Drifting models for evaluating the functional properties of products of innovative value

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Abstract. The article describes the approaches to the analysis of drifting models of the functional properties of products or technological systems. Methods for analyzing the transitional states between modernization and degradation of the potential of a product or a technological system are described. Drifting models are based on the principles of functionally sufficient and functionally necessary states of products.

1. Relevance
The change in the potential of technical, economic systems occurs under the influence of the laws of development of technical systems, economic cycles, life cycles of a product, goods and is described using an S-shaped curve.

The local maximum demand for the functional characteristics of a technical system is achieved through multiple deep modernizations of basic samples, which were based and developed using the principles of "copying" and "analogy" of wildlife and environment objects. However, with the emergence and development of the theory of inventive problem solving, the popularization of domestic inventions, the creation of a base of heuristic methods and tools, it became possible to structure the functional characteristics of products, concentrating resources precisely in those consumer requirements, the implementation of which entails the maximum effect.

2. Problem area
The creation of new technical systems simultaneously opens up many questions related to the reliability and stability of the parameters of the technical system, technical, scientific novelty and practical value for the consumer. In pursuit of primacy in the sales market, cognitive limitations arise that direct the development of technical systems towards multiple, deep modernization of narrowly focused consumer characteristics of products, giving preference to the existing specialized segment of the market, with low rates of development, ignoring the potential prospect of diversification.

Diversification of the functional characteristics of technical systems, reduces the risks of losing the prospects of the product line and excessive focus on the monopolistic requirements of consumers inherent in a specialized segment. When investigating the possibility of diversification of the functional characteristics of technical systems that reproduce the main value of the process, drift states of the model characteristics may occur. Figure 1a shows a model of the drift of numerical values characterizing the potential of a process in four states: dead process, critical process, boundary process and controlled process. All these states are described using criteria of a sufficient process based on the rating qualimetric scale of names described in GOST R ISO / IEC 15504-2-2009 [1].
Figure 1. Model of the potential of the value-creating process (a) and the drifting model of the basic structure (b).

Figure 1b shows the flexibility indicators of a technical system in accordance with the concept of operational change in a critical process, thus, the space of a set of process states is characterized by a requirement for the required level of maturity of the process under study. The value of the main production facility depends on the degree of flexibility of the technical system, and if the boundary state is reached, the process should be restructured using advanced standardization methods to form a future foundation for deep modernization. In the zone of the critical state of the process, there is a risk of technical inertia in the process change, that is, disruption of functional connections that fulfill the main goals and objectives of the process, which occurred in connection with the drift of the current model. Thus, when conducting a study of the possibility of diversifying the functional characteristics of technical systems, the concept of a basic product sample or the basic structure of a technological system or process arises [2].

Figure 2. Membership functions that characterize the state of the technical or technological drift under study.
The concept of quality management by basic structures is based on the concept of a basic model, which was created and adopted to solve the current tasks and problems in the industry. The basic sample is a constituent element of the paradigm generally accepted at the time for the scientific methodology that existed at the time of its creation. Existing models and methods for the formation and selection of options are the theoretical basis for assessing the novelty of the product. However, the well-known answers to the question «can a new product always be considered the best? » are not unambiguous. The tasks of ensuring the priority functional significance of the designed products, presented in the form of a set of technical parameters, do not take into account social requirements and restrictions caused by the social significance and value of new products.

The localization of the basic sample as a set of functionally necessary and functionally sufficient parameters occurs under the influence of various scientific, production and social factors, therefore, turning to social requirements when developing a vector of functionally significant parameters will create an opportunity for product diversification in the market. Preventive rationalization of functionally necessary parameters as a factor in the presence of technical novelty of a product or the degree of novelty of a product allows to remain in the local extremum of product parameters. Achievement of an equilibrium state of functionally necessary and functionally sufficient parameters is achieved through a systematic audit of internal divisions for the presence of a regulatory and technical base of documents regulating innovation, scientific and engineering activities [6, 7].

The main achievements of manufacturing organizations are governed by a gap in technical characteristics between basic samples and developed prototypes, thus the phenomenon of drift in technical characteristics is formed in relation to the development trend of technical systems or technological processes.

The systemic concept of the reasons for the gaps in technical characteristics between the basic and new products contains the structure of the trend characterizing the potential of technical and technological systems synthesizing an innovative innovation [8,9] or supporting an existing basic sample. Technical information is presented in regulatory and technical documents such as a technical level map, a bill of purchased products, technical specifications. With the help of models of fuzzy representation of breaks in technical characteristics, a structural description of what is happening within the trend is possible. Fuzzy logic models use several membership functions characterizing the state of the investigated technical or technological drift (figure 2a, b). Models are suitable for describing transitional boundary intervals and characterize the conditional growth or technical stagnation of technical or technological systems.

Events reflecting the degree of degradation of technical characteristics (figure 2a) in relation to the changed market requirements and functional parameters of the technical trend curve are presented in an interesting way. The main questions that are formed in the process of recognizing a product, technical system or process, technological system morally and technically obsolete, accumulate in the course of operation and the comparison of useful functionality. Thus, an idea is formed about the need to modernize or modify objects that form the basis for the formation of production capacities of an industrial enterprise [9-12].

3. Practical use
Fuzzy logic models are applicable to assess the state of a product being developed and to form an assumed trend, within which the development of technical and economic indicators will take place. The models use the coordinate-axial representation of the potential of an object in the form of a tuple of states characterizing a trend and a series of benchmarks reflecting the prospects of the potential of products, technical systems or technological systems (figure 3).
Figure 3. Representation of sets of values characterizing the potential of products, technical systems or technological systems.

In terms of technology, the assessment of the degree of progressiveness of the technologies used is a rather difficult task, implemented in the framework of the study of a parametric series based on preferably numbers. The distance between the reference points of the preferred numbers can make a judgment about the potential of the product under study; on the scale of relations, the gap interval can be visualized.

The concept of functionally sufficient and functionally necessary characteristics is reduced to the following implementation conditions: the sufficiency of the resource base for operation in the specified modes of the equipment, the presence of employees serving the equipment, the competence of operators who directly perform the target work. All complex components have an impact on the drift of the numerical characteristics of products, technical systems or technological systems. Figure 3 shows a set of values characterizing the potential of products, technical systems or technological systems, which are characterized by the results of the scale presented in table 1.

Table 1. Scale of changes in the potential of the investigated products.

| Value | Designation | Name of changes         |
|-------|-------------|-------------------------|
| 0.2   | Q1          | Modification            |
| 0.4   | Q1          | Surfaceimprovement      |
| 0.6   | Q2          | Deepimprovement         |
| 0.8   | Q3          | Modernization           |
| 1.0   | Q4          | Innovation              |
| 1.2   | Q4          | Innovation              |
| 1.4   | Q5          | Innovation              |
| 1.6   | Q5          | Innovation              |
| 1.8   | Q5          | Innovation              |
| 2.0   | Q5          | Innovation              |
Other environmental factors that must be taken into account when planning changes or introducing innovations can be expressed in the form of the phenomenon of innovation lag, which occurs when the technical parameters of the device under development drift and is as follows: the expectation of technical characteristics stagnates and shifts according to the results of verification at the test phase. All such changes and events arising from the test results are well described in all foreign and domestic sources, including certain methods and ways of adjusting the test results.

4. Conclusion
The proposed approaches and methods are suitable for obtaining an evidence base for an acceptable level of operation of a device or system, as well as making a decision on the need for change. The application of these approaches can be attributed to the analysis of the possibility of upgrading products, technical systems or technological systems. Signs of advanced standardization, laid down by the results of the implemented promising standardization program operating in the 50-s or 80-s, created a deep potential for modernization even for those technical systems that are still in operation, so the need to develop new methods and approaches relevant to this day.

References
[1] GOST R ISO / IEC 15504-2:2009 2018 Information technology (IT). Process evaluation. Part 2. Assessment – Standartinform p.20
[2] Nazarevich S A, Vinnichenko A V and Kurlov V V 2020 Applicability of the reverse engineering model for unification tasks in systems engineering processes of engineering enterprises IOP Conference Series: Metrological Support of Innovative Technologies (Krasnoyarsk Science and Technology City Hall of the Russian Union of Scientific and Engineering Associations Krasnoyarsk Russia) 52076
[3] Nazarevich S A, Balashov VV, Gulevitsky A Yu and Chabanenko A V 2018 Quality assessment of drifting models of basic structures of innovative technologies Questions of radio electronics 10 109-14
[4] Korshunov G I, Balashov V V and Polyakov S L 2013 Estimation of efficiency of technological modernization of assembly and assembly production of REA Questions of radio electronics 2(2) 100-9
[5] Nazarevich S A, Urentsev A V, Kurlov V V and Balashov V V 2019 Management of development of basic structures of technological systems of machine-building production IOP Conference Series: Materials Science and Engineering. International Workshop "Advanced Technologies in Material Science, Mechanical and Automation Engineering – MIP: Engineering (Krasnoyarsk Science and Technology City Hall of the Russian Union of Scientific and Engineering Associations) 42024
[6] Semenova E G, Antokhina Yu A, Balashov V V and Smirnova M S 2020 Features of the QFD method in the development of software and hardware complexes for controlling groupings of unmanned aerial vehicles IOP Conference Series: Metrological Support of Innovative Technologies (Krasnoyarsk Science and Technology City Hall of the Russian Union of Scientific and Engineering Associations. Krasnoyarsk, Russia) 32050
[7] Batkovskiy A et al. 2019 Sustainable development of industry 4.0: the case of high-tech products system design Entrepreneurship and Sustainability Issues 6(4) 23-38
[8] Korshunov G and Polyakov S 2020 Information and thermodynamic fundamentals of cyber physical systems modeling IOP Conference Series: Metrological Support of Innovative Technologies (Krasnoyarsk Science and Technology City Hall of the Russian Union of Scientific and Engineering Associations. Krasnoyarsk, Russia) 22065
[9] Semyonova E and Makhrov N 2020 Digital transformation in product design and production Metrological support of innovative technologies. International Forum (Spb.: GUAP) p 139
[10] Lipatnikov V, Nazarevich S and Rabin A 2015 Models methods and tools for improving the
quality of training of engineering and technical personnel: Monograph (SPb.: GUAP) p 211

[11] Korshunov G and Polyakov S 2019 Creation of cyber-physical systems based on basic structures in conditions of uncertainty Journal of Physics: Conference Series. International Scientific Conference ‘Conference on Applied Physics, Information Technologies and Engineering (Krasnoyarsk Science and Technology City Hall of the Russian Union of Scientific and Engineering Associations; Polytechnical Institute of Siberian Federal University) 22034

[12] Polyakov S, Solenaya O and Markelova N 2020 Development of algorithms for the operation of PLM-system of electronic Smart Innovation Systems and Technologies 154 87-95