Classification of Systems and System Entities

Igor Lutsenko

Doctor of Engineering Sciences, Associate Professor
The department of electronic devices
Kremenchuk Mykhailo Ostohradskyi National University
Kremenchug, Ukraine
E-mail: delo-do@i.ua
http://orcid.org/0000-0002-1959-4684

Abstract
An approach to the synthesis of simple systems is suggested. The concepts of "basic operation", "basic mechanism" and "dual system" are introduced. It is found that the classification criterion of the number of the basic system operations is the number of its control subsystems.
The definition of the "dual system" concept is given. The concepts of "simple system", "control system", "complicated system", "large system" are clarified. A refined classification of systems and system entities is suggested.
Keywords: SYSTEM, SIMPLE SYSTEM, DUAL SYSTEM, COMPLICATED SYSTEM, LARGE SYSTEM, CONTROL SYSTEM

1. Introduction

To achieve these objectives it is necessary to create or use the existing systems or system entities. A reasonable choice of architecture of the control system allows us to fully implement the principles of structural and parametric optimization [1], to ensure the adaptation of optimized processes under conditions of market change [2].

This means that the concept of "system" is one of the most important in cybernetics, and the "system" object is the basic object of control.

However, there is no complete certainty in science today of what is "a control system", " a complicated system" or "a large system".

Nevertheless, if there is no complete understanding of what is the large or complicated system, at first we can decide what the «simple system» is. Then starting from the basic conceptual model we pass to the formulation of more complicated or large system entities.

In general, the lack of classification of the systems and the system entities holding back the development of such areas as the design and creation of optimal control systems, the development of the "operations analysis" discipline and the widespread introduction of the optimal control principles.

The work objective is to develop the clarified classification of the systems and the system entities.

Before Rutherford concept of the atom internal structure was obtained, in the beginning, as the working concept of the atom as the smallest indivisible entity had been adopted. Indivisible used in the sense that the fission process would change the properties of the investigating matter.

A similar situation exists with respect to the system. Intuitively, the system is determined as the entirety. And the removal of any internal object of the system violates its entirety, thus changing the researched essence of the "system". That is why the system is determined as a set of interrelated elements that interact with the environment and acts as a single unit. But the concept of the indivisible whole can be referred both to the simple system, and to the more complicated system entities.

Difficulties with the perception of the "system" concept are associated both with the variety of systems in terms of the method implementation of reaching objective, and with many possible modifications of the particular system. Thus, the technical system will operate without the evident exchange processes, without the optimization module, and even without the explicit information exchange with other systems.

To illustrate the information above, let us consider the system entity, which task is to provide an object with the liquid heated to the desired temperature (Fig. 1). Such a structure is often created to provide a supply of running heated water by controlling the faucet of the water valve and gas or electric heater handle.

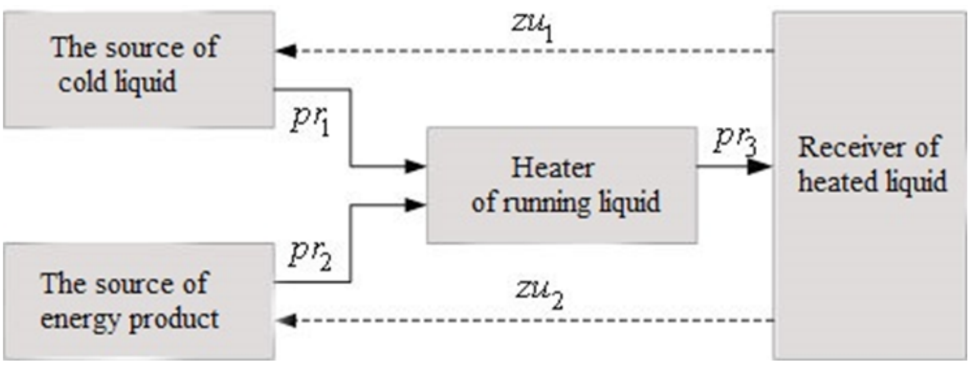


Figure 1. System entity provided execution of the heating function of the running liquid to a predetermined temperature

How does the process implement?

The receiver of the heated liquid by using the channel zu_1, sets the necessary intensity of the cold liquid supply that through channel pr_1, heating mechanism and channel pr_2 passes into the receiver. Further, the receiver by using channel zu_2 sets such an intensity of the energy product supply over channel pr_2, which provides the necessary liquid temperature at the output of channel pr_3.

Since for a given liquid temperature at the output of the heater each control zu_2 (for setting the supply rate of the liquid) corresponds to its control zu_1 (to set the intensity of energy product supply), tight controls relationship excludes the possibility of optimizing this process.

Naturally, all controls are implemented within the restrictions imposed.

The question arises whether the structure shown in Fig. 1 a system or a set of systems interacting with each other? And if it is the set of systems, why information interaction is only between the source and the receiver? What is the fundamental difference between the liquid heater from the other objects at the system level?

As can be seen (Fig. 1), the running liquid heater does not control sources of technological products. This means, there is no part of the heater, which provides control functions.

However, this does not mean that the control part is absent in principle. It says only that the structure of

Fig. 1 does not show the real picture of the objects interaction. The heater control functions are performed by the part of the structure that is indicated as the receiver of the heated liquid.

Move the control module into the structure of the heating we get the scheme of systems interaction (Fig. 2).

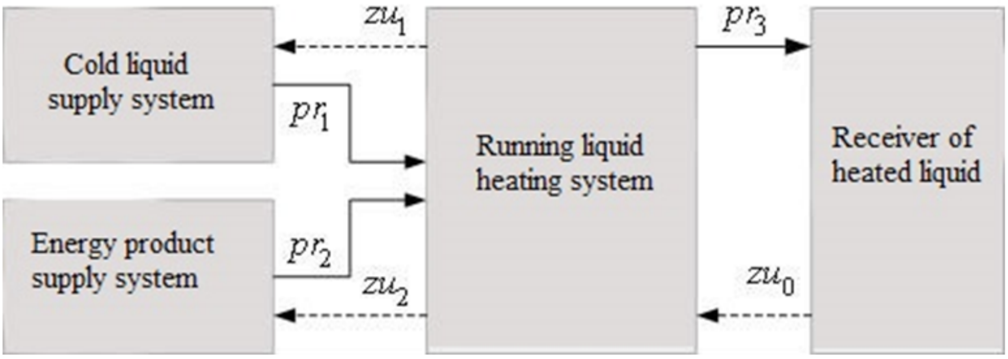


Figure 2. Control heating system of running liquid

From the standpoint of the internal structure of the heating system research is the object of study. Is it a **simple system**?

To answer this question it is necessary to try to divide the heating system into simpler systems. And if it's done the fission process must be repeated for as long as the objects obtained after the procedure of decomposition retain features of the system: the reference input, control outputs, inputs and outputs of technological products.

However, for the procedure of decomposition a set ideology is needed. The essence of the proposed method is that the process of decomposition continues as long as the number of **basic operations** in object under the study is more than one.

Naturally, the question about the concept of "basic operation" arises.

Basic operation determines the purpose of the system. For example, heating operation is the basic operation of the heating system. That is, if the system performs one basic operation it can be argued that the studied system is simple.

To implement the basic operation naturally the basic mechanism is required.

Whether the heating system of the running liquid is within the definition of the simple system? Of course, it is not.

Besides the liquid heating operation to the predetermined temperature, this system simultaneously performs at least one more function - a function of buffering the heated liquid. The system basic operation of which is buffering, we define as term "buffering system."

After having carried out the selection of simple operation of portion liquid heating and buffering operation from the complex operation of the running liquid heating, we obtain the following model of the control **system** in which the heating system performs a simple basic operation (Fig. 3).

Definition. A control system is an integral organized structure, the processes of which are intended to achieve the control objectives by solving the problem of consumer (the product of the desired quality and quantity) in relation to the system of consumption.

The structure (Fig. 3), exactly as the previous structures, conceptually solves the problem of the liquid supply to the consumer. The intensity of the distribution and its duration are determined by the system of consumption. However, a feature of this structure is that the heating system provides heating of liquid in portions. In this organization, the heating mode can be performed optimally.

Portions of the liquid passed to the buffering system and form the heated liquid stocks. The speed of the boosting must be in such condition that the continuous water intake by the consumer of accumulated stocks at the maximum intake does not reduce them to zero.

However, the separation buffering system performs not only the basic operation of buffering. Besides this operation, it also makes a distribution of the heated liquid to the consumer.

Yes, the operation performs the distribution of the final product, for example, conversion system. But this distribution is carried out at a time when the basic operation ends. The distribution operation, as well as the supply of cold liquid is performed **automatically**. Therefore, either supplying operation or the distribution operation is not basic for the portion heating system.

The separation system in this respect is unique. Completion of basic buffering operation automatically does not result in distribution of the finished product to the consumer. The distribution of the finished product or heated liquid with predetermined intensity and duration is available upon request of the consumer.

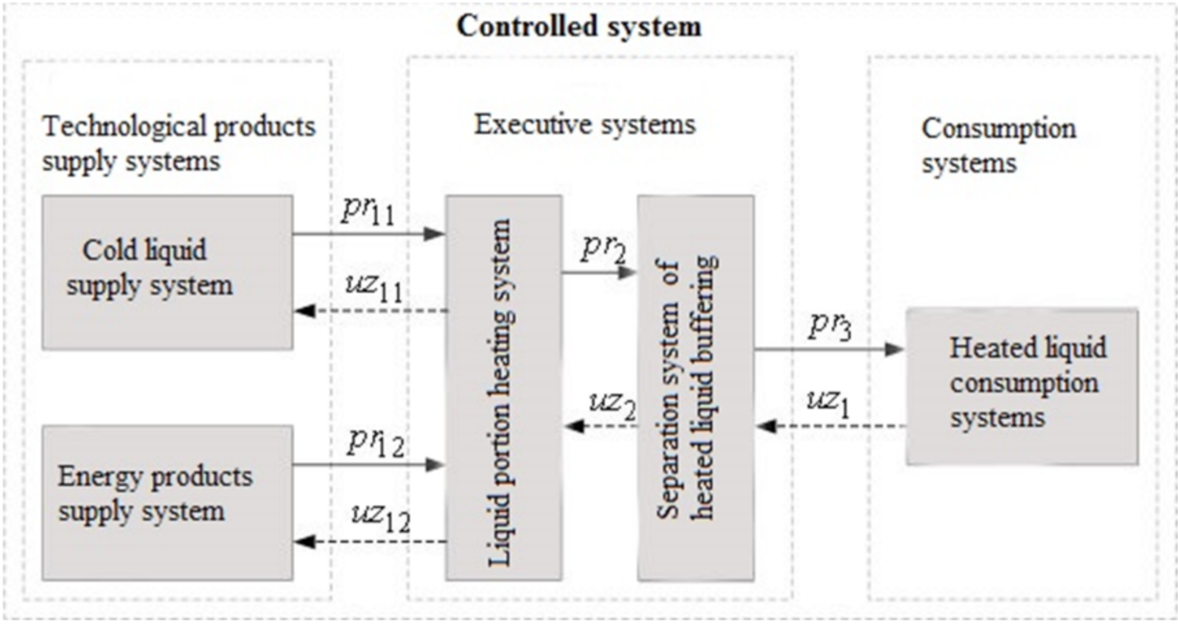
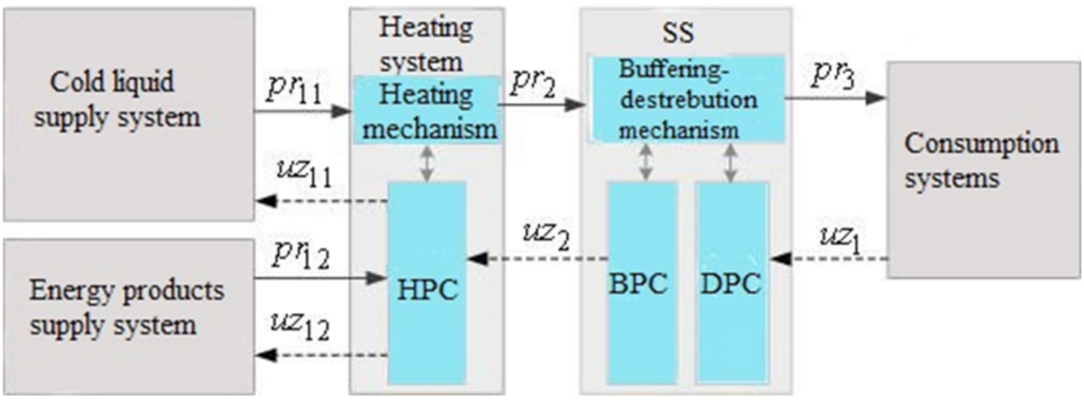


Figure 3. A control system of supplying the consumer with heated liquid

Therefore, the separation system can be classified as the dual systems (the terminology of the author), because the system of this class has two built-in control subsystems.

One of the control subsystems ensures realization of the basic buffering operations, with respect to input products of the separation system. The second control subsystem provides the realization of the basic operation of distribution of the buffering product with specified quantitative parameters for the system of consumption. Therefore, for this system name of "separation system" or "buffering-distribution system" is more suitable (Fig. 4).

The first name displays the conceptual nature of the system, and the second - a functional purpose.



SS – separation system; HPC – heating processes control;
BPC – buffering processes control;
DPC – distribution processes control

Figure 4. The control liquid heating system with marked basic mechanisms and control subsystems

Upon receiving a request on distribution of the consumer product, the simple systems make requests on the supply of technological products, take these products, process them and transmit them to the consumption systems at a time when their basic processing operation is completed.

In the separation systems their inner product is buffered before it is requested from the system of consumption, i.e. beforehand. Therefore, distribution operation begins immediately at the request of the consumer. That is why the distribution operation as well as the operation of buffering is basis for the separation system.

The implementing of the decomposition operation for the separation system does not work, since both control subsystems interact with the same basic mechanism [3]. At the same time, there are no control channels of direct interaction between these control subsystems.

Definition. Simple system is a system created for the carrying out of the system process directed to the formation of a consumer product with the specified quality parameters within which only one simple **basic** operation is implemented.

Definition. Dual system is a system created for the carrying out of the system process aimed at the formation of a consumer product with specified quantitative parameters within which, the controls implement two simple basic operations.

On the next step we move to a model named interface part (Fig. 5), in order to research the internal structure of conversion system. Internal structure of the conversion system is simpler than the internal structure of the separation system

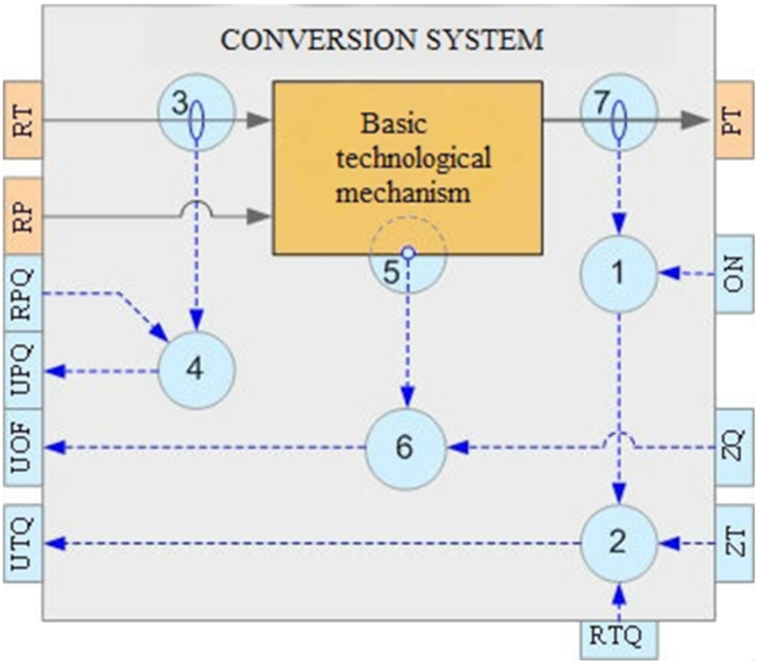


Figure 5. The internal structure of the conversion system in the form of the agent model

Any system object has the interface part, each element of which provides the function of receive-transmit of the system products. We define a set of interface elements as the concept of "port".

Each port consists of the named port sections.

RT, RP and PT port sections of the conversion system provide the technological products motion. Section RT ensures receive-transmit of the input transit product, RP - receive-transmit of energy product, PT - receive-transmit of the output transit product.

Another port sections are related to the solving of control system problem: RPQ - the amount of the processing product supply is given; UPQ - the signal of the energy product supply is formed; UOF - the signal tripping of the energy product supply is generated; UTQ - the signal processing product supply is formed; ON - initialization of the starting process is carried out; ZQ - the reference value of the product quality is given; ZT – the task to supply the product to consumer is formed.

The synthesis of conversion system structure gave us the opportunity to explore its system objects.

As you can see, the whole set of objects can be divided into 3 classes: displacement mechanisms (shown with directed arrows); mechanisms for information signals converting (agents) and basic mechanism.

Based on the intersystem processes analysis it can be concluded that all specifics of the converting processes is concentrated within the base of the technological mechanism.

This means that, except for the basic mechanism all other objects have a cybernetic nature. In other words all conversion systems have a single application architecture on the conceptual level.

It may be noted that, except for the basic technological mechanism, all other objects in the system can be both mechanisms and independent systems.

This means that the internal system architecture can have unrestrictedly large nesting level. Such systemic organizations can be defined as the concept of "complicated system."

In order to improve efficiency the control systems try to be grouped in immediate vicinity to each other. This creates large enterprises. System organization of such associations is convenient to define as the concept of "large system."

Definition. Complicated system is a system in which all or some of the internal, not basic functions are provided by the systems.

Definition. Large system is an organized structure consisting of several (sets) of control systems.

Conclusion

The structure of the control liquid heating system is studied in the article.

On its basis generalized control system is synthesized the executive part of which is represented by the simple and dual systems.

The definitions of the simple system, dual system, control system, complicated system and large system are given.

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