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OPTIMISATION RESEARCH METHODS OF PROCESSES AFFECTING TECHNICAL CONDITION OF ENGINEERING OBJECTS SUCH AS RAILWAY ROLLING STOCK

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Key words: *Railway rolling stock; production, repair and maintenance; technological design; optimization methods; mathematical model of the process; Information Technology; computer-aided design.*

Abstract: The article contains a method for constructing models of technological processes of production, repair and maintenance of railway rolling stock, which serves as the basis for the development of information, mathematical and methodological support for the technological process CAD system. The use of computers to solve the problems of technological design has given impetus to the development of optimization methods of design, which has recently received more and more intensive development. The research results showed the effectiveness of the optimization approach to solving technological problems of the repair base. Automating the design and adjustment of technological processes based on the use of information technologies will reduce the time to introduce new technical means and technologies into production, improve the efficiency of production, repair and maintenance of railway rolling stock.

Now the enterprises performing maintenance and repair of the railway rolling stock (RS) design new and update the existing technological processes without assessment of their quantitative indicators. This is due to the fact that the design is carried out either without the use of a computer, or only some of the design operations are automated.

The use of computers to solve the problems of technological design stimulated the development of optimisation methods of design, which is rapidly developing now. The research results proved the optimisation approach effectiveness to solving repair base technological problems.

For the solution of repair processes optimization it is necessary:

- to define an optimisation criterion;
- to develop an optimised system mathematical model;
- to develop methods and algorithms for solving the given problem.

The general scheme of formation of mathematical model of technological process of rolling stock or its node repair is given in Fig.1.

Technological process (see Fig.2), can be represented as:

$$\boldsymbol{S(T)}=\{Idn^T, Prp^T, Atr^T, X^T, Y^T, Q^T, C^T, Str^T, \}, \quad (1)$$

where Idn^T - system identifier of repair technological process ;

Prp^T – process objectives;

Atr^T – system-wide attributes;

$X^T=\{x_1^T, x_2^T,..., x_n^T\}$ - the input parameters of the technological process primarily include: the type of repair, the model of the repaired RS or its node, its technical condition, the requirements of normative documents to the repaired RS;

$Y^T=\{y_1^T, y_2^T,..., y_m^T\}$ - technological process output characteristics such as: labour intensity, duration, consumption of materials, spare parts, energy resources, operation costs;

$Q^T=\{q_1^T, q_2^T,..., q_k^T\}$- the impact of the external disturbances, including: changes in the repair rules requirements, the emergence of new technologies, equipment and gear, the repair of new RS structures or its nodes;

$C^T=\{c_1^T, c_2^T,..., c_h^T\}$- technological process internal properties such as: means for technological equipment , number and qualification of performers, work shop, site, workplace of operations realisation;

$Str^T=\{T, R^T\}$ – technological process structure;

T – process elements that include all operations and transitions;

R^T – technological process elements relations.

The system identifier *(*Idn^T*)* is a combination of two fields: <designation of the technological process > and <name of technological process >, for example:

(Idn) = <10.00001.00017> <Bogie dissemblance> (2)

The main tasks of technological processes improvement at the repair and operational enterprises include:

- overall improvement of the enterprise efficiency;
- RS repair and maintenance quality improvement;
- reduction of the labour intensity and repair costs;
- reduction of the technological cycle duration.

The functional purpose of the technological processes of repair and maintenance enterprise is to convert the parameters values characterizing the technical condition of the RS needing repair or maintenance.

As *inputs* of technological process we may consider, first of all, set of the parameters values characterizing technical condition of RS needing repair or maintenance, and as *outputs* we may consider set of the parameters values characterizing technical condition of RS after repair or maintenance.

The *impact of the external disturbances* on the technological process can be random and manifested in the change of material, energy and information processes of interaction. For technological systems of repair and maintenance companies external influences can be:

- changes in the production program;
- RS and its nodes condition when arriving for repair or maintenance;
- new technologies and technological equipment;
- changes in the rules of repair and maintenance;
- technological equipment condition.

Internal properties (C^T) and structure (Str^T) of the system at the most general level of modeling are described by enumeration of elements, their properties and connections.

The technological process should be considered as a system consisting of two levels - technological operation and technological transition.

In general, the properties of the system elements of any level should include set of values of the technological processes parameters, operations and transitions such as:

- means of technological equipment (equipment, devices, tools);
- professional staff and number of performers;
- main, auxiliary and preparatory-final time;
- consumption of materials and spare parts;
- place of operation realization (workshop, site, workplace), as well as working conditions;
- controlled parameters;
- modes of repaired products processing.

Figure 3 represents the technological process generalised block diagram of the repair or operational enterprise consisting of two levels:

$$\mathbf{T} = \{ \mathbf{T}_1, \mathbf{T}_2 \} \quad (3)$$

where **T** – set of technological process elements;

$\mathbf{T_1}$ = elements of the 1st level (technological process operations);

$\mathbf{T_2}$ = elements of the 2nd level (technological process transitions),

M1 - number of elements on the 1st level.

M2 - number of elements on the 2nd level.

The relation between the system elements are defined as $\mathbf{R}^T$, herewith:

$$\mathbf{R}^T = \{\mathbf{R_1}^T, \mathbf{R_2}^T\} \quad (4)$$

where $\mathbf{R}^T$ – links between the system elements;

$\mathbf{R_1}^T$ = inter-level links of elements on the 1st level;

$\mathbf{R_2}^T$ = inter-level links of elements on the 2nd level.

S1 - number of inter-level links of elements on the 1st level;

S2 - number of inter-level links of elements on the 2nd level.

Mathematical model of technological process structure (relational system) can be represented as follows:

$$\mathbf{Str}^T = \langle \mathbf{T}, \mathbf{R}^T \rangle \quad (5)$$

where **T** – system elements (model carrier);

$\mathbf{R}^T$ - system elements relationship (model signature), that is, the sequence of operations and transitions'.

Conclusion

To reduce the time for introduction of new technical means and technologies in repair process, to improve the RS repair and maintenance quality it is necessary to increase substantially the labour productivity of engineers and quality of engineering documentation that defines the parameters of all operations performed on the production floor. This task can be solved by automating the design of new and adjusting of existing processes based on the use of information technology.

The offered method of construction of models of RS repair and maintenance technological processes serves as a basis for the development of information, mathematical and methodical support developed by the system of CAD for TP of repair productio

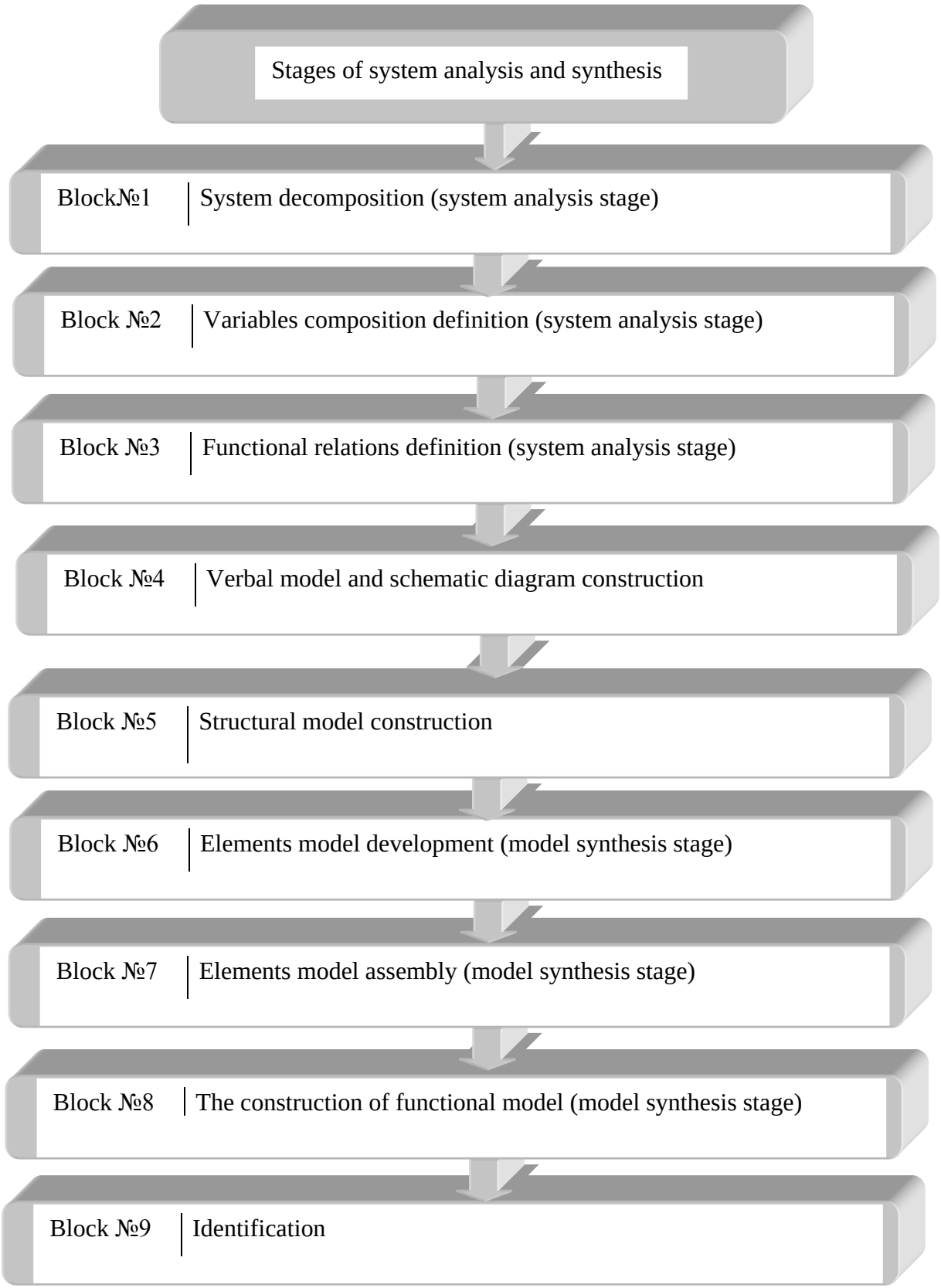

Figure 1. General scheme of system mathematical model formation

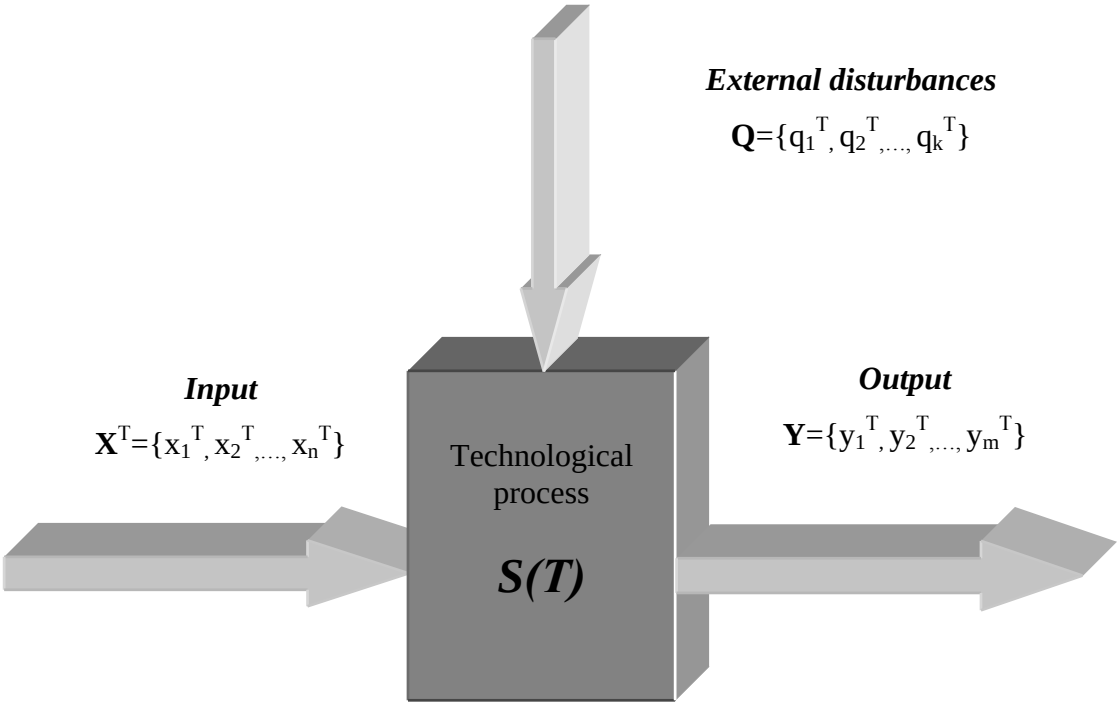

Figure 2. Technological process generalised schematic diagram

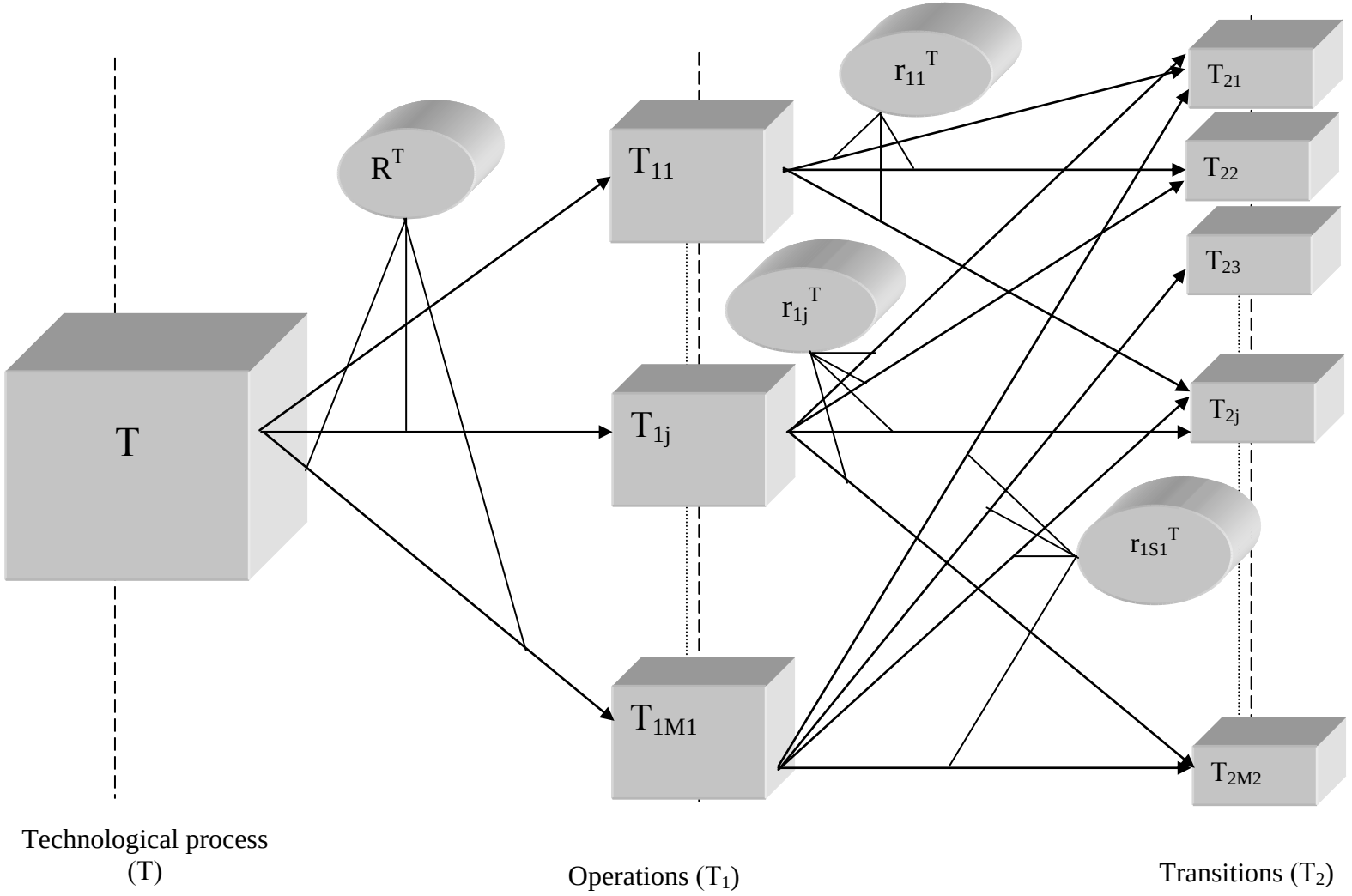

Figure 3. Technological process generalised block diagram

ОПТИМИЗАЦИОННЫЕ МЕТОДЫ ИССЛЕДОВАНИЯ ПРОЦЕССОВ, ВЛИЯЮЩИХ НА ТЕХНИЧЕСКОЕ СОСТОЯНИЕ ОБЪЕКТОВ МАШИНОСТРОЕНИЯ, ТАКИХ КАК ЖЕЛЕЗНОДОРОЖНЫЙ ПОДВИЖНОЙ СОСТАВ

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Ключевые слова: *Железнодорожный подвижной состав; производство, ремонт и техническое обслуживание; технологическое проектирование; оптимизационные методы; математическая модель технологического процесса; информационные технологии; автоматизированное проектирование.*

Аннотация: *В статье предлагается методика построения моделей технологических процессов производства, ремонта и технического обслуживания железнодорожного подвижного состава, которая служит основой для разработки информационного, математического и методического обеспечения системы САПР ТП. Применение ЭВМ для решения задач технологического проектирования дало толчок к разработке оптимизационных методов проектирования, что в последнее время получает все более интенсивное развитие. Результаты исследований показали эффективность оптимизационного подхода к решению технологических задач ремонтной базы. Автоматизация проектирования и корректировки технологических процессов на основе использования информационных технологий позволит сократить сроки внедрения в производство новых технических средств и технологий, повысить эффективность производства, ремонта и технического обслуживания железнодорожного подвижного состава.*