Представлені результати досліджень, які були проведені з метою виявлення базових класифікуючих ознак системних механізмів і системних продуктів. Розроблено принципи ідентифікації моделей системних операцій, пов'язані з агрегуючими ознаками системних механізмів. Визначено поняття «операція» і «модель операції». Результати досліджень супроводжуються ілюстраціями моделей механізмів і моделей операцій на прикладі, що пов'язаний з порційним нагріванням рідини

Ключові слова: класифікація механізмів, класифікація продуктів, операція, модель операції, ефективність використання ресурсів

Представлены результаты исследований, которые были проведены с целью выявления базовых классифицирующих признаков системных механизмов и системных продуктов. Разработаны принципы идентификации моделей системных операций, связанные с агрегирующими признаками системных механизмов. Определено понятие «операция» и «модель операции». Результаты исследований сопровождаются иллюстрациями моделей механизмов и моделей операций на примере, связанном с порционным нагревом жидкости

Ключевые слова: классификация механизмов, классификация продуктов, операция, модель операции, эффективность использования ресурсов

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DEVELOPMENT OF SYSTEM OPERATIONS MODELS HIERARCHY ON THE AGGREGATING SIGN OF SYSTEM MECHANISMS

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1. Introduction

The solution of the theoretical and practical questions connected with automation of technological processes has allowed achieving the solution of such tasks as an increase of productivity and quality of finished goods. The same obvious fact is the presence of manual control associated with the solution of optimization problems.

Daily and seasonal temperature variation, daily variation in electricity rates, changes in demand and prices require an immediate reaction in the form of a search for a new optimum. This means that any external change demands operative, preferably automatic, control change.

At the same time, developments associated with the development of optimal control theory, are incompatible with the practice. One reason for this state of matter, according to the authors, is the conceptual uncertainty connected with such cybernetic categories as "product", "mechanism", "system", "operation" etc.

So, for example, the operation of the substance volume heating up to the set temperature can be carried out with different intensity of energy product supply. Thus, achievement of set heating level can be reached by different controls, and the choice of optimum control is carried out by results of operation parameters identification [1].

However, each of operations of heating, movement, crushing, etc., in turn, is followed by operations set of measurement, control, the account, coordination and identification. And each of these operations can also consist of operations set of the lower level.

Even simple discussion of questions connected with operations research causes difficulties, in view of the abundance of private definitions that narrow the subject area.

The relevance of the work consists in the expansion of opportunities of the conceptual and methodological framework of operations research.

2. Analysis of literature data and problem statement

The guess that the purposeful world around is shown as a set of the interacting systems, each of which in the course of functioning uses the general principles of management has inspired many schools of sciences on interdisciplinary researches in the field of control.

However, despite impressive efforts, 75 years later from the moment of publication of the Norbert Wiener`s book "Cybernetics or control and communication in the animal and the machine, the concept "product", "mechanism", "system", "purpose", "operation" haven't received the generally accepted definition.

The problem consists that in a chain of cybernetic categories it is impossible to allocate a link, having pulled for which it is possible to solve other problems consistently. The terms "product" and "mechanism" get sense only in relation to the concept "purpose". To achieve the goals, people make objects that are determined by the concept "system", and it is possible to identify the system only on its directed movement. Each step of such movement is defined by the concept "operation". In turn, the operation is a process of interaction of system products and system mechanisms.

Therefore, starting identification and classification of such cybernetic categories as "mechanism", "product", "operation" and "operation model", it is necessary to consider their coherence in space and in time.

In the work Science of Logic, the idea that the science should define the concept "mechanism" regardless of that area of use from which this category has received the name is expressed [2].

In the philosophical encyclopedic dictionary the concept mechanism is defined as system of movements or events, and also the device in which and by means of which these movements determined by the laws of nature [3].

Such definition, on the one hand, covers all set of mechanisms, both objects of intellectual activity, and natural mechanisms. On the other hand, such definition doesn't connect the object and the subject of transformation by the relation of their interaction.

The uncertainty of the concept of system has led to the use of the basic concept of mechanism for the characteristics of objects of the highest hierarchical level.

So, in work [4] the concept of "economic mechanism" is introduced. A subtype of the economic mechanism (formation, development, transformation, adaptation), a class (stimulations, organizational, planning, control ...) and a subclass (innovative, labor, investment) are defined. In this work, as a sign of a subclass of the category "mechanism", the identifier of the object to which action is directed is used.

So, the concept "innovative mechanism" includes both a sign of the object of transformation (a mechanism), and a sign of the object to which the operation of the mechanism is directed – (an innovative product) [5].

In turn, the category "product" is periodically used for display of the general essence of the object which is exposed to transformation with the use of this or that mechanism [6]. Generalizations of the concept "product" in relation to the definition of the entire class of such objects are even more often shown at the same time [7].

Concerning physics of the process, the mechanism influences processing product, using the energy product (Fig. 1).

From the cybernetic point of view, the products of the operation of transformation/conversion are both the product of processing, and the energy, that is necessary for the impact of the mechanism on this product, and the mechanism (Fig. 2).

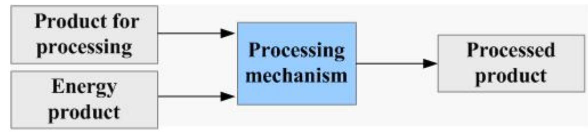

Fig. 1. Physical model of processing of conditional product

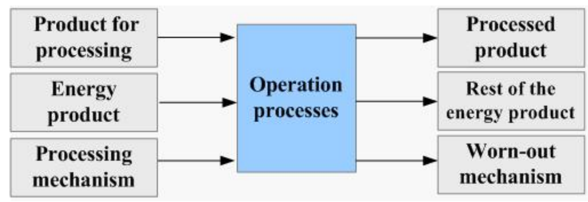

Fig. 2. Cybernetic operation model

Thus, the mechanism, from the cybernetic point of view, is the same product of the operation, as well as all other objects of the process of transformation/conversion.

However, in the field of operations research, the terminological composite by mixing of different cybernetic categories is also formed.

In the work [8], the concept concerning the way of the operation carrying out is integrated into a certain operations class. As a result, there is the concept "tactical operation", for example.

Of course, this or that tactical opportunity can be used for the operation carrying out (a way of its carrying out). For example, delivery of freight can be carried out by train, car or plane. The question of the choice of freight is strategy; the question of the choice of the movement mechanism is tactics.

Strategy and tactics working out is also the result of separate operations.

Terminologically, definition of operation can include the sign, concerning an output product. For example, it can be "transport operations". In this case, it is possible to speak about the operation of strategy development or operation for making a tactical decision. An attempt of the introduction of "strategic operation" or "tactical operation" concepts [9] logically gives the opportunity of definitions of movement operation of freight as "cargo operation".

As the data introduction for the operation registration also is an operation, in the number of works, not the operation itself, but operations on data recording of the operation [10], or a way of data recording is subjected to classification [11].

The movement of exchange products between open systems also leads to problems of system mechanisms classification and system products [12].

The last example shows that technological and exchange products registration as data of one system operation leads to impasses in problems of operations research because the exchange products movement rules are in "competence" of the separate controlled system.

Because of the fact that data of the exchange system are not synchronized with data of the product transformation/conversion system, the performance indicators value of each of these systems can differ significantly.

3. Purpose and objectives of research

The purpose of research is to develop the signs for the system operations identification, and determine such concepts as "operation" and "operation model".

Achieving this goal leads to solving a number of tasks such as:

– development of the basic classification of system products and mechanisms;

– development of identifying signs of system operations models;

– determination of such categories as “operation” and “operation model”.

4. Basic classification of system products and mechanisms

The world around us is always changing. The part of changes of the environment is caused by the functioning of objects, which are defined by the concept “**mechanism**”.

Any mechanism makes action on objects that we will determine by the concept “**products**” in relation to the action mechanism. However, each processed product by itself as a mechanism makes action on the mechanism as on a product.

For example, the waterfall is a mechanism, if the treatment product is a stone, the surface of which is treated under the influence of falling water energy. If the product is air moistening, the stone, causing water flow dispersion is the mechanism.

Thus, the division of objects into the class “mechanisms” and the class “products” can be carried out only in relation to the central cybernetic category determined by the concept “**purpose**”.

In turn, the results of the functioning of controlled systems are used to achieve the purpose. And in relation to systems, it is possible to identify the objects determined by the concepts “product” and “mechanism”.

The EFFLI program complex has been developed for the solution of the research problem of the internal structure of controlled systems [13].

Initially, the purpose of the research was the synthesis of the structure of the controlled system. To solve this problem, it was planned to create a class of object models, each member of which would perform one simple function. And, the essence of the operational interaction of products and mechanisms, during which the mechanism is exposed to wear, shouldn’t have been lost in modeling the objects connected with power-intensive converting processes.

During the synthesis of basic objects, it has been found that the entire set of system mechanisms is presented by two classes: channel-forming mechanisms and action directing mechanisms.

The channel-forming mechanism provides the function of buffering of the canalized product, and the action directing mechanisms provides a change of properties of the buffered product. If a problem of the channel-forming mechanism isn’t a function of synchronization of processes in time (the storage mechanism), the channel-forming mechanism is aggregated with the action directed mechanism.

The channel-forming mechanism and the action directed mechanism are simple mechanisms.

The aggregated system mechanism that provides the simultaneous performance of the function of buffering and transformation of the buffered product is defined in the work as the concept “complex mechanism”.

Interaction of simple and complex mechanisms is provided with the use of special mechanisms which are defined by the concept “service mechanism”.

The aggregated channel-forming mechanisms, action directed mechanism and service mechanisms are defined in the work as the concept “sets mechanism”.

Objects that are moved on channel-forming mechanisms are defined by the concept “products”. In relation to mechanisms, it is possible to identify two classes of products.

The first class is the class of products to which action is directed.

At the present time, there is no acceptable concept by means of which it is possible to characterize a class of products to which action is directed. For example, the concept of “raw material” or “raw product” is used only to determine the input products, which can be processed. Generally for designation of the objects, determined by the concepts “raw materials”, “freight”, “preparation”, “goods”, etc., it is necessary to use the sign, characterizing any product of this class. As in the course of movement on the trajectory, limited by channel-forming mechanisms, products of this class are always affected, in this work they are defined by the concept “**action directed products**” (ADP).

The second class is the products providing an active impact on ADP, defined by the concept “**energy products**”.

Let’s introduce a set of the objects used in this work.

Using symbols, we will designate the properties and the relations between these objects:

M\` – a set of simple mechanisms;

M\`\` – a set of the aggregated mechanisms;

G – a set of processes;

B – a set of products.

Since, in terms of classification, the set of all mechanisms can be divided into two classes – the class of simple mechanisms and the class of the aggregated mechanisms, then:

$$M^{'} \cup M^{''} = M,$$

where M – a set of all mechanisms.

Properties of the mechanisms:

K (x) – to be the channel-forming mechanism;

N (x) – to be the action directing mechanism;

A (x) – to be the complex mechanism;

B (x) – to be the service mechanism;

C (x) – to be the sets mechanism.

Relations between the mechanisms:

P (x, y) – the existence of the product transfer relation from the mechanism x to the mechanism y.

Properties of the processes: T (x) – the process x is an operation.

Properties of the products:

V\` (p) – the product p is an input product;

V\`\` (p) – the product p is an output product.

Relations between a product and mechanisms:

S (x, y) – relation of the interaction of the product x and the mechanism y.

Definition 4. 1. Channel-forming mechanism is the system object that provides the possibility of storage, buffering, processing and movement of intrasystem products.

The channel-forming mechanisms aggregate with power products transformation/conversion mechanisms or use the potential or kinetic energy of the system product to provide action on system products.

Definition 4. 2. The mechanism of directed action formation is the system object that transforms/converts the energy product into power for performing an action on ADP.

The channel-forming mechanism, aggregated with the action directing mechanism we will determine by the concept **complex mechanism**.

Definition 4. 3. **Complex mechanism** is the channel-forming mechanism, aggregated with the action directing mechanism

$$(\forall x \in M')(\forall y \in M')\left[K(x) \wedge N(y) \Rightarrow (\exists z \in M'')(A(z))\right].$$

The complex mechanism for providing the function of system products movement, we will determine by the concept "service mechanism".

Definition 4. 4. **Service mechanism** is the system complex mechanism that provides transfer of the product from the previous channel-forming mechanism or the complex mechanism to the subsequent channel-forming or complex mechanism

$$(\forall x \in M')(\forall y \in M')\left[K(x) \wedge A(y) \wedge P(x,y) \Rightarrow (\exists z \in M'')(B(z))\right] \vee$$
$$\vee (\forall x \in M')(\forall y \in M'')\left[K(x) \wedge A(y) \wedge P(x,y) \Rightarrow (\exists z \in M'')(B(z))\right] \vee$$
$$\vee (\forall x \in M'')(\forall y \in M')\left[K(x) \wedge A(y) \wedge P(x,y) \Rightarrow (\exists z \in M'')(B(z))\right] \vee$$
$$\vee (\forall x \in M'')(\forall y \in M'')\left[K(x) \wedge A(y) \wedge P(x,y) \Rightarrow (\exists z \in M'')(B(z))\right].$$

The channel-forming mechanism and the transformation/conversion mechanism that carry out a function different from the service function, we will determine by the concept "sets mechanism".

Definition 4. 5. **The sets mechanism** is the channel-forming or complex system mechanism, aggregated with the service mechanism, and carrying out a function different from the service one.

$$(\forall x \in M')(\forall y \in M'')\left[K(x) \wedge B(y) \Rightarrow (\exists z \in M')(C(z))\right] \vee$$
$$\vee (\forall x \in M'')(\forall y \in M'')\left[A(x) \wedge \overline{B}(x) \wedge B(y) \Rightarrow (\exists z \in M')(C(z))\right].$$

For definiteness, the processes connected with the portion heating of liquid are considered in the work. The example of display of technological mechanisms interrelations in the portion heating liquid system is represented in Fig. 3.

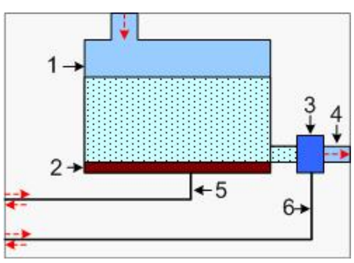

Fig. 3. Mechanisms of the liquid heating technological subsystem: 1 — mechanism of (liquid) storage-heating; 2 — mechanism of transformation of the electric power in thermal energy, 3 — mechanism of transformation of the electric power to linear motion of the heated fluid; 4, 5, 6 — canalization mechanisms

Mechanisms 2 and 3 are transformation/conversion mechanisms. Other mechanisms of the heating subsystem are channel-forming mechanisms. The mechanism 3 is the service mechanism of the heated liquid delivery, and all mechanisms, except the service mechanism, represent the complex mechanism in total. The entire set of objects 1–6, presented in Fig. 3, is the sets mechanism.

For the functioning of the heating system, its mechanisms carry out a set of transformation/converting functions of various products. The entire set of these objects can be divided into several classes depending on the converting function of the mechanisms of this set.

5. Use of the aggregating sign for identification of models of system operations

Realization of the tasks, connected with control, makes it necessary to use an operational approach where the object of research are processes of interaction of system products and system mechanisms.

The system mechanism in the operation process is affected by ADP and energy product. Such process of action results in wear of the mechanism in the form of a decrease in its technical resource. It allows determining the mechanism contribution to the formation of output products by the concept "**technical product**".

Thus, in relation to the "operation" category, the classes of input products are products of the directed action, energy products and technical products.

Depending on a solvable problem, operations models we can divide into classes of technological (physical) operations models and focused operations models.

As the physical model of operation displays the process of interaction of products and mechanisms, signs of classes of system mechanisms can be the identifying sign of models for this class of operations.

5. 1. Nomenclature

Creation of the operation model, the convenience of its reading and research are closely connected with the system of symbols which is used for display of products and mechanisms procedural interaction results. In the nomenclature, the class of the displayed parameter and the area of the interacting objects has to be considered.

The system of symbols offered in the work is the development of the nomenclature, accepted in [14].

If ADP and energy products generally come to the input of the mechanism, then system mechanisms come to the conditional input of the cybernetic operation in the form of a technical product as well.

Having designated input products by the basic symbol r, products in the interaction process by the basic symbol c, and output products – by the basic symbol p, we will have an opportunity to identify a registration signal of operational interaction with respect to the model representation: input – process – output.

The input product index indicates its class: D – ADP; P – energy product; M – technical product.

The output product index indicates the sign concerning a class of made (R), accompanying (S), processed by-products (E) or transit products (T) (Fig. 4).

The identifier of the product which is in the transformation process or ready-made product can keep the input product index if its nature in the course of operational processing doesn't change (for example, (r_D) – cold liquid; (c_D) – the heating liquid; (p_R=p_D) – heated liquid), and also in that case when the model of quantitative decomposition of products in the transformation process is necessary.

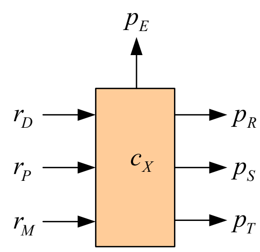

Fig. 4. Conceptual model of cybernetic operation

Display of the quantitative parameter is carried out by the introduction of the additional symbol q, scaling coefficient – by the symbol s, and the given value of the quantitative parameter – by the symbol e.

So, for example, the registration signal of the liquid movement on the input of the heating mechanism $rq_D(t)$ can be scaled with the use of cost estimation rs_D, as a result, the initial registration signal will be reduced to a comparable signal

$$re_D(t) \rightarrow \left[re_D(t) = rs_D \cdot rq_D(t) \right].$$

To denote the integrated parameter of the registration signal, the symbol i which precedes the basic symbol r, c or p is used. For example,

$$ire_D(t) = \int_{t_0}^{t} re_D(t) dt.$$

The integrated function value on certain integration interval is designated by the corresponding symbols

$$RE_D = \int_{t_0}^{t_1} re_D(t) dt.$$

5. 2. Simple operation model

Simple operation model displays the registration signal of movement of ADP or energy product at the input/output of the mechanism or in the process of its linking by the channel-forming mechanism (Fig. 5).

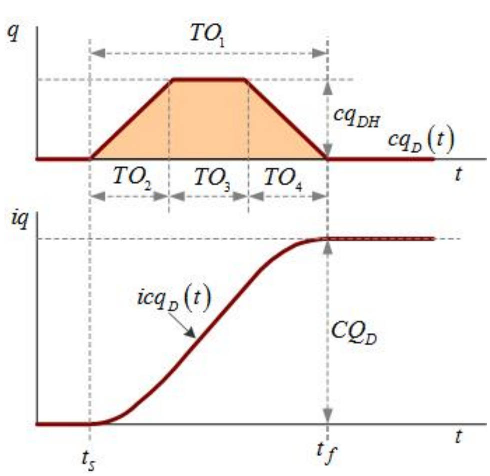

Fig. 5. Simple operation model on the example of registration of the liquid level in the storage mechanism

So, in Fig. 5, the registration signal of the liquid level $cq_D(t)$ in the mechanism of storekeeping is represented. Research of the simple operation allows to estimate, for example, the operation duration (TO_1), the transition process time (TO_2, TO_4), duration of the set storage mode (TO_3) and the volume of stocks

$$CQ_D = \int_{t_s}^{t_f} cq_D(t) dt.$$

Thus, the simple operation model displays the result of registration of the ADP quantitative parameter or energy product in the process of its moving on the input or output of the channel-forming mechanism.

5. 3. The model of complex operation

If the simple operation model displays the results of interaction of adjacent system mechanisms or internal processes of the channel-forming mechanism, the model of complex operation displays the results of interaction of the aggregated mechanisms. Thus, the process of a coherent liquid condition is accompanied by a change of its quality parameter – the temperature of ADP (T_D).

And all parameters of registration signals are interconnected (Fig. 6).

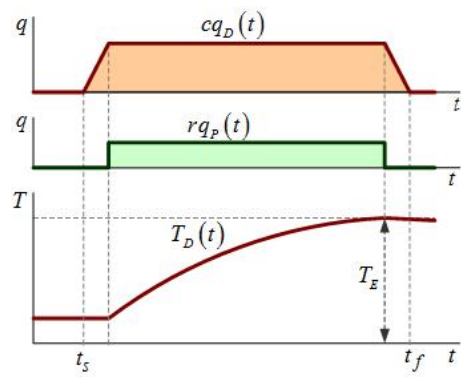

Fig. 6. Timing diagrams, showing registration signals of the complex operation

So, for example, the "temperature" qualitative parameter depends on both the volume of the heated liquid and intensity of giving of the energy product. The operation complex model shows interrelation of the ADP qualitative parameter, ADP quantitative parameter, energy product, and, generally, technical product.

5. 4. Service operation model

The service operation model displays registration signals of the finished product of the channel-forming mechanism and energy product with the use of which the delivery process is provided (Fig. 7).

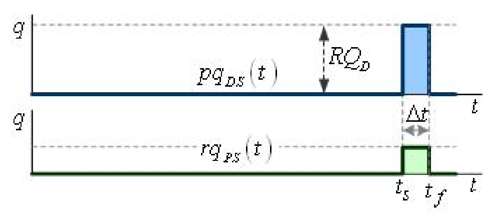

Fig. 7. The timing charts, showing registration signals of the service operation

The service operation is a complex operation. In the service operation model, the registration signal of the energy product $rq_{PS}(t)$ displays giving of the input product, and the registration signal of ADP $pq_{DS}(t)$ – the registration signal of the output product.

5. 5. Model of sets operation

The sets operation model includes complex and service operations registration signals (Fig. 8).

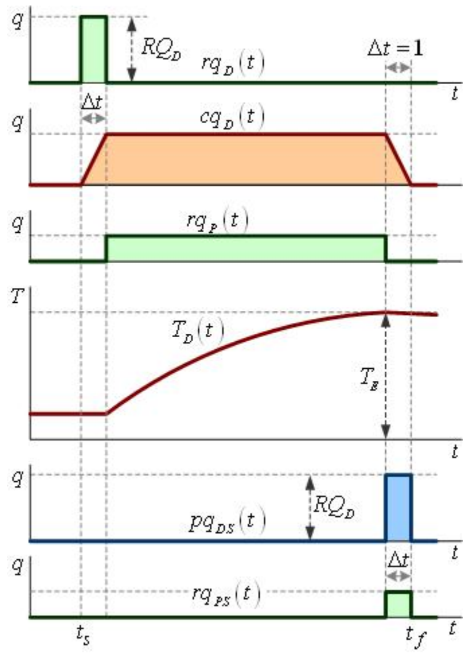

Fig. 8. The timing charts showing registration signals of the sets operation

A distinctive feature of the sets operation model is the registration signals presence of all input products of the sets mechanism. The registration signal $rq_D(t)$ is not accompanied by the energy consumption registration signal as the energy consumption for transfer of ADP belongs to the previous service mechanism.

The conducted researches allow giving of general definition to the "operation" concept.

Definition 5. 5. 1. Operation is the process of interaction of system products and system mechanisms directed on transformation/conversion of input operation products to output operation products

$$\left(\forall y \in M^{'}\right)\left(\forall p \in D\right)\left[V^{'}(p) \wedge C(y) \wedge S(p,y) \Rightarrow\right.$$
$$\left.\Rightarrow \left(\exists p \in D\right)\left(\exists x \in G\right)\left(V^{''}(p) \wedge T(x)\right)\right].$$

Definition 5. 5. 2. Operation model is the visualized form of data presentation that displays the results of procedural interaction of system products and system mechanisms which time starts with the moment of the beginning of the first input technological product registration, and finish time – by registration of the completion moment of the last technological product delivery.

5. 6. Model of single-product sets operation

An approach to the operation research can be carried out concerning of transit of separate ADV or ADV group (monoproduct) from the input to the output of the sets mechanism. If two or more ADP products are supplied to the input mechanism and research directed to the subset of these products, then the decomposition operation is carried out.

The need to use such approach arises, for example, at the solution of problems in inventory control. In that case, parameters determination of the monoproduct is carried out by the registration signal processing at the input rq(t) and the registration signal received at the output as a result of decomposition $pq_D(t)$. In case of research of the single-product model (one ADP), the registration signal of the finished product at the output $pq_R(t)$ corresponds to the decomposition signal $pq_D(t)$. Then

$$cq_D(t) = \int_{t_s}^{t_f} rq_D(t)dt - \int_{t_s}^{t_f} pq_D(t)dt \text{ (Fig. 9).}$$

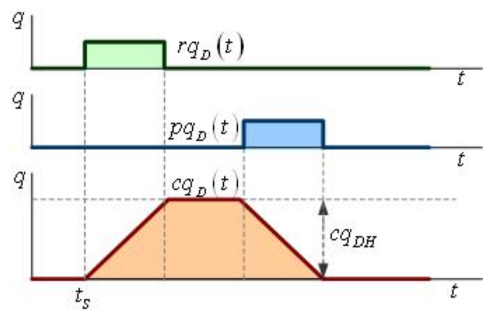

Fig. 9. Temporary charts showing registration signals of the single-product sets operation

5. 7. Model of the identified operation

From the viewpoint of quality assessment of procedural objects interaction, there are many alternatives of the sets operation successful completion. For example, by the change of the intensity of energy product supply, it is possible to change the speed of the ADP heating process.

Thus, the volume of energy consumption and wear of mechanism of directed action will change.

Within the range of admissible controls, there is such value of it, at which the maximum coherence of procedural objects interaction results for the purpose of their owner is reached. Registration signals of the sets operation do not have full information that is necessary for decision-making in respect of control optimality.

Functions $rq_D(t)$ and $rq_P(t)$ quantitatively determine the ADP and energy product parameters on the input and the function $pq_D(t)$ – parameters of the finished product on the output. Besides, the function $rq_P(t)$ uniquely determines the load mode of the system action directing mechanism that allows to define the function $rq_M(t) = f\left[rq_P(t)\right]$.

However, registration signals $rq_D(t)$, $rq_P(t)$, $rq_M(t)$ and $pq_D(t)$ quantitatively are incomparable.

Creation of additional mechanisms in the form of multipliers and adders, and delivery of the information products (signals) on the inputs of these mechanisms in the form of expert (cost) estimates rs_D, rs_P, rs_M, ps_D, gives the opportunity to present these operations in the form that allows to correlate input and output operation parameters.

As any sets technological operation is carried out for the purpose of increasing the cumulative value of output operation products in relation to the cumulative value of input operation products for identification of the operation, concerning the efficiency of resources use, signals of registration of the products movement on input and output have to be brought to comparable sizes.

If the registration signal of ADP, energy product and technical product of the sets operation is brought to comparable values with the use, for example, of price coefficients and represent as the input function signal re(t), and the registration signal of the finished and accompanying product in the form of the output function pe(t), it becomes possible to evaluate the efficiency of the test operation [1, 15].

Here is $re(t)=re_D(t)+re_P(t)+re_M(t)$, and $pe(t)=pe_R(t)+$ $+pe_S(t)$.

The mechanism of formation of input and output functions is represented in Fig. 10. In this example, one channel of ADP and energy product is presented, but it is clear that the number of channels on any type of products essentially doesn't affect the concept of definition of input and output functions.

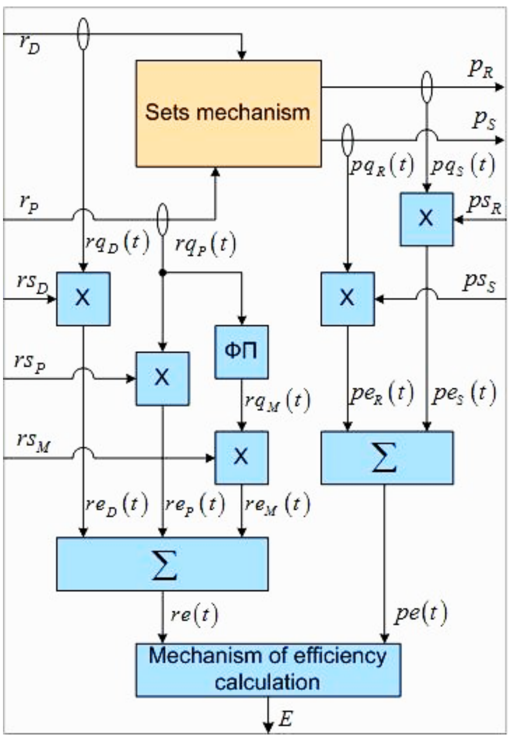

Fig. 10. Principle of structure formation of the sets module computing part

Operation is effective in principle if the condition PE>RE is satisfied (Fig. 11).

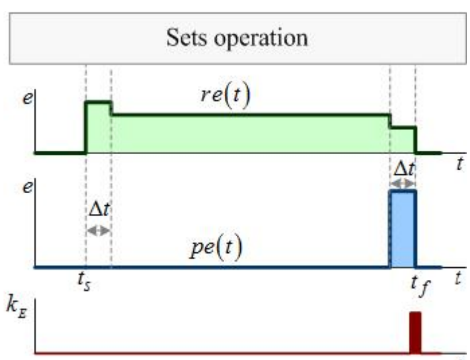

Fig. 11. Timing diagrams showing registration signals of the identified operation model

Each control has its own operation model. As for decision-making it is necessary to be guided by the value of the optimization criterion, the operations models, displaying including the value of the efficiency criterion, we will determine by the concept "**model of the identified operation**".

Input/output function is the registration signals of quantitative parameters of input/output system products, brought to comparable values and summarized in the time domain.

In case the character of the connected condition of distributed in time product in the course of its transformation can be neglected, the input and output function can be replaced with the three (RE, TO, PE). There is TO – the time of the studied operation from the moment of the first giving of the input operation product until completion of delivery of the finished operation product by the service mechanism [16].

6. Discussion of the research results connected with the development of classifications of basic cybernetic categories

As shown in the research of the works connected with control, the model of operation is that psychological barrier which gets in the way of developers of new technologies of optimum control.

Conceptual and classification uncertainty pushes researchers to the use of the concept "process" instead of the "operation" concept that is "safer" from the point of view of "terminological purity" as any operation is a process in time. Consecutive operations performance is also defined by the process.

Indicative is that fact that in the works connected with research of operations, the concept "operation" is practically not used and not discussed, and the model of operation isn't given. Thus, the attention on the importance of discipline "operations research" is focused [17–21].

Data processing of this or that operation is also based on the use of the mechanisms that are presented in the form of formulas and rules of mechanisms interaction and ADP.

For example, the software product represents a set of interrelated mechanisms. Nevertheless, numerous attempts to estimate the efficiency of these or those software products are made. In this case, the result of such attempts is usually the calculation speed estimation.

It is clear that it is necessary to estimate not the software product, but the sets operation of transformation of data (products) within which the software product models the functions of channel-forming mechanisms, mechanisms acting on ADP, the movement of ADP and interaction of products and mechanisms.

Further development of the results of this work can be carried out in several directions: profound classification of system products and system mechanisms, synthesis of subsystems models and systems by the increase of aggregation extent on the basis of sets and system mechanisms.

7. Conclusions

1. It is found that the set of system mechanisms consists of two classes: channel-forming mechanisms and mechanisms of the directed action. The set of system products

includes: the class of action directed products, the class of energy products and the class of technical products.

2. The system of identifying signs of system operations is offered. Depending on a hierarchical sign of the system mechanism, the following types of models of system operations are allocated: models of simple operations, models of complex operations, models of service operations, models of sets operations and model of the identified operations.

3. The category "operation" as the process of interaction of system products and system mechanisms directed to transformation/converting of input products of the operation to output products of the operation is conceptually defined. The category "operation model" as the visualized data presentation form representing the results of procedural interaction of system products and system mechanisms, the time of which begins with the moment of the beginning of registration of the first input technological product, and the end time – registration of the completion moment of delivery of the last technological product is conceptually defined.

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