ON THE EVOLUTION OF TECHNICAL PROBLEMS

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ABSTRACT

The article systemizes notions of socio-economic formations and civilizations. It demonstrates approaches to the formation of criteria of periodization of the history of society, technology and production, based on indicators defined by the pyramid of quality: quality of goods, quality of production, quality of the enterprise, quality of life. The integrated criterion of periodization (classification) is offered, which takes into account the degree of importance of quality indicators under study. The classification of technical devices is considered as a set of governing mechanisms with the ability to modify any of their properties as conditions change, and as a set of links, replacing a man in the production process. The history of structures of hydraulic, elastomeric and friction draft gears of automatic coupler of freight cars is shown. The conditions are represented, which contribute to the development of devices, the role of scientists, scientific schools and enterprises.

Keywords: technology, history, civilization approach, periodization, historical and technical analysis, labor productivity, material production, wages, quality pyramid, control mechanism, the coefficient of importance, integral criterion.

Background. *Modern science has developed different ways of periodization of the history of technology and civilization. The author considers the following circumstances:*

- *history of technical problems (technology) – the history of human activity, coordinated by the human mind;*
- *rise in the development of the productive forces and production relations (the mode of production of material goods) did not always coincide with the development of technology, however, «the establishment and development of technology is an essential factor in the formation and development of social being, immanent technical factor of state of society» [1, p. 73];*
- *quality of engineering is always an indicator of the quality of life, and its qualitative states correspond to different historical periods [2, p. 17–18];*
- *as a sphere of science history of technology may give clues to the general trends of development of productive forces and production relations in the development of modern society [1, p. 248].*

Objective. *The objective of the author is to analyze the evolution of technical problems on the basis of study of draft gear of automatic couplers development.*

Methods. *The author uses analysis, comparative method, historical method, evaluation.*

Results.

Laws of compliance

Turning to the history of technology, we should rely on civilization grounds. The category of «civilization» reflects the qualitative features of the society when the dominant factors in material production, cultural-historical and personal activities are technical and technological priorities.

Based on the grounds of civilization, society is divided into pre-industrial (agrarian), industrial and post-industrial (technocratic) when the production of knowledge and information, science and its achievements dominate human activity [3, 4].

The possibility of civilized approach is well marked in [5]: «the concept of civilization allows to comprehend the history of large regions of the globe, and long periods in their specific diversity, which can be missed at the formational analysis, as well as to avoid economic determinism, identify largely determinative the role of cultural traditions and continuity of manners and customs, specifics of the consciousness of people at different times».

Hence there is every reason to say that the civilization approach helps us to understand and reveal the mechanism of evolutionary process of occurrence (due to natural or human challenge), development, prosperity and decay (due to stagnation, changes of direction, internal turmoil or external interference) of terrestrial civilizations; identify and explore the socio-cultural differences; assess the role of the relevant geographic scope and an individual in the fate of ethnic groups, nations, states and addressing historical problems; reveal the features of the material and the production and socio-political development of civilizations.

One of the angles in the periodization of the history of technology and civilizations is the quality of the commodity world, and so it is quality problem in relation to the most diverse forms of labor, which is particularly important for historical research.

By the law of correspondence of production relations to the nature and level of development of the productive forces the quality of technology must conform to one or another civilization [2, p. 17–19]. Then it is natural to assume that a particular set of indicators that reflect the qualitative state of society, can characterize a whole civilization, used as benchmarks of its development.

Researchers distinguish certain levels (hierarchy) of civilization quality: the quality of products (goods); quality of production; quality of the enterprise; total quality – quality of life, quality of science and technology, the quality of the economic system, the quality of the legal system, the quality of culture [6, p. 13–15]. This hierarchy has its meaning and its own logic.

The criterion of the quality of goods

Goods are products of human activity, intended for sale, purchase or exchange, which are characterized by the ability to meet any human need. Products, as well as equipment, are divided into capital goods (machine tools, machinery, equipment, vehicles, tools), transport (rolling stock and other vehicles), road construction, military, domestic and other purposes.

In [7, p.52] it is shown that the quality of the product, its operational safety and reliability, the design, the level of after-sales service are the main criteria for the modern buyer when making a purchase, and therefore, determine the success or failure of firms in the market. Goods must match their purposes. Quantitative measure of their quality is the degree of customer satisfaction, which is determined by the relation of value and cost of goods [8, p. 47]:

$$Q_g = \frac{V}{C}, \qquad (1)$$

where Q_g is quality of goods – customer satisfaction; V is value of goods; C is cost of goods.

The best option for the consumer is when the value of a defect-free product is above cost. Assessment of the quality of goods according to the formula (1) in the framework of historical analysis presents significant difficulties, since this formula characterizes use value.

In particular, it can be assumed that the product has the greater quality and relevance if it is able to automatically change its properties (parameters, modes, etc.), and its production is carried out on automatic equipment. These conditions contribute to improving the shape, appearance of the goods, improve reliability and reduction of the influence of the human factor. For this purpose, any technical device should be understood as a set of governing mechanisms (inverters), which have the ability, provided for in the design, to modify certain properties of technical products as conditions change (impacts).

For classification of governing mechanisms the principle of conditional link rate is applied [9]:

$z = 0$ – governing mechanism is absent or is unable to perform its function as conditions change;

$z = 1$ – governing mechanism changes a particular property by participation of a man, using a simple converter (steering wheel, lever, pedal);

$z = 2$ – governing mechanism modifies a particular property by participation of a man, using a mechanized device (drive); for example, the control valve in the water pipeline with a reversible electric motor (gearless) and a pressure regulator;

$z = 3$ – governing mechanism adjusts one or another property with the assistance of a man, using a motor unit with a converter; for example, a pressure regulator with a drive and double-arm lever in a hydraulic drive of rear brakes, which provides pressure control depending on the load on the rear axle;

$z = z_{max} = 4$ – automatic control: for example, the automatic transmission in a car; hydro-gas three-chamber draft gear of the automatic coupler, harness coupler device (automatic distributor of compressive and tensile forces); automatic pneumatic regulator of truck braking modes depending on the loading of a car and others.

After identification of appropriate governing mechanisms in any technical device and establishment of their conditional link rate it is possible to determine an average nominal link rate of a device:

$$\bar{z} = \frac{\sum_{j=1}^{n} z_j}{n}, \qquad (2)$$

where z_j is a link rate of the j-th governing mechanism; n is a number of governing mechanisms in the analyzed device.

Then, to evaluate the quality of the technical device (product) it is logical to assume that its value increases in accordance with the change in its mean conditional link rate and cost:

$$V \cong Ce^{(\bar{z} / z_{max})}. \qquad (3)$$

As a result, we obtain the dimensionless criterion of quality of goods

$$Q_T \cong e^{(\bar{z} / z_{max})} \geq 1. \qquad (4)$$

The formula (4) will allow simply and objectively evaluate the quality of the product for different socio-economic formations (epochs and civilizations).

The criterion of production quality

Its meaning is mainly determined by the quality of equipment and the quality of the labor force. The remaining components (quality of technology, quality of production processes, and quality of working conditions) to some extent depend on the level of productive forces (personnel and means of production, which are used). Likely, therefore, in [4] it is stated that «the main criterion for the progressive development of society, ultimately, is the knowledge in two forms: embodied in the instruments and means of production and «alive», the carriers of which are people themselves, the producers, i. e. their skills, experience and professional skills. This criterion applies to all stages of the development of civilization and is universal in world history».

Taking into account the principle of substitution [10] of a human by machines, we assume that for the history of society and technology quality of the equipment can be quantified by the average link rate of machines that replace a human in a particular historical period, referred to its maximum value in modern conditions:

$$Q_e = \frac{Z_i}{Z_{max}}, \qquad (5)$$

where Z_i is an average link rate of machines, replacing a human in production process for the analyzed period of history; $Z_{max} = 5{,}5$ is a maximum possible link rate of machines for the current level of development (intelligent automatic machines of the first generation [10, p.163], which are intelligent industrial robots).

Equation (5) allows evaluating objectively in a view of modern advances in science techniques the past of technology for a particular historical period.

The quality of the workforce is identified with human capital (characterizes a person's ability to work, his knowledge, skills, social and psychological characteristics, motivation, mobility and others), requiring investments for its development in order to increase productivity and efficiency, quality of life [11].

Since improving the quality of labor is the source of productivity growth, for the quantitative assessment of this indicator it is possible to apply the ratio of labor productivity LP_i (workplace, production site, company, region, sector, country) achieved at this historical stage to its average value LP_{av} reached in modern production:

$$Q_{wf} = \frac{LP_i}{LP_{av}}. \qquad (6)$$

According to the rating center AK & M the average labor productivity of Russian industry in 2001 amounted to 548,6 thousand rub per person. (http://www.akm.ru/rus/analyt/ratings/reotrosprom020322.stm).

In 2009, this figure corresponded to the level of 3656,2 thousand rub. (http://rating.rbc.ru/article.shtml?2010/04/04/32759812).

These data indicate an increase in the labor productivity, depending on the development of production in time. Then as a quantitative measure of the quality of production can serve a dimensionless index

$$Q_p = \alpha_1 Q_e + \alpha_2 Q_{wf}, \qquad (7)$$

where $\alpha_1 = 0{,}6$ is a coefficient of importance of the first indicator, characterizing the quality of the equipment; $\alpha_2 = 0{,}4$ is a coefficient of importance of the second index characterizing the quality of the workforce.

The company's quality criterion

Here the assessment depends significantly on the quality of management and the quality of managers.

The level of management is a totality of links occupying a certain stage in the management of the organization. Steps of this kind are in the vertical dependence and obey each other in the hierarchy.

The main purposes of any production are to provide the consumer with necessary products on time and of a given quality, the most rational connection in time and space of workforce, tools and objects of labor by using certain techniques and methods of management. Quality management and performance of leaders (their efficiency, organization, ethics, culture) should be reflected in the final results of the production process – the release of demanded products (goods), maintaining a required level of labor productivity.

Based on the foregoing, a quantitative measure of the quality of the company or the quality of management of the company should be a dimensionless indicator, including product quality index and the index of quality of the workforce:

$$Q_{\mathrm{m}} = \alpha_1 Q_{\mathrm{g}} + \alpha_2 Q_{\mathrm{wf}}\ . \qquad (8)$$

The criterion of quality of life

As a quantitative measure of the quality of life within the framework of historical research should be used an economic characteristics – per capita income or wages, the amount of which, to some extent takes into account the social position of the individual in the society for a given civilization, as well as the estimate of its labor on the part of the employer.

At the present stage researchers as the criteria use magnitude of the average, median wages, income disparities, the heterogeneity of society (the Gini coefficient). Being flexible enough, the Gini coefficient [12] characterizes the distribution of the entire amount of income of the population among individual groups. Its numerical value ranges from 0 to 1. For a uniform distribution of income it is close to zero, and the higher is the value, the more evenly income is distributed in society, the stronger is social stratification of society.

According to [12], the median salary of Russians in April 2013 was 21,3 thousand rub (average – 28,8 thousand.), the Gini coefficient in Belgorod region (the lowest) – 0,286 (this indicates a relatively uniform distribution of wages), and in Moscow – 0,393, St. Petersburg – 0,347, the Republic of Tuva – 0,385, on average, in Russia – 0,378.

The average salary in Russia for employed people (71 million people) is 31 000 rubles [13]. In this case, 37,8% (27 million people) get paid well below the average (from 5800 to 17000 rubles.). The average pension in the country is 11000 rubles (there are 41 million pensioners), but 45,1% of the elderly people get the retirement pension, which is less than its average value. At the same time, the average annual household income in the 100 richest families of Russian officials and deputies is approximately 234 million rub [14]. In [4] it is shown that in the developed capitalist countries there is a tendency to consider the difference in salary that goes beyond 1/5 as unfair.

These data allow us to offer a ratio of salaries as a quantitative measure of the quality of life

$$Q_{\mathrm{L}} = \frac{S_1 N_1}{S_2 N_2} > 0{,}2\ , \qquad (9)$$

where S_1 is an average salary of the working population with wages below the median; N_1 is a number of the working population receiving such a salary; S_2 is an average salary of the working population with wages above the median; N_2 is a number of the working population receiving such a salary.

Suggested quality indicators can be used for periodization of the history of the civil society both individually and as integral dimensionless quality criteria:

$$Q = \beta_1 K Q_{\mathrm{L}} + \beta_2 Q_{\mathrm{m}} + \beta_3 Q_{\mathrm{P}} + \beta_4 Q_{\mathrm{g}}\ , \qquad (10)$$

wher $\beta_1, \beta_2, \beta_3, \beta_4$ are importance coefficients of summable indicators.

For practical calculations importance coefficients are determined from the relation

$$\beta_i = \frac{\lambda_i}{\sum_{i=1}^{4} \lambda_i}\ , \qquad (11)$$

where $\lambda_i = i/2^i$. Then the numerical values of these coefficients are equal to:

β_1=0, 31; β_2=0, 31; β_3=0, 23; β_4=0, 15. Their sum should be equal to 1.

Periodization and classification criteria

The main driving force behind the development of technology and production is the society's need for material and cultural wealth. The development of techniques (primarily production machines) is a sequential release of a person from the physical and administrative work in the production process. In this case, the machine is defined as «any developed machine device consisting of three essentially different parts (links – author): machine-motor, gear, finally, machine-tool and working machine» [15, p. 384–385].

If a machine-tool does not have a machine-motor and a transmission gear (drive), it is a simple tool with zero link rate (Z = 0). If a working machine has only a transmission mechanism (lever, paddle, gear, assembly unit, wheel, etc.), using physical force of a human or an animal for the movement, it has unit link rate (Z = 1) – sled, cart, chariot, plow, rowing boat, etc. Machinery and apparatus equipped with a machine-motor and machine-tool, suggest link rate Z = 2 (pneumatic hammer, electric wrench, electric plane et al.).

If the machine has link rate of more than Z = 3, it is assumed that it is provided with superlinks and belongs to the class of automatic machines. Automatic machines can be equipped with rigid or flexible control devices (superlinks), replacing human when performing management functions. Machines with links higher than 5 refer to the intellectual automatic machines [10].

As noted, tools and machines are a commodity, so the criterion of their development can be a measure of «quality of a product» – the formula (4). For cases where the cost of goods of the same purpose shows a large dispersion, their characteristics affect the safety of any object (system) or it is difficult to set a conditional links of governing mechanisms, then the quality of such goods under certain normative values of the characteristics is defined by the formula

$$Q_{\mathrm{gn}} = 1 + \sum_{i=1}^{n} \frac{T_i}{T_{\mathrm{n}i}}\ , \qquad (12)$$

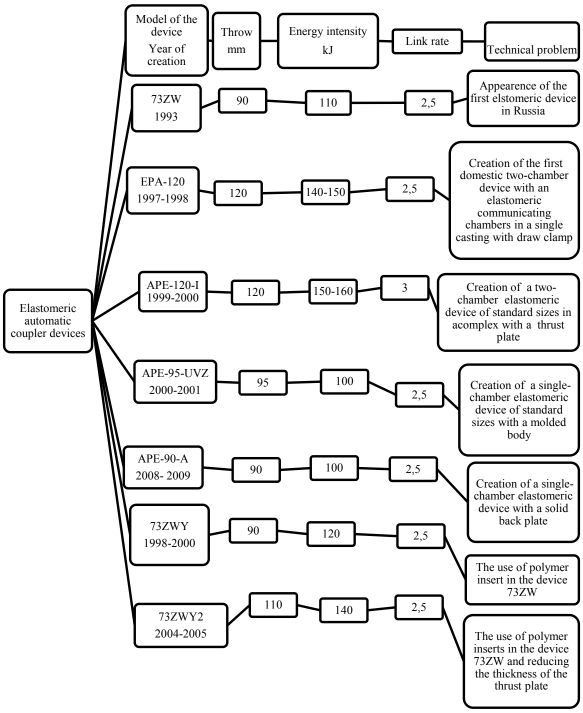
where T_i is a numerical value of the i-th technical characteristics of the analyzed product of any manufacturer; T_{ni} is a normative value of the i-th technical characteristics of the product.

As shown in the formula (5), the quality of production depends on the quality (links) of machines, so for periodization of its development, in addition to well-known criteria (technical level of production, the level of automation, labor productivity, output and so on [16, pp. 16–17]) it is possible to apply the proposed

Table 1

The numerical values of the criteria of working qualities and quality of the goods

Indicators	PMK-110A	PMKP-110	RT-120	73zwy	73zwy2	EPA-120	APE-120-I	GA-500
Average link rate	1,25	1,5	1,5	2,5	2,5	2,5	3	4
Q_d	1,085	1,157	1,182	1,317	1,449	1,564	1,847	2,69
Q_g	1,366	1,454	1,454	1,868	1,868	1,868	2,117	2,718



Pic. 1. Development chronology of elastomeric draft gears of the automatic coupler.

criteria for the quality of the goods, the quality of production, the company's quality, quality of life and integral criterion of quality.

Examples of implementation of the criteria

Let's apply chronological- problem criterion and criterion of the quality of goods to the analysis of the history of draft gears of the automatic coupler, which essentially influence the security of freight cars and transported goods.

The draft gear of the automatic coupler is a device with a constructive course of not more than 120 mm, being a part of the automatic coupler of cars and locomotives and designed for cushioning of longitudinal forces acting on them (OST 32. 175–2001).

The following conditions contributed to the creation and development of domestic structures of draft gears of the automatic couplers:

- *Transition of domestic cars to automatic coupler (1935–1957 years).*
- *Creation of the first domestic single-section spring-friction draft gear SH-1-T (hexagonal, first, heat-treated), using dry friction forces for energy dissipation (1940). Design and production (1959–1960 years) of a two-section spring-friction draft gear with sets of wedges in each section placed in one case, the construction of its two-stage (variable) power characteristics with less stiffness in the beginning of the course and greater rigidity at the end of the course [17, p. 338–341].*
- *Development at MIIT (1962–1968 years) of a series of hydraulic- gas draft gears of the automatic coupler (e. g., GA-500) using the new layout principles (three-section or three-compartment design). New materials for the manufacture of machine elements (alloy steel 30KhGSA), creation of hydraulic resistance (mineral oil AMG-10) and the elastic resistance (inert gas – nitrogen). New ways of energy dissipation in shunting and train works (by simultaneous throttling of the oil from the oil chamber to the other chambers, equipped with floating pistons and compression of the gas in separated gas chambers).*
- *Implementation in Russia (1993) of the project of the first elastomeric draft gear type 73zw.*
- *The appearance in 2001, prepared by VNIIZhT, of the industry standard OST 32.175–2001, which gives a classification of draft gears in classes (T0, T1, T2, T3) and a method for impact energy dissipation (friction, hydraulic and elastomeric), normalized numerical indicators are set (constructive course, static power consumption, nominal power consumption, maximum energy consumption), as well as indicators of the power characteristics.*
- *Creation of the theory of the train in the works of Russian scientists, development of mathematical models and methods of calculation of draft gears of the automatic coupler, the criteria of technical and economic efficiency, competitiveness of such devices and their operating characteristics.*

With chronological- problematic criterion chronologies of development of domestic hydraulic, elastomeric and friction draft gears of the automatic coupler are composed. Pic. 1 shows the dynamics of the evolution of elastomeric devices as an example.

This study found three development periods of draft gears of the automatic coupler: friction – 1940–2005 years (average conditional links 1,25–2,25, product quality 1,37–1,86); hydraulic – 1960–2005 years (average conditional links 1,5–4, product quality 1,45–2,72); elastomeric – 1993–2005 years (average conditional links 2,5–3, product quality 1,87–2,12).

To assess the criterion of «quality of goods' Q_g (formula 4) we compare the numerical values of the coefficients of working qualities Q_d [18] with the calculated data on the quality of devices listed in Table 1.

The table shows a fairly good conjunction of comparative assessments of the quality of designs of draft gears of the automatic coupler in terms of «product quality» criterion and criterion of working qualities. Thus, we can talk about the permissibility of using the criterion of «quality of goods' (formula 4) for the approximate evaluation of technology in its historical and technical analysis. In addition, there are significant benefits of hydro- gas (GA-500) and elastomeric (APE-120-I, EPA-120, 73zwy, 73zwy2) of draft gears in comparison with other considered designs. From these facts and chronology of elastomeric devices we can see the possibility of creating combined three-chamber hydro-elastomeric draft gears of the automatic coupler with an average conditional link rate 3,75–4.

Conclusions. *The article gives a theoretical justification for the possibility of using a set of quality criteria for the periodization of the history of civil society, technology and production. The methods for their quantification are offered. Based on the chronological- problematic criterion the history of the development of domestic elastomeric draft gears of the automatic coupler is analyzed.*

The article contains the examples of the use of the indicator «quality of goods' to assess the structural perfection of draft gears of the automatic coupler from the position of the principle of conditional link rate. The trends of their further development are shown within increasing link rate (sectional design) and the creation of the combined hydro- elastomeric devices.

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