The Modeling of Mineral Water Fields Data Structure

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***Abstract*— The article deals with development methods of mineral water fields data structure model. It provides a practical example of data structure for the mineral water deposits complexes model. This work determines data structured base principles for the hydromineral resources deposits models design. The proposed data structure model is most effective for development of deposits control system.**

Keywords—Data structure model; information system; control system; mineral water fields; data structure

I. Introduction

The mineral water fields are a very important research object because there are many processes that must be modeled to provide good ecological being. For example, in (1) authors discussed different parameters of the mineral data fields and the resume of this article describes the difficulties in obtaining such recourses description. The same story happens when we try to develop the control system for this complex object (2).

Methods of the mineral data fields control systems development need the transfer function calculation. Nonlinear behavior of this complex object requires more studies for control system developers (3). If we want to obtain better results in this study we must begin the control system development from the modeling process (4). The mineral data fields control systems are distributed control systems, it imposes additional difficulties for the system structure model development. There are some basic information technologies that help us to acieve success in our studies of the distributed control systems (5).

One of the well known information technologies is database development. All of our nature experiments and mathematical models (6) need a good database structure. This specified database will allow accumulate more information about parameters of mineral data fields. Thus we can perform calculations (7), accumulate calculation results in that database, and get more information.

What is the problem for us with mineral water fields database development? Data structure modeling problems are associated with the complexity of the object. Most important problem that we want to discuss in this study is the problem of the mineral water fields' data structure modeling. We try to check out the solutions of this task. This article explains the effectiveness of our proposed solution.

II. Problem Description

Mineral water deposit is a complex hydrogeological object. Structurally, the field is represented by a hydrogeological section, schematically representing the location of aquifers, sands and production wells. The mathematical model describing the distribution of mineral waters in the specified structure is complex (Figure1). The computational scheme, which allows obtaining results using the model of water distribution in reservoirs, requires significant power in the calculation.

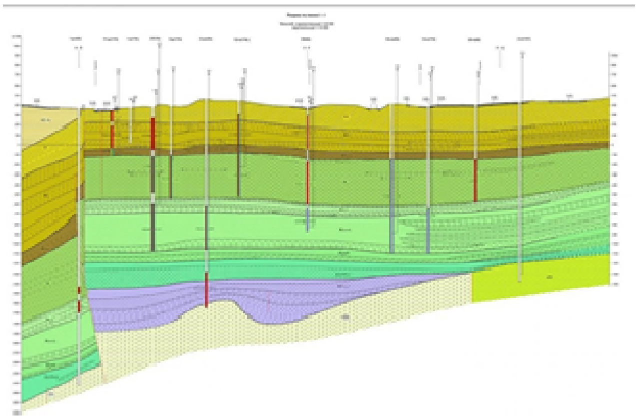

Fig. 1. The water field structure

The mineral data fields control systems are distributed control systems and there are a lot of research on this topic. These studies did not address the issue of database development. Such a database is a component of the information system for managing the exploitation of mineral water deposits. A number of problems arise associated with the development of a database for a system for controlling parameters of mineral water deposits.

One of the problems is associated with a large number of specialized hydrogeological characteristics of the field that are difficult to formalize. Another problem is the collection of information on the parameters of the regulator of the distributed control system. The water field deposits are the nature objects and regulator synthesis process for each other

978-1-6654-0476-1/21/$31.00 ©2021 IEEE

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deposit is a new task. In this way control system regulator parameters not are the same in every other case. The development of a control system requires an ordered data structure both in terms of the parameters of the fields and in terms of the parameters of the regulator of the distributed system.

Our analysis of the data on mineral water deposits showed that it is necessary at the first stage to select the most important parameters that are really necessary for the synthesis process of the controller of the distributed control system. This choice is not an easy task. The maximum simplification of the regulator synthesis process makes it possible to schematically represent the operation of the interface control system shown in Figure 2.

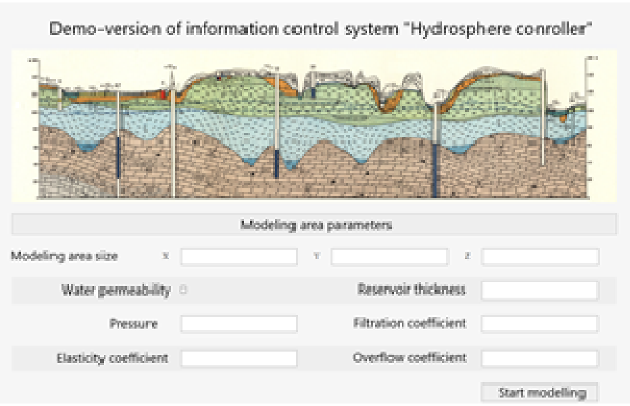

Fig. 2. Base parameters of the distributed control system regulator

As shown in Figure 2, a simplified process for constructing a regulator requires knowledge of such parameters of the field as its size, number and nature of bedding, location and depth of wells (hydrogeological section in Figure 1). Also, for the simplest model, you will need to know the permeability coefficients of each reservoir and the flow rates between the layers, as well as the flow rate of the investigated well in the field. The set of parameters of the field given by us will allow us to compile an overall picture of the processes occurring in the well, but the results of modeling will be rather arbitrary.

To improve the accuracy of modeling, it is necessary to move from point studies, when all parameters are unique characteristics of a single natural object, to complex, generalized models that include all possible variety of the considered characteristics. The development of a generalized approach to modeling the data structure in this case requires careful study of the data accumulated by researchers. It is necessary to highlight the parameters of the field, which have a significant impact on the processes occurring in the section.

The next step in the study will be modeling the structure of the database. This stage will require determining the range of variation of the parameters selected for study. It is also necessary to determine the nature of the change in the permeability and overflow coefficients. The speed of the processes occurring in the field is an important factor that makes it possible to correctly assess the nature of changes in the parameters of the field. Note that a number of external factors can radically change the state of the field, and this is not only the process of exploitation, but also standard natural conditions, technogenic impact, impact of closely located objects, and so on.

III. MINERAL WATER FIELDS DATA STRUCTURE

The modeling of the database structure made it possible to represent a set of field parameters in the form of a database segment. Previously, the parameters of the field were entered manually when modeling hydrogeological processes and building a regulator. As noted above, this stage of modeling is very simplified. We want to present a generalized conceptual model of the data structure. The purpose of this simulation is to develop a unified data structure for a distributed waterfield control system.

In the course of our conceptual modeling, not only the problem of structuring complexly formalized data arose. The problem is the problem of presenting data on the parameters of the field, as well as data on the technological parameters of the control system. The information should be displayed on the interface of the control system in such a way that it is possible to quickly evaluate both the basic process parameters and the results of the regulator synthesis.

Figure 3 shows a segment of the control system database. This is a very simplified view to test the proposed model structure. The interface of the control system is developed in the format of a web application; accordingly, Figure 3 shows not only the elements related to the description of the parameters of the field, but also the elements that form the structural framework of the web interface.

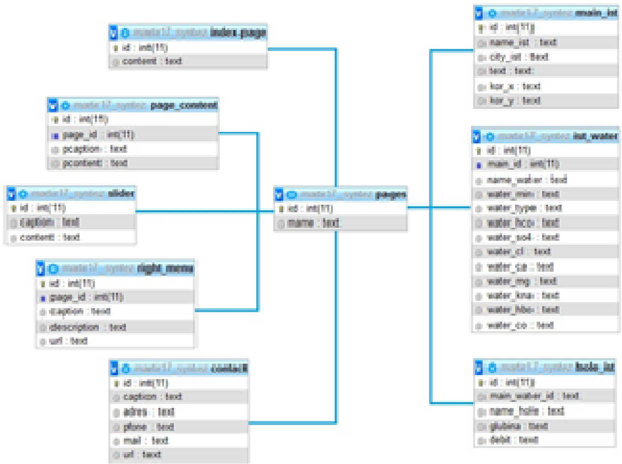

Fig. 3. Example of a figure caption. *(figure caption)*

In the process of modeling the presentation of field data, a problem arose related to the description of the composition of mineral water. As shown in Table 1, the presentation of data on the composition of mineral water is determined by the key field of the name of the mineral water. In addition, the table "Water" contains an external key field associated with the belonging of this mineral water to a certain deposit. Also included in the description of the entity is a set of attributes describing the chemical composition and salinity of water, as well as the type of water corresponding to the amount of salinity.

TABLE. I. STRUCTURE OF THE "WATER" TABLE

Entity name	Entity structure			
	Attributes	***Type***	***Key***	***Capture***
Entity «Water»	id	int(11)	PK	Water ID
	name_id	int(11)	FK	Field name ID
	name_water	text	no	Water name
	water_min	text	no	Mineralization
	water_type	text	no	Water type
	water_hcl	text	no	Chemical element 1
	water_so4	text	no	Chemical element 2
	water_iii	text	no	Chemical element i

An approach to describing well data is shown in Table 2. Description of well data is determined by the identifier and name of the well. The belonging of a well to a field is determined by the inclusion of an external key field "Field ID". Depth and flow rate are important technological parameters, since these data are included in all calculation algorithms.

TABLE. II. STRUCTURE OF THE "WELL" TABLE

Entity name	Table Column Head			
	Attributes	***Type***	***Key***	***Capture***
Entity «Well»	id	int(11)	PK	Well ID
	field_id	int(11)	FK	Field ID
	name_well	text	no	Well name
	glubina	int(11)	no	depth
	debit	int(11)	no	flow rate

The presentation of data on a mineral water deposit is shown in Table 3. The deposit data is uniquely identified by an identifier, and the name of the deposit is also presented. The page identifier allows you to implement the binding of the placement of the considered data segment as an object on the page of the web resource. Attributes such as field description and map data are included in the data presentation. The city or other territorial unit to which this deposit belongs is indicated.

TABLE. III. STRUCTURE OF THE "FIELD" TABLE

Entity name	Entity structure			
	Attributes	***Type***	***Key***	***Capture***
Entity «Field»	id	int(11)	PK	Field ID
	name_ist	text	No	Field name
	page_id	int(11)	FK	Page ID
	city_id	int(11)	FK	City ID
	text	text	No	Capture
	kor_x	text	No	North
	kor_y	text	No	East
	name_ist	text	No	Field ID

It should be noted that the presentation of data on mineral water deposits, presented in Figure 3 and Tables 1-3, is very simplified and can be significantly expanded. We deliberately avoided complexities in the description in order to get a working mechanism that adequately exchanges data with a complex computational scheme of a distributed control system.

IV. RESULTS

The development of a distributed system for controlling the operational parameters of fields involves the use of a distributed controller mechanism as software. The data presentation model proposed in this work can be used as information support for the control system. The array accumulated in the database of the control information system will improve the accuracy of the computational scheme.

It should be noted that the presentation of data on mineral water deposits, presented in Figure 3 and Tables 1-3, is very simplified and can be significantly expanded. We deliberately avoided complexities in the description in order to get a working mechanism that adequately exchanges data with a complex computational scheme of a distributed control system.

Note that as a result of mathematical calculations, presented in detail in (4-6), data will be obtained that allow determining the operating modes of producing wells. In these calculations, a distributed controller is synthesized, the transfer function of which has the following form:

$$W(x,s) = E_1 \cdot \left(\frac{n_1 - 1}{n_1} - \frac{1}{n_1} \cdot \nabla^2 \right) + E_2 \cdot \left(\frac{n_2 - 1}{n_2} - \frac{1}{n_2} \cdot \nabla^2 \right) \cdot s + + E_3 \cdot \left(\frac{n_3 - 1}{n_3} - \frac{1}{n_3} \cdot \nabla^2 \right) \cdot \frac{1}{s}, \tag{1}$$

where E_1, E_2, E_4 are the general gains of the proportional, differentiating and integrating links, respectively;

n_1, n_2, n_4 - weighting factors ($n_i \geq 1$, i =1,2,4),

∇^2 - Laplacian.

Figure 4 shows the field operation mode, which can be considered "stable", that is, in this case, the graphical display of the well flow rate versus time is optimal and this flow rate is within the operating range.

Carrying out a calculation that allows one to obtain results similar to those presented in Fig. 4 is a complex procedure that requires significant computing power. In the process of calculations, a transition is made from a system of secondorder differential equations with initial and boundary conditions to a discrete computational scheme that allows calculating the parameters of the regulator transfer function. The computational scheme of the mathematical support of the control system is similar to the computational models used in calculating the processes of the distribution of the temperature field (9). Such models are used to control various technological objects (9). To obtain a reliable result, significant computing power is required; in some cases, hybrid supercomputers are used (10).

Such calculations are laborious both from the point of view of the researcher and from the point of view of the use of computing power. One of the factors complicating the calculations is the need for manual input and manual adjustment of parameters characterizing the hydrogeological properties of the well.

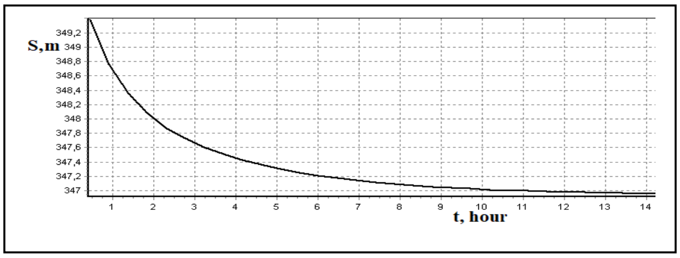

Fig. 4. Well operation mode

So we must develop data model structure and use the database in our study of the mineral water deposits.

The performed modeling of the presentation of data on the parameters of the field and the hydrogeological characteristics of production wells significantly simplifies the interaction of the computational algorithm with the data. The transition to the unification of data presentation will make it possible to develop a computational model common for all previously studied fields.

Modeling of control systems for the parameters of mineral water deposits is carried out at the North-Caucasus Federal University on the basis of the scientific school of I.M. Pershin, but there are also developments by other authors, for example, the study of the application of the theory of systems with distributed parameters for the control of objects of the hydromineral complex carried out in (11).

Note that research in the development of control systems for the parameters of mineral water deposits has been carried out for more than twenty years. These studies have proven the possibility of implementing a distributed controller based control mechanism using the example of a number of real fields.

V. CONCLUSIONS

Let us present the main provisions of this study in sequence. In the process of developing a distributed control system for the operational parameters of mineral water deposits, a number of problems arise, the solution of which lies in the unification of the data presentation used by the control system.

The proposed model of data presentation is quite simple; nevertheless, it has proven its efficiency in experimental studies.

The specified model allows displaying data on mineral water deposits on a web interface, managing this data using a content management system. The data representation model makes it possible to automate the transfer of object parameters to a software module that implements the computational scheme. Thus, a new stage has been implemented in the development of a control system for field parameters. The next stage will be the complication of the proposed data structure and experiments in expanding the power of the computational scheme, which will allow obtaining more accurate results.

In the course of the study, the possibility of unifying the presentation of data on mineral water deposits was proved. The proposed data presentation model will allow moving to a new level of development of the system for managing the operational parameters of fields. Mathematical algorithms for the synthesis of a controller of a distributed control system can use the data model we propose. The results of the synthesis of the regulator will also be saved in the database, which will make it possible to use the results of the studies carried out as a basis for modeling such complex hydrogeological objects as mineral water deposits.

ACKNOWLEDGMENT

We should note that person without whom these studies could not have been carried out. This most famous and important person is Doctor of Technical Sciences, Professor, Head of the Department of Management Systems and Information Technologies of the Institute of Service, Tourism and Design, North-Caucasus Federal University Pershin Ivan Mitrofanovich. Professor Pershin I.M. also is an actual member of the Academy of Natural Sciences, Honored Worker of Higher Professional Education of the Russian Federation.

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