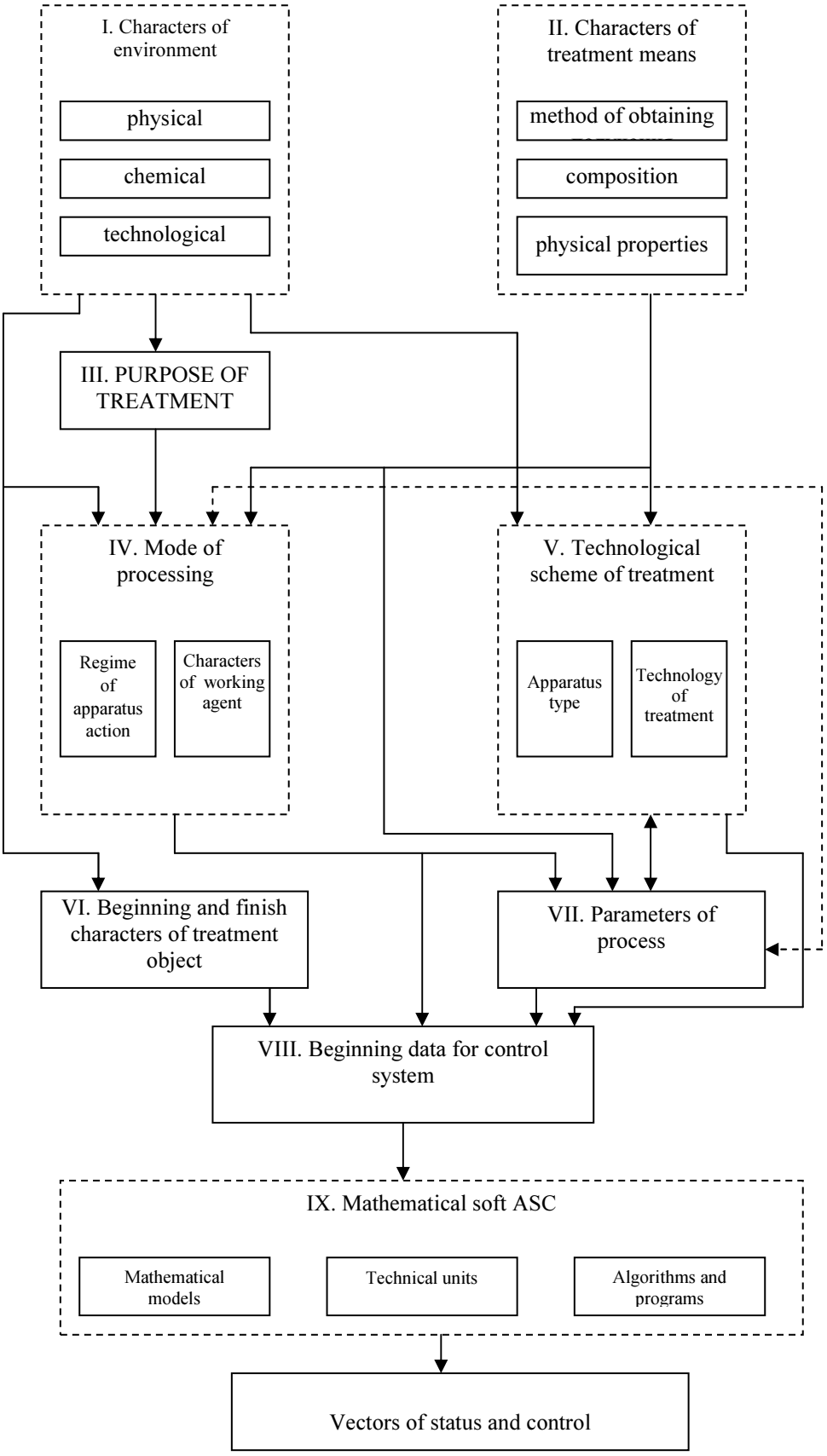

Figure 3 – Functional-logical structure of the system Automatic Control System (ACS)

Selection and subsequent design of the system is complicated by uncertainty, which is a fundamental feature of the implementation process and the impact of management principles algorithmization. Table 1 shows the comparative characteristics of the main types of management structure: functional, matrix and project [5].

Simulation modeling to determine the overall trend in the direction of a process runs automated selection of parameters of operational management. However, it is necessary to have the current choice of the complex algorithm parameters. Fig . 4 shows a block diagram of the control of the selection algorithm set close to optimal.

Table 1 – The main types of control structure

Criteria for assessing the structure	Functional	Matrix	Project
Uncertainty medium	low	high	high
Technology implementation	standard	complex	new
The complexity of process	low	medium	high
Duration of the process	short	medium	high
Mutual relationship between the individual components	low	average	significant
Criticality runtime	low	medium	high
Communication with higher-level systems	strong	medium	weak

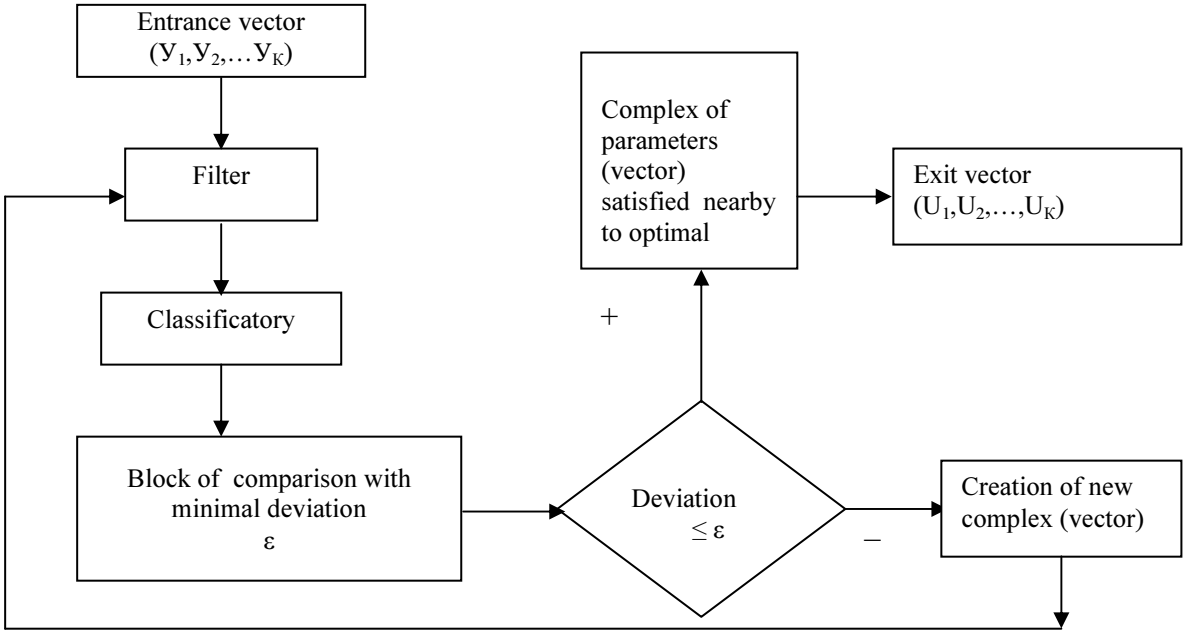

Figure 4 – Flowchart selection of the current control vector.

Conclusion

As a result of technological implementation process pneumohydrodynamic anisotropic effects on underground saturated mass is forced introduction of air and liquids under high pressure in natural cavities, causing an array of structural changes, accompanied by the expansion of pores and cracks.

After discharge the activated selection of hydrocarbons into the well of the array.

On the basis of theoretical concepts, received practical advice on choosing the structure and technological parameters of the automated control system, developed an algorithm for selecting the optimal approximate vector control process pneumohydrodynamic impact.

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RESUME

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Background: In given work the problem of application of computer methods for solution of the task of increasing the intensity of extraction of useful product from anisotropic underground rock massive, saturated with useful minerals, is considered. One of the ways is a purposeful change in the properties of the array by external treatment, particularly pneumatic and hydraulic dynamical processing, while negative effect anisotropy array. Quality implementation exposure provided by automatic process control, which allows you to quickly react to put out of negative influence of anisotropy and ensure the stability of technological parameters.

Materials and methods: Pneumohydrodynamic saturated groundwater treatment is carried out by high-pressure arrays aerated fluid injection through wells drilled from the surface on the horizon is to change its status to intensify the yield of usable product. In addition, hydrodynamic impact on the producing formation is carried out in order to alter the balance of his status as a method of pre-selection activation of hydrocarbons.

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– the original model of the rock massive with its characteristics of geological data;

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Results: As a result of technological implementation process pneumohydrodynamic anisotropic effects on underground saturated mass is forced introduction of air and liquids under high pressure in natural cavities, causing an array of structural changes, accompanied by the expansion of pores and cracks.

Conclusion: Simulation modeling to determine the overall trend in the direction of a process runs automated selection of parameters of operational management. However, it is necessary to have the current choice of the complex algorithm parameters.

On the basis of theoretical concepts, received practical advice on choosing the structure and technological parameters of the automated control system, developed an algorithm for selecting the optimal approximate vector control process pneumohydrodynamic impact.

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