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System representation of objects in the context of the practical tasks solving

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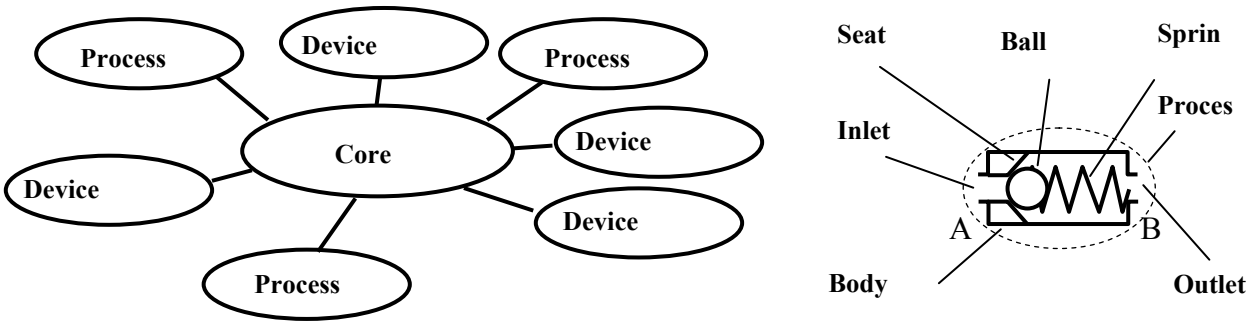
Abstract. *The work aim is to improve the efficiency of problems solving of analysis and synthesis of complex technical objects. Unlike the traditional representation of objects in the form of interactive models of the structure and functions offered its representation is in the system of concepts - the structure, properties and functioning. This has revealed the mechanism of interaction between structure and properties of the object. The mechanism is the elements of the structure produce the planned set of properties through the process of functioning. It is shown that the sequence of activation of these components is determined by task which is solved. The scheme, which reveals the mechanism of interaction between structure and properties of the object illustrated by the example of a hydraulic device - check valve. General scheme of interaction of the structure and the functioning of complex technical object is represented. The proposed representation can be used to solve practical tasks.*

Keywords: Complex object; analysis; synthesis; structure; functioning; properties; mechanism of interaction

Motivation. The objects of consideration are the complex technical systems in which interact in space and in time a large number of components with different physical nature, having its own characteristics and features. Specialists have to solve some practical tasks that related to specific stages of the life cycle of the object. In order to solve such tasks some time is necessary. The time required essentially depends on the degree of certainty tasks. In turn, the degree of certainty each task associates with level of understanding of the object. Generalized expression of this understanding is a model that shows the relationship of the structure, function and properties of the object. Model, in one form or another, displays a representation of the specialists about object: what parts are, how the parts are connected, how the interaction of parts leads to the appearance of properties.

Increasing the accuracy of the model or deepening of its compliance with the real object composition, communication and action, raises certain tasks and, consequently, reduces the time required for their solution.



a *b*

Fig. 1. Scheme of interaction of the functioning and structure of the object in the object-oriented approach (a) [5] and an example of the schematic diagram of a technical object - check valve (b)

Known studies address the complex structure of the object and its representation as model [1-6]. One such model of a complex object is represented by a composition of a set of processes and devices that interact through a coordinating core (Fig. 1 a) [7].

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The usefulness of such model consists in simplifying the task of designing computer programs, such as programs for the management of complex objects. At the same time, this simplification hides the structural organization of the functional object. But, on the other hand, even on a simple example of a technical object - check valve which is to control the movement of fluid flow: passing or stop, depending on the sign of the differential pressure at its inlet and outlet, it is very difficult to identify the mechanism of the interaction the structure elements, process and coordinating core (Fig. 1 a, b).

It is very important to disclosure this mechanism because without his knowledge the practical tasks can not be effectively solved, for example, the task of complex object testing [8]. Communication between the structure and functions of an object is shown in known research [8]. Such communication indicates compliance between the separated nodes construction (elements) and specific functions, however, the mechanism are not disclosed, but only emphasize the need and importance of its detection. Also noted, that for creating of modeling systems is necessary to disclose "a mechanism of supporting of the hierarchically interconnected system models of the functioning of complex object at different levels of structural and functional organization" [8]. There is research that identified several regularities relationship structure, functioning and properties of the object, as well as the model that shows the changes of the object in the process of solving design tasks [9, 10]. At the same time, a variety of practical tasks contributes to the overall complexity of solving them. The situation is further complicated if the object used several algorithms aimed at solving different tasks. Therefore, it is necessary additional research to obtain a systematic representation of the mechanism of interaction of the structure, functioning and properties of the object in context of practical tasks.

This research should determine how the actions of the structural elements of object associate with object properties and how the practical tasks determine the look at object. The relevance of these issues has led to research in this direction.

The aim is to increase the efficiency of solutions engineering and research tasks through the development of ideas about the relationship of the structure, functioning and properties inside complex technical objects.

The tasks are following:

• detect and justify the mechanism of interaction of the structure, functioning and object properties in the context of tasks;

• illustrate the mechanism on a practical example.

Results of the research

Representation of an object in operational environment.

Analysis of the relationship of the object, the operational environment and tasks led to a generalized view that shows the relationships between these components (Fig. 2). Object shows its properties when it is in operational environment. Properties, in turn, are a response to the action on the environment and the result of functioning of object. The object, the operation environment and their interaction can be the subject of solved tasks.

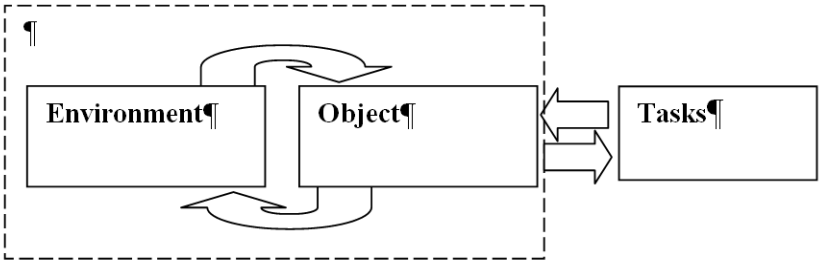

Fig. 2. Scheme of interaction object, the operational environment and complex of tasks

Context of practical tasks.

An object can exist or not exist. In the latter case therein might be a need. Existing object has a structure, one performs its functions, which leads to a number of properties. The practical tasks which relevant life cycle stages of the object are the following: analysis of the object, design, modeling, research, testing, diagnostic, followed troubleshooting. To establish links each task with the structure, functioning and object properties it is necessary to consider their appointment.

Analysis of the object involves the elucidation of its structure and functional load on each element, identify links between the elements and rules for their interaction.

Design of the object involves converting needs in a number of properties to the design documentation for the object that these properties will produce.

Model building and modeling of the object functioning involves creating an adequate mathematical model and its application to solving problems in designing, researching, testing, diagnostic, such as forecasting characteristics or ensuring the desired properties and characteristics of the object, etc.

Research of the object (in natural or model form) involves getting new knowledge about the process of functioning, structure or object properties.

Testing of the object (in natural or model form) intends to verify compliance with the actual properties and the properties that have been scheduled.

Diagnostic of the object (in natural or model form) assumes status checks, troubleshooting and their causes that led to the loss of properties.

Already at this level, it becomes clear that each of these tasks is touching specific sides of the object and the operational environment. To identify these sides of the object and operational environment it is necessary to detail them and trace their connection with each other and with the tasks.

Detail representation of the object in operational environment and establishing its connections with the tasks.

Operational environment is represented by control, conditions, regimes, energy, requirements to an object, the object constraints, required properties. Object is represented by structure, functioning process and the properties set. Operational environment and object interact through communication channels (Fig. 3). These channels are shown as lines with arrows. In describing the interactions between operational environment and object, the arrows indicate the direction of information or energy flow. In describing the interactions between tasks, operational environment and the object, the arrows indicate the direction of the object information or the direction of application of mental effort.

Each specific task brings together a group of components. These groups will be represented by considering statements of the tasks and algorithm of their solution.

The task of analyzing. The analysis task has the following formulation. There is operational environment where the object performs some functions. It is necessary to determine the types of impacts and action channels operational environment on an object, component composition of the object, the relationship between the components, the component actions, the process of functioning and structure of properties. There is the algorithm for task solving such as analysis of the available data, their subsequent identification in accordance with the composition of the operational environment and the object, as well as identifying the object structure and the process of its functioning.

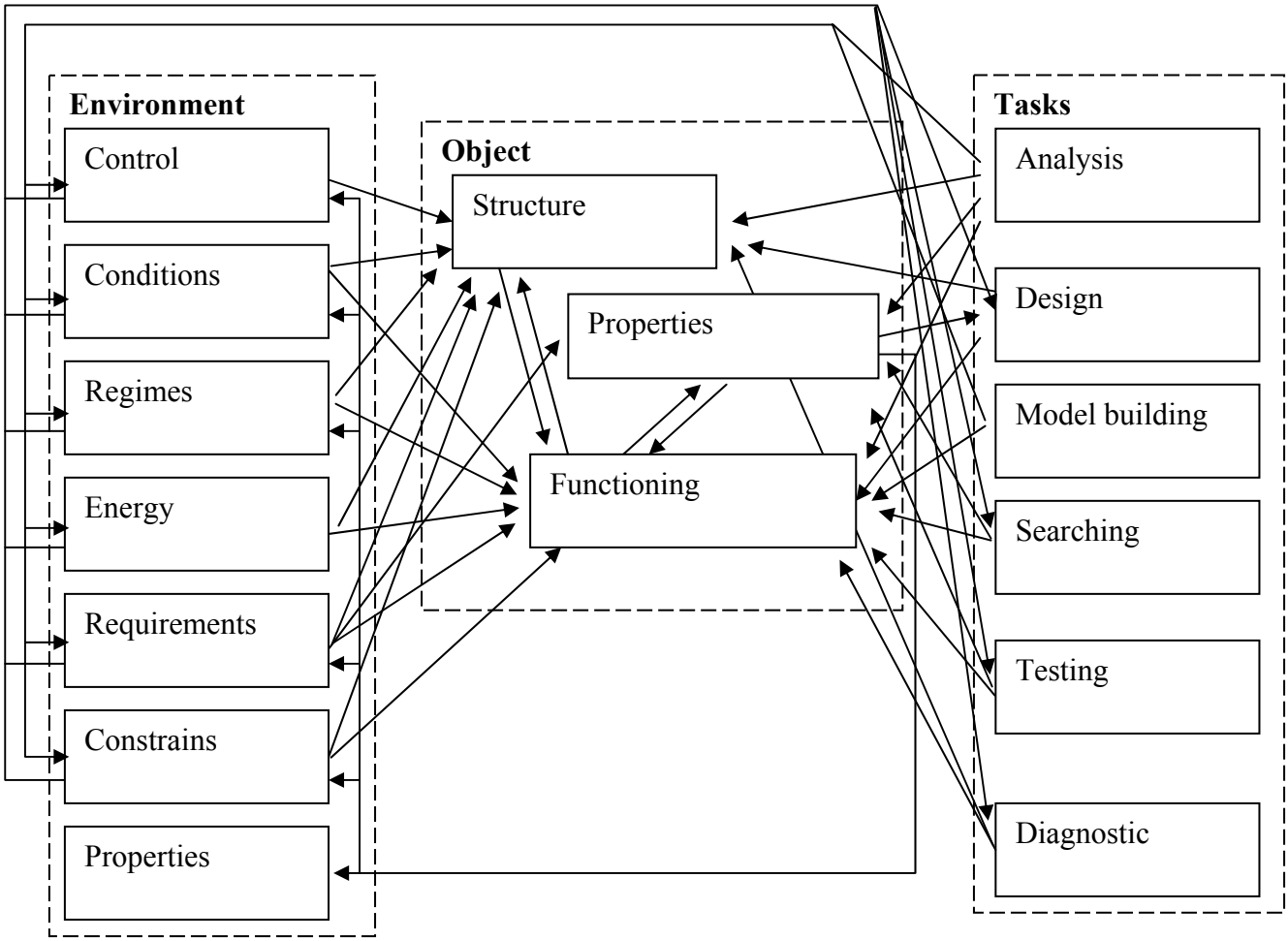

Fig. 3. Detailed scheme of the object interactions with operational environment and complex of practical tasks

The task of designing (synthesis). The statement of the designing task is the following. It is known the object properties, its characteristics and parameters of the operational environment, it is necessary to develop a construction of object. The algorithm of the task solving is the following. Based on the requirements to the functional purpose of the object the operating principle is selected; the operating principle is represented in form of the structure of functioning process that includes the set of actions; to implement the acts in the functioning process the principles of the element acting is selected; in order to get the required set of properties the regimes of functioning is modeled for a given energy, operational environment, conditions and control. During the modeling, the element parameters are determined. Criteria for choosing of the parameter values are the predetermined characteristics, the set of requirements and constrains. Selected constructions of the execution elements are combined into construction to meet the requirements and constraints for the object.

The task of model building. The statement of the task of model building is the following. There are a schematic diagram of an object, the object parameter values and the operational environment. It is necessary to construct a

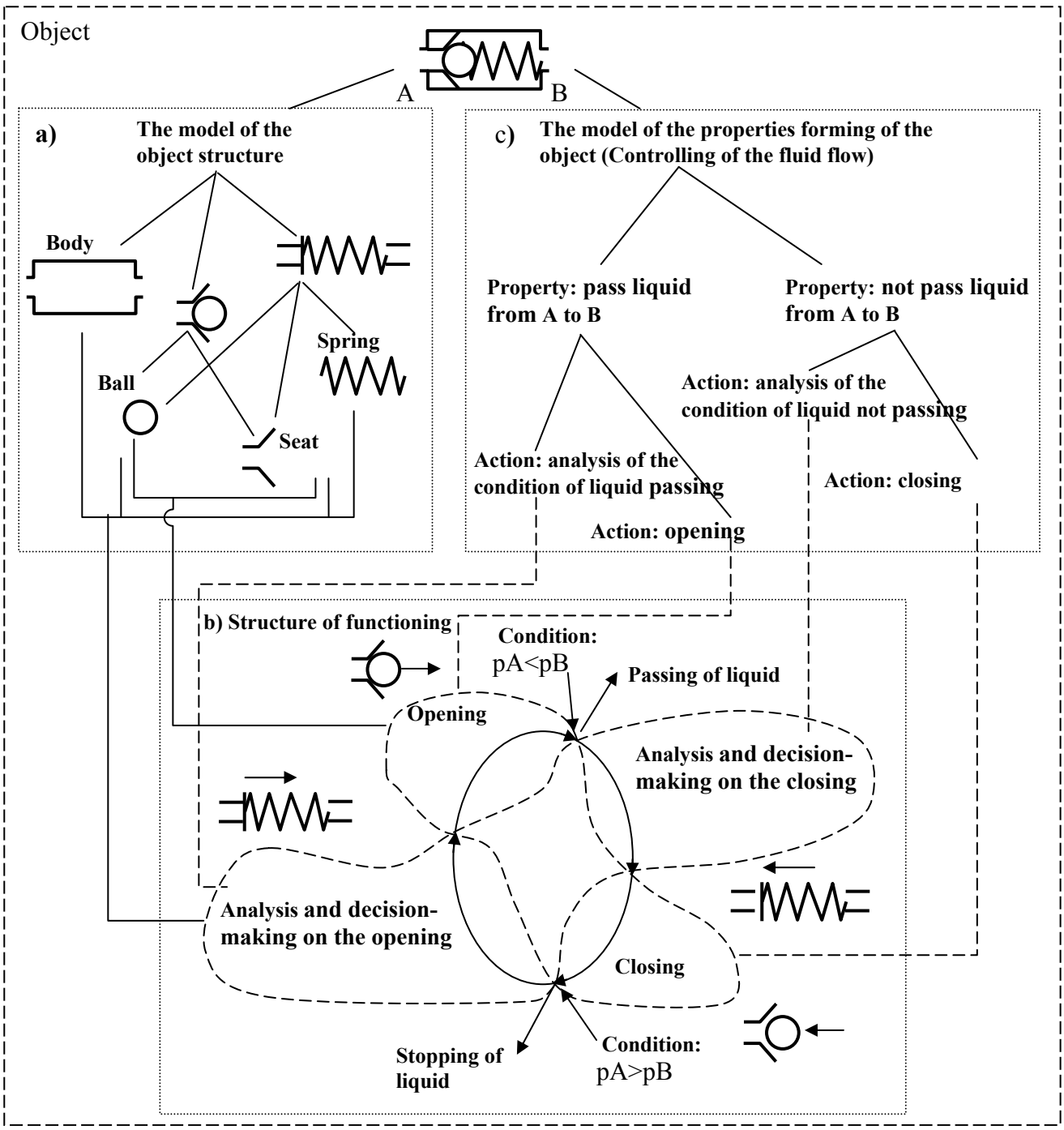

Fig. 4. Diagram of the relationship between the structure and properties of the object on an example of the check valve (a – the model of the object structure, b – the model of the properties forming, c – description of the functioning process)

mathematical model. Algorithm for solving the task is the following. It is necessary to describe the process of functioning, this process is divided into separate actions, is replaced of individual actions by their mathematical interpreters, is united of individual interpreters in a mathematical model of the process of functioning. Further, the mathematical model can be used in order to solve the task of researching, testing and diagnostic.

Research task. Formulation the problem of research is the following. The object and conditions are set and the questions that cannot be answered are formulated; new knowledge is required. Algorithm for solving the task is the following. It is necessary to develop a methodology, mathematical model of the object, schematic diagram of an experimental stand, experimental stand (physical or its mathematical model), conducting experiments, compiling results and formulation of new regulations on the understanding of the object.

Testing task. Formulation of the task is the following. There are an object and set of properties, a set of requirements to its parameters and characteristics and parameters of the operational environment. It is necessary to determine compliance the actual properties of the object with the properties that have been declared. Algorithm for solving of the task includes the steps as developing test procedures and schematic diagram of experimental stand, creating of the experimental stand (physical or its mathematical model), conducting experiments, comparing the results with passport data, formulating of the conclusions.

Task of diagnostic. Formulation of the diagnostic task is the following. A schematic diagram of an object and features of the lost property are known. It is necessary to determine the parts of the object that requires some adjustments. Algorithm for solving the diagnostic task is the following. It is necessary to make a projection of the lost property signs on the construction of the object, to determine the cause of the loss of properties and to identify the parts that require some adjustment.

Detailing of the object. As already noted, the object is represented by three components: a structure, a set of properties and process functioning (Fig. 3).

The structure of the object is represented as a structural model, which shows the components of the object and their relations between each other in the object. Functioning of the object is represented by the structure of the process that is formed by a set of actions and that must be met for implementation purposes. The structure of the process shows the sequence and content of actions that leads to the formation properties of the object.

The object properties are represented by model of the object properties. This model shows the object destination that is provided by set of properties and the required action groups that responsible for obtaining the individual properties. Usually, the structure, functioning and properties have a hierarchical organization.

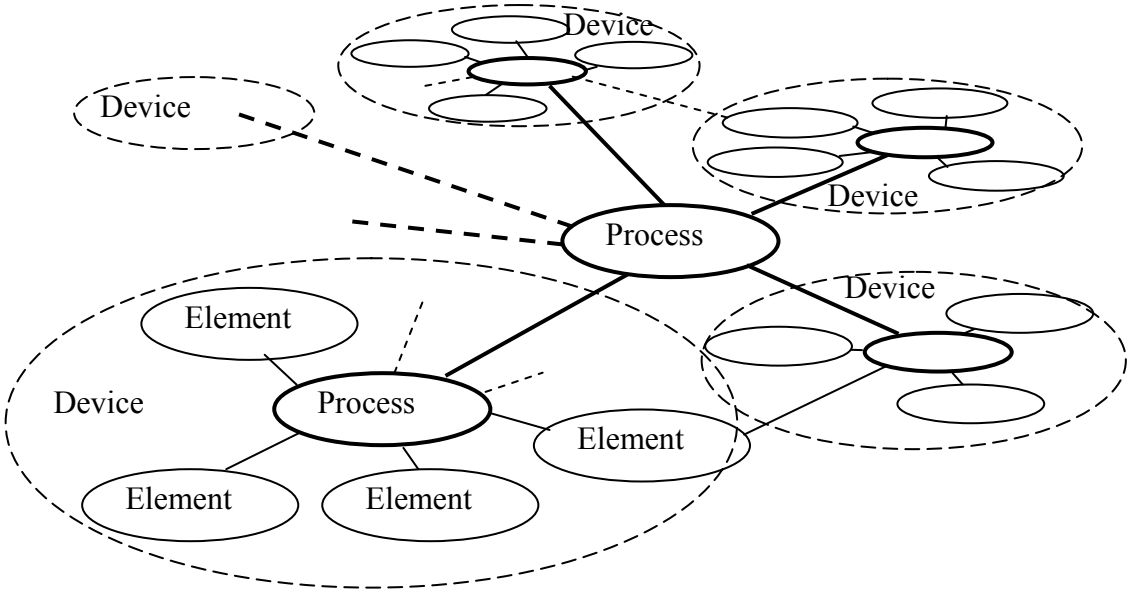

Fig. 5. Representation of the interaction of the functioning and structure of the complex technical object in the cyclically-modular approach

The structure, functioning and properties interact with each other. Dwell in more detail on the mechanism of this interaction.

The mechanism of interaction of the structure, functioning and properties of an object depends on the task that is solved. The solving tasks such as analysis, model building, testing and diagnostic are based on the use of an existed object. At the same time under the existence of the object is meant any level of its representation: a schematic diagram, a mathematical model, structure. The mechanism of interaction is as follows. Activation of the structure of the

object leads to the implementation of the process of functioning. This leads to realization of the functions. Realization of functions leads to a set of object properties.

In the context of solving the task of designing a mechanism is as follows. The set of desired properties are converted into description of the functions of the properties obtaining, then on the basis of function descriptions the functioning process is formed, further the means of functioning process implementation are chosen, after the means are combined into object structure.

Detailed representation of mechanism on the example of the check valve. The interconnection of the structure, functioning and properties are represented by example of the check valve (Fig. 4). Valve structure is represented as a structural model, which shows the components of the valve and its relation to the whole object. These parts are the seat, ball, spring and body. Seat and ball surface are formed a locking unit. Area ball in section along the line of contact of the ball and a preloaded spring are the means of implementing logic function. Together in one body, the locking unit and means of implementation of the logical function form a check valve.

Functioning of check valve is represented by the structure of the process, which includes the following actions: opening, closing, analysis and decision-making on the opening, analysis and decision to close. Implementation these actions in the sequence set leads to formation of the valve properties.

Properties of the valve are represented by the structure of the properties forming. It shows that the property "pass liquid from A to B" is the result of two actions - "analysis of the transmission conditions" and "opening". In turn, the property of "not pass liquid from A to B" represents the result of the other two actions - "analysis of the conditions - do not pass" and "closing". Two properties - "pass liquid from A to B" and "not pass liquid from A to B" lead to the realization of the property "control fluid flow."

In the course of solving a model of the properties forming of the valve interacts with its structure. Interaction occurs through the process of functioning. Dashed lines indicate the connections the actions of properties model of the check valve with the actions of the functioning. Thin lines show the connection elements of the structure of the check valve with the actions that they perform in the functioning.

Solving practical tasks in the light of the proposed interactions mechanism of the structure and properties in complex technical objects. The proposed model of the interaction between the object structure and its properties is the key for solving the tasks associated with complex objects. Model of a complex object is represented as interaction the set of processes, elements and devices (Fig. 5). The core of the object is represented by union of processes of the functioning. The core has hierarchical organization. The processes of low level unite the elements of the object into devices. The processes of more high level unite the devices into system. The core coordinates all processes of functioning of the object. The sets of elements form the structure of the devices and sets of devices form the structure of the object. The core activates the elements and devices of the object structure through the coherent interaction of the processes in all process functioning.

Knowledge of relationships between the structure, functioning and properties allows the transition from properties to a structure in the course of solving design tasks, or the transition from structure to properties in the course of solving the tasks analysis, searching, diagnostics, etc.

Effect of applying a systematic representation is the reducing the time spent on the preparation of technical specifications and solution of practical tasks due to:

- replacement the process of studying and finding ways of representing components (the object and the operational environment in the context of the task being solved) by formal separation into components and their identification by known components;
- reduce the complexity of representation of the object by splitting into simpler component parts while maintaining its integrity;
- traceability relationship structure, functioning and object properties.

Conclusion

Practical tasks associated with complex technical objects were successfully resolved, are solving and will be solved. However, the limits of time on solving tasks, reduction of these terms can be achieved through more accurate and thorough understanding of the object, which in turn can lead to more formal approaches to solving tasks. As it seems, the proposed mechanism of interaction the structure, functioning and properties clarify understanding of the object.

Системне уявлення об’єкта в контексті вирішення практичних завдань

О.В. Узунов

Анотація. *Робота спрямована на підвищення ефективності вирішення задач аналізу та синтезу складних технічних об’єктів. На відміну від традиційного представлення об’єктів у формі взаємодіючих моделей будови та функцій, запропоновано його представлення в системі понять - будова, властивості та функціонування. Це дозволило розкрити*

механізм взаємодії будови та властивостей об'єкту, який полягає у формуванні елементами будови через процес функціонування запланованого комплекту властивостей. Показано, що черговість активізації вказаних складових визначається задачею, яка вирішується. Схема, що розкриває механізм взаємодії будови та властивостей об'єкту ілюстрована на прикладі гідравлічного пристрою – зворотного клапана. Наведено також загальну схему взаємодії будови та процесу функціонування складного технічного об'єкту. Запропоноване представлення може бути використано для вирішення практичних задач.

Ключові слова: складний технічний об'єкт, аналіз, синтез, будова, функціонування, властивості, механізм взаємодії.

Системное представление объекта в контексте решения практических задач

А.В. Узунов

Аннотация. *Работа направлена на повышение эффективности решения задач анализа и синтеза сложных технических объектов. В отличие от традиционного представления объектов в форме взаимодействующих моделей строения и функций, предложено его представление в системе понятий – строение, функционирование и свойства. Это позволило раскрыть механизм взаимодействия строения и свойств объекта, который состоит в формировании элементами строения через процесс функционирования запланированного набора свойств. Показано, что очередность активизации указанных частей определяется задачей, которая решается. Схема механизма взаимодействия строения и свойств объекта проиллюстрирована на примере гидравлического устройства – обратного клапана. Приведено также обобщенную схему взаимодействия строения и функционирования сложного технического объекта. Предложенное представление может быть использовано для решения практических задач.*

Ключевые слова: сложный технический объект, аналіз, синтез, строение, функционирование, свойства, механізм взаимодействия.

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