This is the published version of a paper presented at 7th International Symposium on Machine and Industrial Design in Mechanical Engineering, Balatonfured, Hungary, 24 – 26 May, 2012.

Citation for the original published paper:


N.B. When citing this work, cite the original published paper.

Permanent link to this version:
http://urn.kb.se/resolve?urn=urn:nbn:se:lnu:diva-73015
GENERALIZED ALGORITHM FOR A FUNCTIONAL - STRUCTURAL ANALYSIS OF TECHNICAL SYSTEMS

Valentina HARALANOVA
Borislav ANGELOV

Abstract: A generalized algorithm for functional-structural analysis of the technical systems based on the hierarchical relationship between the system for conversion of material, energy and information, the technical system and the executive organs of the technical system, is proposed. The universality of the proposed algorithm is a prerequisite for solving important problems in the theory of the technical systems for revealing regularities, generally valid for all technical objects and transferring knowledge from one scientific field to another one.

Key words: system for transforming of material, energy and information, technical system, executive organs (units) of technical systems, algorithm for functional-structural analysis.

1. INTRODUCTION

The second half of the twentieth century was characterized by a rapid development of technology and related technical sciences. The wide variety of technical means - complex technical systems - designed and used by human in all the diversity of its activities and the highly developed branches of technical sciences lead to the present complicated state in the field of techniques. Currently knowledge of technical systems is obtained through training in various technical subjects. Despite the aspiration after gripping fully the existing information it is clear, it is not possible to obtain specific knowledge about each technical object. As a result, the engineers after higher education, not only objectively have a deficiency of specific knowledge in their field of study, but furthermore they do not receive the necessary information on the whole picture in the field of techniques. An increase in the quality of engineering training can be achieved if the university curricula introduce a new subject concerning techniques, revealing the general regularities in the construction, design and exploitation of the technical systems. The investigated object in this scientific subject, which is beyond the individual branches of the technical sciences, is the abstract machine. On one hand, this abstract machine is an element of the system for transforming material, energy and information, standing at a higher level; on the other hand, it is itself a complex system consisting of executive units, interacting to each other.

From a systematic point of view, the executive organs are also systems having their own structure and where pass parallel internal processes.

A similar approach to study the object of knowledge in other scientific fields, exploring minerals, plants, animals or human society, has led to rising of generally adopted interdisciplinary scientific complexes. The contours of a general scientific subject about technical objects are outlined in the researches of many famous scientists [2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18]. However, there are poorly understood issues [5, 9, 13, 14, 17, 18], one of which is the creation of a generalized algorithm for functional-structural analysis based on the internal hierarchical relationship between the system for transformation of material, energy and information and the executive units of the technical system.

2. GENERALIZED ALGORITHM FOR FUNCTIONAL-STRUCTURAL ANALYSIS OF THE TECHNICAL SYSTEMS

A basic problem, met during the synthesis of a generalized algorithm for functional-structural analysis of technical systems, is the combination of requirements for universality of the algorithm and the specificity of the task for a functional-structural analysis, which is always solved for a particular technical object. Therefore, the generalized algorithm for a functional-structural analysis should present such a universally valid accumulation of consecutive operations, which is applicable in each case.

Assuming that individual technical objects compose an "information space" of the man-made technical systems, then the generalized algorithm of the functional-structural analysis must fulfil the role of "navigation software" in this space. If an “unexplored” object comes across, the generalized algorithm, through its tools, should support the independent acquisition of new knowledge.

Through the medium of such approach it is possible to solve also the important problems in the theory of technical systems. Detecting regularities valid for all technical facilities will allow the flow of scientific knowledge from one scientific field to another one. In a hierarchical perspective the technical system is an element of a higher level system for transformation of matter, energy and information. Within this system it interacts with other elements (human and object) and with environment. Through this interaction, performing the principal function (purpose) of the technical system and by its means is achieved the desired change in the properties of the object. Applying systematic approach, the technical system could also be presented like a
complex system consists of elements interacting with each other. Its inputs and outputs can objectively be clarified only if it is considered as an element of the system of transformation of matter, energy and information. Implementing the main function of the technical system its elements also interact, i.e. in technical system runs parallel internal process.

In the machine sciences an object of study is the specific technical system. After clarification of its structure and the characteristics of the processes running in it, the functional-structural analysis continues on the lower level, whereas object of study are taken the executive units of the technical system. Rarely, during the functional-structural analysis, the system for transformation of material, energy and information is involved, standing at a higher level, whose element is the technical system itself.

From a systematic point of view it is more correct (Fig. 1) that the functional-structural analysis of the technical systems starts at a system for transformation of material, energy and information (I level), continues to the technical system (II level) and finishes at the level of the executive units of the technical system (III level).

It would not be reduced the methodological role of the generalized algorithm for a functional-structural analysis if at the different levels is applied the approved way of presenting information in various branches of the engineering sciences and the appearing there terminology.

On Fig. 1 are used the following symbols: TS - technical system; EN – environment; EU, 1...5 - executive units (organs) of the technical system.

The first step for the different levels of the generalized algorithm for a functional-structural analysis, shown on Fig. 1, is the definition of the primary function (purpose) of the respective system.

The main functions of the systems at the different levels also have a vertical hierarchical dependence.

By the means of a technical system is realized the desired alteration of the properties of the object in the system for transformation of material, energy and information.

The executive organs of the technical system fulfill their purpose, interacting within the ongoing internal technical process.

The executive units themselves are also composed of structural elements. They interact within the range of the parallel internal processes occurring in the executive units.

The next step of the generalized algorithm is to clarify the structure of the technical system and an analysis of the internal process in it.

The elements of the system for transformation of matter, energy and information are of various origins and in the most general case, the relations between them have a material, energetic or informational nature.

The desired change of the properties of the operand is done by a technology (recipe, algorithm), which was previously known.

Due to the high degree of generalization at this level of the functional-structural analysis, it is appropriate that the system for transformation of material, energy and information and its internal process, to be presented in an abstract way.

In turn, the technical system consists of executive units which relate each other also in a material, energetic or informational nature. In implementing the basic function of the technical system, its executive units interact, i.e. an internal technical process takes place in it.

The issue of abstract presentation of the technical system by its elements (its executive units) and by objectively existing relations between them is not resolved at the appropriate level to date. The main reason is the wide variety of technical systems developed and used by people in different areas of their activities.

Additional difficulty appears by the fact that it is necessary to define such abstract executive organs that are present in the structure of any technical system.

Known methods for constructing the functional structure and the structure of organs in the technical system are not applicable to the examined case [5, 8, 9, 14, 18]. They were created for realization of individual stages in system design and therefore are always specific.
Solution can be found if the executive units of the technical system are attributed to one of the following five main groups:
- Working outfit;
- Source of energy;
- Transmission;
- Suspension (supporting) system;
- Control system.

The proposed five main groups of executive organs can also be considered as a system of lower hierarchical level. In different branches of technical sciences these executive organs are studied in their concrete realization.

Despite the low level of generalization, at this level of functional-structural analysis it is appropriate to use methods of abstract representation. Suitable for this purpose is the model of the technical system based on its executive units.

The structure and the action of the executive units are studied in various technical objects. Some systematization can be obtained if each executive unit of the technical system is related to one of the mentioned five main groups.

The algorithm for a functional-structural analysis, developed, based on the presented above considerations, is shown in Fig. 2. It is structured in three stages and within each level it consists of four identical operations.

In the block diagram in Fig. 2 are used the following symbols: FSA – functional-structural analysis; TS - technical system; STMEI - system for transformation of material, energy and information; EU - executive unit.

It is seen from Fig. 2 that the functional-structural analysis of the executive units continues until their depletion. Each of them should be studied in its concrete realization. Therefore, at this level it is appropriate to use the established methods for analysis and graphical presentation of the executive units in various technical sciences.

The functional-structural analysis should be completed with an evaluation of the effectiveness of the ongoing processes in the systems of the different levels. The efficiency of the performed change in the properties of the operands in the system for transformation of matter, energy and information can be defined as the ratio between the usefulness of the process and the costs incurred for its implementation.

The effectiveness of the ongoing internal technical process in the technical system can be determined by a quantitative assessment of the properties of the technical system, and the efficiency of the parallel internal process, taking place in the executive units of the technical system - by an analysis of the advantages and shortcomings of the specific executive units.

3. CONCLUSION

The proposed generalized algorithm for a functional-structural analysis of technical systems is based on the hierarchical relationship between the system for transformation of matter, energy and information, the technical system and the executive units of the technical system.

Therefore, it is structured in three stages and within each level it consists of four identical operations.
In the basis of the proposed algorithm underlies the abstract presentation of the system for the conversion of matter, energy and information and the technical system. This determines the general validity of the algorithm and the possibility of its use in each specific case, too. The algorithm is a prerequisite for solving important problems in the theory of technical systems for the disclosure of regularities, valid for all technical objects and for the transfer of knowledge from one scientific field to another one.

REFERENCES


CORRESPONDENCE

Valentina HARALANOVA, Assist. prof.
University of Ruse
Faculty of Transport
Department of Machine Science,
Machine Elements and Engineering graphics
8 Studentska Str.,7017, Ruse, Bulgaria
viharalanova@uni-ruse.bg

Borislav ANGELOV, Assoc. prof. Ph.D.
University of Ruse
Faculty of Transport
Department Engines and Transportation Equipment
8 Studentska Str.,7017, Ruse, Bulgaria
bangelov@uni-ruse.bg