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Intellectual Guidelines (References) of Engineers in Renovating Modern Production

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Abstract

Engineers lack sound guidelines to identify the level of changes in constructions and technologies. It leads to problems in planning and managing the renovation of modern production. The article discusses guidelines for gradual identification of level of changes in technologies and constructions based on interconversion of object and process systems.

Key words: innovative activity, competitiveness of enterprises, thematic plans of rationalization and invention, level of changes in constructions and technologies, system operation principles.

Relevance of the issue

The world changes constantly. Karl Marx stated: "Everything that is fixed is dead; everything that is in progress is imperfect. The modern dynamic environment requires companies' managers to receive the slightest signal of dangers and possibilities [1]. The signal sources are not only global trends and political events, but technological shifts (new materials, fundamentally new technologies and constructions). This approach is deeply rooted in the strategy of leading companies. The list of actions to manage changes, which is mentioned in the famous work by Igor Ansoff, includes the following points: 1) to create "a launch pad"; 2) to plan a process of changes; 3) to prevent conflicts between strategic and current processes; 4) to plan implementation; 5) to manage current production processes; 6) to institute the new strategy; 7) to maintain strategic response [1].

The areas of innovative activity in modern companies are multifaceted. All their subsystems (social, psychological, technical, economical) need changes. However, it is the technical and technological subsystem that is the dominant area in the structure of changes. Describing the new role of a company director, researchers note that it is the ability to manage continuous sequence of technological steps that determines the company's survival [2].

Currently Russian economy is not in the best state. A lot of companies are looking for investments all over the world to upgrade their production cycle, though there are resources inside the companies. The portal "Production management" provides the opinion of a German consultant in production management, who states that Russia has lost the rationalization system that the Germans once learnt from [3]. The necessity to restore this activity is proved by the leading companies ("Votkinsky zavod", "Proton-PM", "Russian Railways", "Taifun", "NEVZ", "Kirovsky Zavod" etc.) [4–7]. It is a very important issue. There are a lot of examples in the Russian history when the state pays special attention to the area of invention and rationalization even in the hardest period – the Great Patriotic War [8].

The current synonyms for "rationalization proposal" are "Kaizen proposal", "total production optimization", "improvement proposal" and even "Stop losing!" (Russian branches of Alcoa) [3, 9]. Each of the terms has its particularity, however there is the only aim – to stimulate staff initiatives, to find inner resources and make them work for the sake of a company.

However, the experience of the leading Russian companies [10] proves that management in the sphere of rationalization mechanically inherits the soviet approach with its formal attitude to thematic plans ("temniks") on inventive activities. The thematic plans often include only the title of the theme (according to the production area), current state, technical specification, aim of the theme, expected results, and names of consultants. There are the following reasons for that: 1) top management does not understand the importance of production renovation; 2) there is a lack of specialists involved in rationalization at a company; 3) the skills and qualification of the staff in patent office do not meet the requirements; 4) there is a shift in responsibility for plan implementation (the responsibility for production plan performance is greater than that of rationalization plan) etc. According to IP specialists (CNIITMASH) it is the liquidation of patent groups of companies that has recently led to the disastrous state of the invention area in the domestic industry [11]. Currently the Southern Korea produces about 18 thousand inventions annually, which is 4 more than Russia (!). To compensate the lack of specialists involved in rationalization in modern companies, it is necessary to institute "management of rationalization" departments in the leading companies of the country (for example in the workshop of OJSC "NEVZ") [12].

To develop a profound thematic plan (temnik) is a deep intellectual work. Currently, the most advanced temnik inherited from the Soviet past time is the plan developed by Scientific production association "Tzellulozmash". It was created by A.B. Selutzkii as a set of tasks applied to the manual for invention and rationalization "Algorithm for solving inventive tasks" (ASIT) with "Album of main ways to eliminate technical contradictions" [13]. All the 25 topics are presented there in the form of technical contradictions and have a sound informative support (UDC, IPC, etc.), targeted consulting support, and detailed motivation mode (minimal remuneration for invention).

Problem statement and solutions

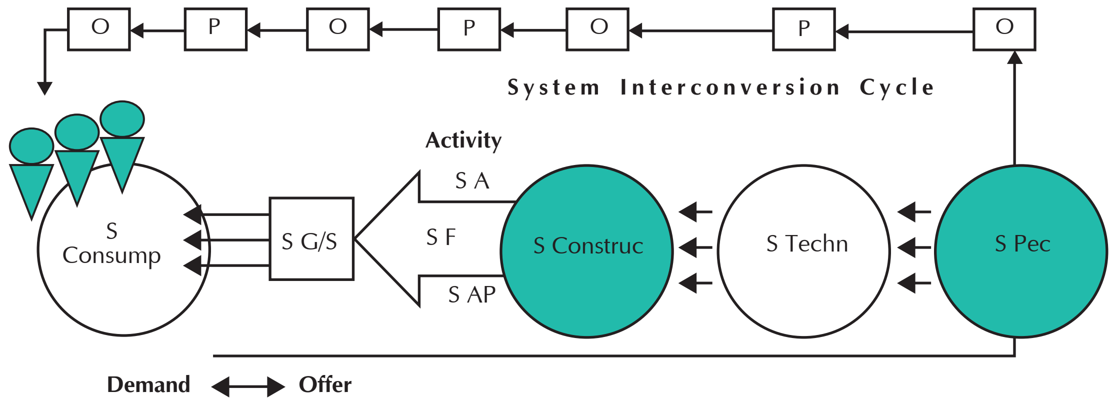
The recent analysis of rating "100 top rationalizations in industry" shows that statements of the required system changes are out of date. They do not meet the realias in terms of the accuracy in determining necessary and sufficient levels of changes in constructions, technologies and materials. It can be proved by the example from OJSC «Production system Rosatom» («PSR») related to complex testing (diagnostics) of the company (CTC) developed on the basis of cooperative work with c McKinsey, knowledge in Toyota Production System, and "Guidelines for complex testing in searching the resources to increase labour efficiency at the enterprises and construction sites of Minsredmash 1962" [14]. The result of the activity is "The Instruction to input CTC database". Several check-lists allow making a list of problems at the company for 4-5 days. The problems are classified then and serve as a base for a calendar plan of production improvements.

It is natural to strive for cost reduction (to save time, money, and labour spent on production changes). It would be perfect to obtain the required changes without any efforts at all. However, the reality proves that we should score twice before we cut once. Thus, it is necessary to know clearly what to be scored for better changes.

We suggest using the notion about the interactions between process and object systems. Fig. 1 schematically shows the cycle of system interconversion aimed at satisfying a complex of customs' needs (S Consump).

In terms of economics it is "Demand". It is satisfied by "Offer", which is made by goods and services (S G/S) produced by the totals of constructions (S Construc.). The latter is the total of material (object) systems.

Fig. 1. Cycle Scheme of interaction between process (P) and object (O) systems, where S Consup, S G/S, S A, S AP, S F, S Construc, S Techn, S Res – totals of needs, goods/services, actions, action principles, functions, constructions, technologies, and resources



Their activity is shown as a stream of total actions (S A) that implements the total of functions(S F) via total of action principles (S AP).

The functions are understood as a content of actions and are placed inside the arrow S A, while the action principles are in the arrow gap, thus opening the ways the actions are implemented.

S Construction, in its turn, is made of the totals of process systems (S techn) and (S resources). All the totals are incorporated in the cycle of system interconversion – object (O) and process (P) ones.

Let us prove the complementarity of opposite actions (A) and functions (F) by the following dialectic scheme. Table 1 shows that different action principles (AP), which are between the actions and functions like between the opposite poles (– and +), constitute a spectrum of forms of relations and links.

Dictionaries traditionally define a principle as the basic property of a device or a mechanism. The search for the principle as the basis for all existing things was the main activity of Greek philosophers. Thales considered it to be water, Anaximenes called it "apeiron", and Anaximander thought it to be "amorthic air". Modern scientists believe that the difference between the notions "principle" and "law" is the issue of terminology.

Based on interrelation between the object and process systems, we offer a procedure of a gradual identification of a desired (necessary or adequate) level of changes in them. The procedure is primarily focused on technical systems; however, it can be applied in managerial systems as well. It is reasonable to rely on a system of test questions that are used in TRIZ engineering [15]. According to them, if a technology is modernized, it is prohibited to change the construction; however, it is necessary to define the rate of restrictions for technology changes. The next stage of changes is the modernization of the construction (device), which does not have restrictions in technology changes; however, it is necessary to identify the restrictions imposed on the construction itself.

Let us present these steps in the matrix form (table 2). The main diagonal is a zone of restriction specification, which is shown in dark color. The grey zone above the diagonal is the zone of prohibited changes. The light zone under the diagonal is the zone of any permissible changes of the system [16].

It is known that an alternative system with the same function as an existing system, but having other action principle (AP), is the

Table 1. Action-function interaction

Action (A) as a phenomenon (–)	Action principle (AP)	Function (F) as an essence (+)
To cut a steel sheet in half with an abrasive disk	Mechanical	To divide a sheet in half
To cut a steel sheet in half with gouging		
To cut a steel sheet in half		
To cut a steel sheet with guillotine		
To perforate a steel sheet in the middle		
To press a piece		
To etch a sheet with acid in the middle	Chemical	
To burn a sheet in the middle	Physical	

most competitive one. The other principle ensures the most functional feedback [17]. In this case we face the replacement of the "old" system with the new one that has resources for a quantum jump of the basic parameters.

A good example of such replacement is plant grafting – the "new system" (scion) is joined to the "old system" (rootstock) to produce stronger and efficient species. The choice of "old system" as a rootstock is reasonable in terms of economy and sociology, since it takes into account the inertness of a human being.

The "old system" is dialectically presents sustainability, while the "new system" is the variability. In this case, we observe a qualitative change.

When alternative systems are united together, it can be compared with injection of "new blood". It is a moment of replacement

Table 2. Degrees of permissible changes in engineering

Levels of changes	Object of changes				
	Techno-logy	Constru-ction	AP	Function	Needs
Modernization of technology					
Modernization of construction		Restricted changes		Prohibited changes	
Reengineering of construction					
Creation of new object	Acceptable changes				
Prognosing					

of old laws, principles and structures with the new and more efficient ones. According to R. Foster, it is a "technology gap" [2] or according to M. Hammer, J. Champy, it is the situation when reengineering is urgent [18].

Thus, the suggested procedures to gradually identify the desired level of changes in constructions and technologies ensure principally new regulations for planning and managing inventive and innovative activities of domestic industry. The topicality of the issue is proved by a great number of current articles devoted to the assessment procedures in the spheres of invention, rationalization and innovation [19–21].

Conclusion

To increase the competitiveness of the domestic production industry, it is necessary for engineers to understand the levels of technological and constructional changes. To identify the action principles of the system is of special importance. The system efficiency can be radically increased only on condition that the newly identified action principles are applied in production renovation. The suggested procedures for gradual identification of the desired level of technology and construction changes are based on the interconversion cycle between the process and object systems, and are aimed at achieving the goals mentioned above.

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Peculiarities of Engineering Education Within the Innovation-Based Economy

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Abstract
In today's fast-changing market, the link between the decisions made in different fields is of significant importance. This peculiarity should be reflected in engineering education. The theory of technological modes serves as a methodological basis for the current research. It has been revealed that engineering-economic environment is shaped as a combination of technological modes, within which the problems of harmonized development of technologies are solved. The models to shape engineering knowledge under modern conditions are proposed.

Key words: innovation, engineering, models, multidisciplinary, technological mode, economy.

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Introduction

An ongoing shift in global economic activity [6, p. 391; 12] (development of innovation-based economy) stipulates the changes in education [7, p. 245; 20]. It is required to consider the link between the changes in engineering knowledge and innovation market.

The thing is that in the modern highly-integrated market technical objects definitely perform their applied (technical) functions. However, they increasingly perform so-called systemic functions, i.e. the functions that affect constructive processes of economic environment.

In practice it means the following. A new integrated circuit is designed. Its introduction into the market stipulates rapid changes. As a result, new conditions for advancing the integrated circuit emerge: new consumers' requirements, technological capabilities, use options. All this advances the integrated circuit and contributes to further change in the market conditions. In this context, the changes of the integrated circuit should not cause the discrepancies in the constructive processes of economic environment. Otherwise, an ongoing advancement of the integrated circuit will cease. Therefore, the integrated circuit should possess systemic characteristics that manage the concurrence of market changes (concurrence of constructive processes).

It is essential to secure the required technical and systemic properties of an engineering object. While designing an education programme, it is reasonable to find the answer to the following question: how a complex of engineering objects ensuing concurrence of changes in technical and economic environment is formed?

For this purpose, it is necessary to examine the processes of modern engineering knowledge acquisition, develop the models of knowledge acquisition and design the corresponding curricula. These issues have been addressed in research literature [1, p. 57; 2, 5, 17]. Precisely, they are examined in the works dedicated to "Knowledge Management" [14, p. 37; 15, p. 46]. However, the fundamental processes of an innovation-based economy have not