Modelling an Integrated Control Object

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Abstract. The paper investigates two schemes for modelling an integrated control object: with an embedded model in the loop and with the selection of several levels of control. It is noted that the multi-level scheme allows the solution of individual tasks to be divided into fairly independent levels. This allows you to reduce the multi-connectivity of the system and apply coordinate-parametric control. Coordinate control is carried out within the limits of levels, and the impact of hierarchically higher levels change the parameters of the structural elements of the underlying subsystems. In this case, the contribution of each influencing factor to ensuring the achievement of the highest goal of managing the integrated object is more accurately estimated. At the same time, the integral assessment makes it possible to objectively evaluate the contribution of each of the control actions listed in the work and, accordingly, optimally divide the control resources between them with maximizing the overall level of achieving the goals of the upper levels of management. The revealed theoretical results were applied to develop a multi-level scheme for managing the quality of the development of a hydrocarbon field.

1. Introduction

Control can refer to specific properties of one object, such as the temperature of milk in a pasteurizer - this is a classic case. But the managed value can refer to a set of objects, such as the level of information security of an enterprise, when information resources are distributed over many objects: an enterprise library, a corporate network, a set of paper documents. Such an object, by its nature, can be called integrated. In this case, the integrated controlled value is only a part of the controlled properties of each of the integrated objects and is not always the most important part. Control actions are distributed over the totality of integrated objects, as well as the measurement of results from their implementation. The unifying view here can be the model of the integrated object.

2. Theory

Modelling is the main tool for system analysis and is used in management most often in the case of complex control objects [1,2], or in adaptive control with a model [3,4]. Let's start the analysis with the second case, when the integrated control object is displayed by the model and inserted into the adaptive control loop shown in Figure 1.
Here, the subject of management directs control actions at the same time both to real objects and to the model of an integrated object, which is shown in Figure 1 by arrows. At the same time, by measuring the indicators of the state of real objects, and comparing them with those obtained on the model, the control system initiates the procedure for making a decision on corrective actions or their absence.

Such a control scheme will be successful if a fairly accurate model description of the integrated object is possible. However, this scheme is complicated, since there is a simultaneous effect on several objects that can be connected and, due to this, influence the reaction of each other, that is, the system will be multiply connected [5-8]. In addition, it seems that the control of each component of an integrated object is solely individual, while it may well be built into other contours.

Another representation of an integrated object can be multi-level and, due to the allocation of level control subsystems, partially remove the multi-connectivity (Figure 2) [9,10]. In this case, real objects are integrated by the second level either into an object or into a process. So, for example, an enterprise is the integration of personnel, buildings, structures and utilities, technological equipment and stocks of finance, materials, spare parts and blanks. An example of a process is the educational process that integrates students, professors and teaching staff, classrooms, laboratory and computer equipment, methodological support for the development of professional competencies of students [11].

![Figure 1. Diagram of adaptive control with a model.](image-url)

Already at the second level, management objects become integrated. However, the controllable value of the second level does not always suit the external requirements for the system; their concentrated expression can be located at the third level. In the case of an enterprise, this may be profitability, in the case of the educational process, it may be the quality of education. In general, there
can be many higher levels. For example, the educational process can be aimed at developing competencies at the third level, at the fourth at increasing readiness for professional activity, and only at the fifth level, the goal of management becomes the quality of education.

3. Modelling quality management of hydrocarbon field development

The theoretical provisions described above are applicable to modelling the management of the development of a hydrocarbon field [12,13]. Currently, direct development is a well-oiled process, and the attention of managers is focused on improving the quality of this development and, naturally, the quality of the result, that is, the extracted hydrocarbon raw materials [14,15]. Considering that qualimetry dealing with quality assessment is based on the principle of the unity of process and result [16], let us call this integrated object the quality of hydrocarbon field development and place it at the highest level of the management system (Figure 3).

In this case, the quality of field development, as an integrated management object, includes three components at the first level: personnel, technological equipment and an exploited hydrocarbon field, as shown in the lower part of Figure 3.

However, separately, these components will not ensure the production of hydrocarbon raw materials, therefore, the goal of the second level of management is to organize the connection of these components and ensure an uninterrupted process of hydrocarbon production.

On the other hand, additional activity is required to maintain the volume of hydrocarbon production at a given level, since the energy of the formation decreases as the hydrocarbons are withdrawn. Therefore, the purpose of management at the third level is to provide additional inflows of hydrocarbons, either through the construction of new wells (injection or production), or through geological and technical measures that are adequate for each production well.

The quality of the final product, in addition to high physical indicators, is also determined by its price. At the fourth level, an organizational strategy is implemented to integrate production and operations of human resources management, financial management and asset management, which
ultimately provide all these quality indicators.

Such a multilayer representation of the system and the control object allows one to transform the controlled quantities, important from the point of view of quality, into fairly independent coordinates and, therefore, to weaken the multi-connectivity of the control object.
In such a scheme, it immediately becomes obvious that each component of an integrated object becomes an object of multipurpose control, which is difficult to detect when implementing the scheme shown in Figure 1. This scheme also makes obvious the need for the use of coordinate-parametric control [17,18]. In this case, coordinate control is carried out within the levels, and the effects of hierarchically higher levels simultaneously change the parameters of the subsystems and represent parametric control.

Indeed, each of the components of the integrated control object located at the first or higher levels has its own control system, and control actions coming from the upper levels should not duplicate the functions of these local systems. The upper levels can only intervene "in a big way": set the values of the parameters of work or parameters of individual elements, that is, to exert parametric impacts, change the elements or their interrelationships in any component, which can be called structural impacts [19] and organizational measures create conditions conducive to the achievement of the goals of the upper levels of management during the functioning of these components, that is, to produce organizational impacts.

In addition, since any process has a beginning and an end, moments of switching operations or modes of operation, the control of such events is realized through the issuance of special signals. On the other hand, even the level of these signals can carry management information, since almost all objects in practice are nonlinear and, depending on the level of signals, their response can be different. From this point of view, the signals of the beginning and end of all types of parametric, structural and organizational impacts of the fifth level on the second, described above, will refer to the signal-level impacts. At the top level, a contour of adaptation to changing external conditions, primarily market conditions, is organized. The contour is based on a predictive model of the development of events, the comparison element monitors forecast deviations and initializes the adoption of corrective management decisions [20-23].

Control will be blind if you do not provide feedback to the integrated object through measuring its behavior after the application of control actions. As in the case of control actions, the assessment is also distributed not only over the components of the integrated control object, but also over the levels of the hierarchy [24].

The achievable level of quality as a result is formed by the integration of indicators of the first level: the degree of motivation of personnel to ensure high quality of products and processes, serviceability and reliability of technological equipment and devices, the level of quality of raw materials and energy.

The second level adds indicators: the level of compliance with technological regimes and conditions of storage and transportation of produced hydrocarbons.

At the third level, the problem of finding the optimal position of new wells should be solved, and the degree of this optimality is an indicator of quality. On the other hand, it is necessary to select geological and technical measures for already operated wells. The adequacy of this choice is also an indicator of the quality of field development.

The fourth level - the level of economic support of the processes [25,26] gives indicators characteristic only of it: the timeliness of financing, the timeliness and completeness of the conclusion of contracts with subcontractors, the level of provision of personnel with appropriate qualifications.

4. Conclusion

Thus, multilevel modelling of an integrated control object allows the solution of individual tasks to be divided into fairly independent levels. This allows you to reduce the multi-connectivity of the system and apply coordinate-parametric control. Coordinate control is carried out within the levels, and the impact of hierarchically higher levels change the parameters of the structural elements of the underlying subsystems.

In this case, the contribution of each influencing factor to ensuring the achievement of the highest goal of managing the integrated object is more accurately estimated. At the same time, the integral
assessment makes it possible to objectively evaluate the contribution of each of the control actions listed in the work and, accordingly, to optimally divide the control resources between them with the maximization of the overall level of achieving the goals of the upper levels of control.

5. References

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