METHODOLOGY OF THE STUDY OF TRANSPORT MACHINERY HISTORY

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ABSTRACT

The article reveals methodological approaches to the study of history of production and cars machinery. The basic concepts of production and transport machinery, machines and tools, as well as the principles and methods of the study of history are described. Particular attention is paid to the periodization of historical and technical processes and experiences in applying chronological and chronological-problematic principles. In addition, the authors consider logical method, historical method, mathematization and modeling method. A generalized principle of links-substitution for periodization of technology development processes is offered. A new category is introduced – the level of intelligence of automatic machines, the method of its quantitative assessment is mentioned.

ENGLISH SUMMARY

Background. *Study of the history of transport and production machinery promotes generalization of historical and technical material, determination of limits of knowledge about the subject, reduction of the area of ignorance by introducing into scientific use new concepts or methodological approaches, reconstruction of a holistic understanding of the processes and phenomena that occur in transport field.*

To begin with reference to the history of production machinery (including locomotives and cars) it is necessary to remember the original concept.

Machinery is set of means of human activity created for the processes of production and service of non-production needs of society [1, p. 497].

Manufacturing machinery includes tools, mechanisms, machines, machine control devices, etc.., And transport machinery includes vehicles (rolling stock: locomotives, diesel locomotives, electric locomotives, cars), technical means of mechanization of cargo handling and storage processes; mechanization and automation in transport infrastructure [1, p. 497].

Tool is an instrument for work (hand tools: hammer, crowbar, hacksaw, wrench, brace, drill, power tools: pneumatic hammer, pneumatic circuit breaker, electric saw, electric wrench, electrical drill) [1, p. 184].

Mechanism is a set of flexibly jointed bodies (links, parts), which under the influence of applied forces make some desirable movements. The totality of power, transmission, and actuating mechanisms (links, parts: of machine- engine, gear or converter and power tool) forms a machine [1, p. 287].

Machine is a mechanical device with consistently working parts, performing certain movements under the control of a man for conversion of energy, material or information [1, p. 278].

Automatic machine is a machine that operates continuously and controlled by hard or reprogrammable algorithm using the energy of inanimate nature without direct participation of people.

Intelligent automatic machine is a machine that operates continuously and controlled by intelligent sensors on reprogrammable algorithm using the energy of inanimate nature, without any involvement of people (intelligent industrial robots, robotic systems).

Objective. *The objective of the authors is to investigate methodological approaches to studying history of production and transport machinery development.*

Methods. *Methods of studying the history [4–7] are research methods of historical and historical-technical processes through historical facts in order to obtain new knowledge. They include: a logical method, providing for application of the method of induction – movement of thought from the individual to the general, the method of deduction – the movement of thought from the general to the particular, the methods of formal logic, including algebra of logic (propositional formulas or Boolean algebra); historical method – the study of phenomena and processes in their chronological development with all unique features, parts, especially on the principles and rules of work with primary sources [3]; method of periodization; mathematization method; modeling method.*

Basic scientific principles of studying the history of manufacturing and transport equipment, the history of civil society are [3–6]:

– The principle of objectivity – the reliance on facts in their true content with positive and negative aspects;

– The principle of social approach – considering the history with account of social interests of all segments of the population;

– The principle of historicism – the study of historical facts, phenomena and events in their development and relationships;

– The principle of systemacity (systems approach) – a set of methodological principles, considering an object as a system composed of interconnected elements (car shed as an automatic control system of performance (Bolotin, M.M.), car-repair complex as a self-organizing system (Sirina, N.F.); rail transport as a system of automated traffic management (Misharin, A.S.); freight car as an essentially non-linear system with variable structure (Filippov, V.N.);

– The principle of chronology – description of events in their time sequence;

– The chronological-problem principle – description of events in periods (stages) with reflection of their internal problems;

– The problem-chronological principle – description of the phased development of a problem in the history of the state [3].

Results.

The method of periodization

It divides the development processes into main qualitatively different from each other periods (stages) in accordance with established criteria (principle) [2, p. 985]. Periodization (systematization) of historical and historical-

technical processes is an essential element of the methodology of history [5, p. 80]. Periodization of the development of civil society is most often carried out using formative, civilization, chronological, chronological-problem and problem-chronological criteria (principles). In [4, p. 75] it is noted that «it is unacceptable to transfer mechanically the criteria of periodization of civil history to the history of technology».

Therefore periodization of the history of production and transport machinery is carried out using the principles of substitution, links, chronology, chronological-problem, and for the classification of machinery within periods energy principle, principle of functional purpose, principle of structural materials, configuration principle, principle of form and others are used. [3 5, 7].

The most popular in the historical and technical study is the principle of substitution of a man with technical devices in the performance of functions related to physical and mental labor. Based on this principle five periods in the history of production machinery are distinguished [4, p. 75]: instrumental (people start using hand tools); mechanical (replacement of motion functions of a man with mechanisms); mechanized (replacement of a man with a machine); automatic (replacement of a man with an automatic machine); cybernetic (replacement of human mental functions with cybernetic devices).

Roughly similar stages of manufacturing machinery are highlighted in [9, p. 13]: the first stage – the use of simple tools; the second – the use of tools and the simplest mechanisms; the third – the use of machines; the fourth – automation of production; the fifth – comprehensive automation of production. The difference of this and the previous periodization of technology development is that in the former case, the process concerns the production machinery itself, and in the second – the development of production.

It should be noted that automation of production (using standard machines, including industrial robots) passes not two, but three stages in its development [10, p. 126–129]: the first – automation of a working cycle of a machine, creating a universal, specialized and special semiautomatic and automatic machines with CNC on the basis of automatic controllers and microprocessors; second – automation of systems of machines (automatic creation of lines of mass production and flexible automated lines); the third – comprehensive automation of production (use of flexible automated sites, shops and businesses).

Classification-periodization of production machinery (production machines) using the principle of links is given in [11, p. 8–15]. Criterion of the principle of links implies that the machine is a set of three links – car-engine, gear, machine-tool [1, p. 287].

Based on the principle of links [11, p. 8–15], we define the following periods of production machinery development: hand tools (hand tools), using the energy of wildlife – machines of zero links (Z = 0); hand tools, equipped with a mechanical amplifier – machines of unit links (Z = 1); power tools, using the energy of inanimate nature, – two-link machines (Z = 2); machines driven by a man – three-link (Z = 3); semiautomatic machines with partial human involvement (Z = 3,5); automatic machines with rigid automatic cycle of operation (Z = 4); automatic machines with flexible (reprogrammable) cycle (Z = 4,5); automatic machines of flexible automated lines (Z = 4,75); automatic machines of flexible automated sections (Z = 5).

Machines having links Z <3 are considered as machines of a low technical level, and machines with links 3 <Z <= 5 – of a high technical level.

The principle of links allows not only to make a periodization of production machinery, but also transport machinery (cars) [10, 11, 13]. For example, in [12] principle of links is first used as a criterion of periodization (classification) of junctions of freight cars, and in [13] – of passenger cars.

Applying the principle of substitution to the earlier given classification of machines based on the principle of links, it is possible to get their enlarged periodization, which includes five stages of development: machine-tools; machine-mechanisms; machines managed by a man; automatic machines with rigid automatic cycle; automatic machines with flexible automatic cycle. This periodization is basically consistent with periodization in [4].

Based on the above results, we propose to combine the principle of links and the substitution principle in one generalized (universal) criterion – the principle of links-substitution. In this case, the category of «links' characterizes constructive engineering excellence, and the category of «substitution» – a function performed by a technical device to replace a person at different stages of development.

Presumably the principle of links-substitution of machines can be applied to the periodization of cybernetic machines replacing mental activity of a person [4, p. 75]. Cybernetic machines should logically be attributed to the machines of a new quality – intelligent robotic, the level of which is higher than the level of machines of flexible automated sites.

It can be assumed that the intelligent automatic machine in comparison with the machines of flexible automated sections are additionally equipped with superlinks of a new quality, independently changing algorithms of the action depending on the state of the environment. For example, a intelligent robotic machine with links Z = 5,5 can be considered as an intelligent machine of the first generation, a machine with links Z = 6 as an intellectual machine of the second generation, a machine with links Z = 6,5 – a machine of the third generation, a machine with links Z = 7 – a machine of the fourth generation. And they all differ in a certain degree of replacement of human mental activity.

The principle of links-substitution allows thereby expanding the limits of variation of links of machines and introducing a new criterion of their perfection – the level of intelligence of automatic machines. By analogy with the formula (1.6) in [11, p. 20], this level can be quantitatively determined from the relationship

$$K_{\text{им}} = 100\,\% \frac{\sum_{1}^{n} q_{\text{им}i} Z_i}{Z_{\max}^{\text{им}} \sum_{1}^{n} q_i},$$

where n – the total number of considered mechanisms (devices) of the intellectual automatic machine;

$q_{ИМi}$ – number of movements carried out by the i-th mechanism of the machine in the cycle of its operation under the control of the smart device with links Z_i;

$Z^{ИМ}_{max}$ – maximum links of intelligent machines ($Z^{ИМ}_{max} = 7$ for this situation);

q_i – total number of movements, carried out by the i-th mechanism of the intelligent automatic machine.

Periodization of the history of technical sciences, production and transport machinery, using as criteria chronological and chronological-problematic principles is carried out in those cases where it is important to emphasize the sequence of historical and technical processes or phased formation of a technical science.

In [15], for a given stage of development of civil society – the slave civilization the issues of formation of technical means of different types of transport are examined in detail using a chronological-problem principle. At each stage of their development the author reveals problems and interprets techniques of their solution, advances in science, technology and energy, explains the signs of transition from one period to another.

Application of chronological principle for periodization of development of technical means and technologies of maritime transport of oil and oil products is demonstrated in [16]. Here, based on the study of historical and technical processes the main event in the field of maritime transport of oil and oil products are highlighted and presented in the form of a chronological table [16, p. 9].

Professor L. A. Shadur [17] applied a chronological principle for periodization of formation and development of domestic science of cars (1835–1994 years) in the field of: longitudinal dynamics, interaction of a car and a railway track, oscillation of cars, strength, reliability, improving the design of cars and thermal engineering of cars, welded structures of cars, automatic brakes, technology and organization of production at car -repair and car-building enterprises.

The work [18, p. 10–24] reflects the experience in forming the chronology of origin and development of rolling stock in Russia from 1846 to 1933, the beginning of the operation of the first freight and passenger cars of domestic production.

Mathematization of processes

It is considered that the mathematization of historical research takes the count «since 1960, when in Russia within the Department of History of Academy of Sciences, in France, the USA, Austria relevant research centers were organized» [19].

A distinctive feature of the present stage of the mathematization of historical and historical-technical processes is the extensive use of a variety of mathematical methods:

– Computing and elements of probability theory [20, p. 347–412, 191–279]; elements of mathematical statistics [21]; statistical methods to establish the equation of connection between random variables and determine the probability of occurrence of events, different prediction methods [22, p. 9–20; 54–61];

– Methods of formal logic (logical foundations of question-answer thinking, argumentation theory, the foundations of logic and evidence, etc.). [23]; Boolean algebra [12];

– Methods of expert evaluation, which are quantitative and ordinal estimates of processes and phenomena, based on the judgments of experts [22, p. 99–112], as well as evaluating the reliability of expert decisions on the frequency criterion and the coefficient of variation [24, 9–10];

– Method of formative analysis, which involves the separation of the elements on the principles of functional significance and role, finding a solution to the problem, which removes existing barriers to the development [25];

– Methods of structural analysis of the production and transport machinery [12], cluster analysis, and others.

Of course, the use of such complex tools requires not only high specific training, but also adequate philosophical knowledge, methodological literacy.

Method of modeling

Modeling is a study of any phenomena, historical and technical processes or systems by constructing and studying their models, which reflect certain aspects of the technology history [2, p. 816; 5, p. 81]. Models of historical and technical processes involve three types:

- models of historical and technical analysis;
- forecasting models;
- models of operations.

In [5, p. 78–79], a multilevel hierarchical model of historical and technical research is offered, which takes in account three interrelated stages: fact (collective), interpretive (analytical), legislative (theoretical). Graphically, it is represented in the form of unwinding spiral of technology development, including four full turns, corresponding to the periods of production machinery development: instrumental, mechanical, mechanization and automation. Cybernetic period is represented by an incomplete turn. [4]

The most common type of modeling of machines and processes is mathematical computer modeling using predictive models to find the best description of the trend and determine the predicted values of the studied parameters [11, p. 9–20; 23, 95–97].

Conclusions. The set of proposed concepts of production and transport machines, principles and research methods of historical and technical processes of their development, methods of their periodization, mathematization and modeling, the use of these theoretical positions enabled to form an appropriate methodology.

The greatest attention is paid to the methods and principles of periodization, as they are essential elements of the methodology of the historical and technical research, the main elements of their scientific novelty. A new generalized principle of periodization of the history of production and transport machinery history – the principle of links-substitution, the authors showed its relation to the principle of substitution and the ability to analyze intelligent machines. A new evaluation category is introduced-level of intelligence of automatic machines, a way of its quantitative evaluation is defined.

The importance of the principle of periodization for the history of development of machines, automation systems and related theory is highlighted. The authors also emphasized the experience of the application of the substitution principle and the chronological-problem principle for periodization of the history of transport and other equipment.

Keywords: history, cars, locomotive, production machinery, methodological approaches, principle of historicism, substitution principle, principle of links of machines, generalized principle of links- substitution, periodization of history of technology, method of mathematization, level of intelligence of automatic machines.

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