International Journal for Quality Research 10(4) 707–718
ISSN 1800-6450

Larisa Alexejevna Ismagilova [1]

Nadegda Aleksandrovna Sukhova

Article info:
Received 10.04.2016
Accepted 12.09.2014

UDC – 332.05
DOI – 10.18421/IJQR10.04-03

ASSESSMENT OF QUALITY OF INNOVATIVE TECHNOLOGIES

Abstract: *We consider the topical issue of implementation of innovative technologies in the aircraft engine building industry. In this industry, products with high reliability requirements are developed and mass-produced. These products combine the latest achievements of science and technology. To make a decision on implementation of innovative technologies, a comprehensive assessment is carried out. It affects the efficiency of the innovations realization. In connection with this, the assessment of quality of innovative technologies is a key aspect in the selection of technological processes for their implementation. Problems concerning assessment of the quality of new technologies and processes of production are considered in the suggested method with respect to new positions. The developed method of assessing the quality of innovative technologies stands out for formed system of the qualimetric characteristics ensuring the effectiveness, efficiency, adaptability of innovative technologies and processes. The feature of suggested system of assessment is that it is based on principles of matching and grouping of quality indicators of innovative technologies and the characteristics of technological processes. The indicators are assessed from the standpoint of feasibility, technologies competiveness and commercial demand of products. In this paper, we discuss the example of implementing the approach of assessing the quality of the innovative technology of high-tech products such as turbine aircraft engine.*

Keywords: *innovations, innovative technologies, quality of technological processes, technological risks*

1. Introduction

Aircraft industry development is one of the key problems of ensuring defense potential. The processes of manufacturing and management of designing and producing aircraft engines in a batch and small-batch production are focused on the integration of the latest achievements of science and business process management techniques (Pekovic and Galia, 2009).

When creating a new generation of aircraft engines, high reliability, quality, technology and technical and economic characteristics of the products are required (AS9100C, 2009; Seth *et al*., 2005). The basis for achieving increased requirements is the development and implementation of

[1] Corresponding author: Larisa Alexejevna Ismagilova
email: ismagilova_ugatu@mail.ru

effective and innovative technologies (Krivokapic *et al.*, 2012). Selection of processes implement innovative technologies by the key criteria of quality processes is also important (Perdomo-Ortiz *et al.*, 2006). These criteria are the efficiency, economy and productivity.

Assessment of innovative technology from the perspective of its feasibility in technology and business processes will allow resolving the contradiction between the possibilities of innovative technologies, demand for these opportunities in the industry and targeted technical and economic indicators of the product, which are formed on the stages of the conceptual design of a new aircraft engine.Conceptual design of the new engine meets the legislative requirements and shall ensure the production of competitive products. The steps of this projection may be shaped by, first, competitive environment, and secondly, technological and business processes to achieve these requirements in the product, and thirdly, the level of development of innovative technology in the industry (Stadnicka and Antosz, 2015).

Assessment of quality of innovative technologies is a complex characteristic and allows reconciling the conflicting requirements for different levels of management processes and different target orientation (Fonseca, 2015; Larson and Kerr, 2007; Prajogo and Sohal, 2004; Singh and Smith, 2004). The selection of innovative technologies from the standpoint ofindustry requirements of innovation performance is realized by using the suggested methodology for assessing the quality level of innovative technology.

The technological advantage of the country is based on the development and implementation of innovative technologies contributing to the emergence of a new, technologically advanced products (Ismagilova and Gileva, 2003). The relevance of developing methods for assessing the quality of innovative technologies and processes of their realization is determined by the specific features of the production of aircraft engines at the present stage.

2. Problem of selection of innovative technologies

To achieve competitive advantage engines and provide the required characteristics can be used innovative technologies developed in high-tech industries and in the manufacture of engines (Russian State programme: Aviation Industry Development, 2012). The production of new systems and new generations of products is possible only on the basis of new technologies.

The importance of innovative technologies for the development of industry and enterprises is determined by the set of indicators that reflect the properties of technology, its feasibility and technical and economic efficiency (Vasilkov and Gushina, 2014). The selection of innovative technologies in accordance with the system of quality indicators is important complex technical and economic problem.

To solve the problem of selection of innovative technology that provides increased performance requirements for aircraft engines,comprehensive approach to assessing the quality of innovative technologies is suggested for selecting the most promising options on the basis of multidimensional comparative analysis (ISO 9004, 2009).

The concept of "quality of innovative technology" is introduced as a reflection of resolving contradictions between the objectives of technological development and the technical and economic, industrial and technological, organizational and managerial resource constraints.

There are a number of characteristics of innovation, but a system of performance indicators characterizing the quality of innovative technologies used in the

manufacture of aircraft engines, is not formed.

Methods of determining the quality of the technology described in the relevant technical literature, are unidirectional and are aimed at solving specific problems (Fedyukin, 2013). It makes difficult the combining them into a single methodology for assessing the quality of innovative technologies.

Let us introduce the basic concepts and definitions related to the quality of innovative technologies.

It is known that innovation is the final result of creative activity, were embodied in the form of new or improved products or technologies, practically applicable and able to meet specific needs (Zivkovic *et al*., 2015). Innovation must possess novelty, feasibility (compatibility with existing practice and technological structure), commercial demand (ability to meet the specific needs of consumers), and the effectiveness (economic, technical, technological, social), which is necessary for the reproduction of the innovation process.

Innovative technology is unique solutions aimed at the development of existing or creation of principally new technical and technological solutions in industrial activity, allowing to achieve in the short term competitive advantages of the product.

According to these definitions, the quality of the innovative technology is the set of technology specifications related to its ability to satisfy stated or implied claims to the quality of products and technological processes of its producing.

For dynamic high-tech industries, which include the production of aircraft engines, innovative design is most often directed to the use of new technologies (Weinstein *et al*., 2009). Determination and selection of the most appropriate technology is although conventional, but very responsible process.The selection should be based on a detailed analysis and comparative assessment of alternative proposals according to the indicator of quality of innovative technologies.

3. The development of innovative technology assessment model

The proposed structure of indicators to assessment of innovation reflects the basic properties of innovation and combines such complex factors as the novelty of the technology, the industrial feasibility, the commercial demand, universally significant effect. Each of these indicators characterizes the separate stages of the creation of high-tech products with high technical and technological characteristics and satisfactory economic results.

The structure and relationship of indicators of quality of formation of integral assessment of innovative technologies are presented on Figure 1.

The novelty of the innovative technologies is assessed at the commercial aspect and also scientific and technical ones.

The industrial feasibility of innovative technologies is considered in time aspect, resource aspect, scientific and technical aspect.

The commercial demand for innovative technology determined by the possibility of implementation in the production and release of new products in required quantities, as well as accordance of innovative technology to the needs of market participants.

The universally significant effect of the innovative technology is defined by the cost of the creation of innovative technology and the benefits resulting from its implementation.

One type of technological innovation is a priority innovations that are important to the economic and technological security. Another kind is commercial innovations, which are needed for the development of the enterprise. Therefore, innovative technologies assessment criteria shall correspond to the requirements of the

scientific and technical public policy, commercial feasibility.

Assessment of the innovation effectiveness of industry according to key innovative technologies is based on the concepts of "quality of innovative technology" and "quality of the process."

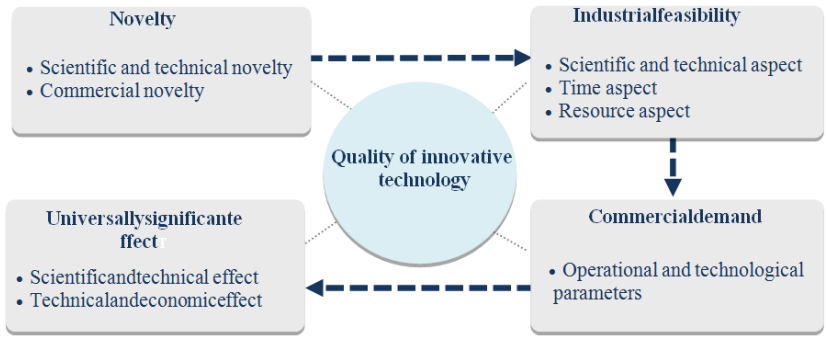

Figure 1. Correlation of indicators of quality of innovative technologies

Comprehensive assessment of quality of innovative technologies is a key aspect in the development of innovation effectiveness of industry.The effectiveness of an innovative product depends on matching of innovative technologies to existing and forecasted production processes.

For successful implementation ofinnovative technologies, it is necessary to select an adequate technological solution and the corresponding level of organization and production (Yuriev *et al*., 2013). Analysis of the level of innovative technology requires not only investigation of novelty and efficiency, but also study of such important features as the ability to adapt, and production flexibility.Assessment of the quality of innovative technologies shall be agreed with the assessment of the quality of the technological process in real production conditions.

The quality of the process is characterized by its efficiency, effectiveness, adaptability and technological risks that are set in the international standards ISO 9000, the AS 9100. Scheme of assessment of the quality of the technological process is shown on Figure 2.

Figure 2. Scheme of assessment of quality oftechnological process

The efficiency of the technological process of manufacturing products with high level of output characteristics is the degree of achievement of predetermined characteristics and results. The effectiveness of the technological process is determined by the degree of utilization of resources. The adaptability of the process reflects the flexibility to changes in production volume. Technological risk is a combination of the probability of occurrence of an unacceptable situation and potential adverse effects.

For the solving the problem of selection of the most perspective innovative technologies, it is important to assess their relevance for the development of the industry and their usefulness to the enterprise. A distinctive feature of the model of assessment of the quality of innovative technology illustrated on Figure 3, is a set of indicators at the level of the industry (Phase I) and at the enterprise level (Phase II).

The suggested approach to assessing the quality of the innovative technology allows to justify the selection of the most perspective technology on industry enterprise. Using multivariate comparative analysis of innovative technology features will increase the feasibility of the technical decisions. Best in quality, innovative technology ensures the effectiveness of innovative development as an enterprise that implements this technology, and the industry as a whole. Manufacturing aircraft engine with prescribed competitive technical characteristics in terms of optimal use of resources is the final target result of the realization of innovative technologies.

According to the developed model of complex assessment of the innovative technology, each phase involves the assessment of technology innovation from the perspective of the relevant innovation criteria.

Novelty is the first criterion of innovations. As an indicator, which characterizes the novelty of assessed innovative technologies, the level of commercial and scientific and technological novelty. Investigation of trends of technological development, on the basis of patent information, allows to assess the level of developed innovative technologies, identify alternative scientific and technical directions, identify qualitatively new ways of creating innovations, which are correspond to the best world achievements.

The second criterion istheindustrial feasibility of innovations, i.e. compatibility with past practice and technological production structure. The indicators characterizing the possibility of practical implementation of innovative technologies, guaranteeing the release of technologically advanced products, are the indicators of the innovation potential of enterprises in the industry. Assessment of industrial feasibility on the basis of analysis of scientific and technical capacity allows to investigate the possibility of achieving the prescribed properties (technical, technological, operational, etc.) of product. Assessment of the industrial feasibility based on analysis of the time aspect allows exploring the possibility of the works and measures on implementation of the technology in a timely manner according to the regulatory technological cycles of research and development activities (R&D) and manufacture. Assessment of the industrial feasibility based on resource potential analysis allows exploring the scope of ensuring the implementation of the technology by all necessary kinds of economic resources including financial, material, labor, and manufacturing.

The third criterion of innovation is commercial demand, i.e. ability to meet the specific needs of consumers.The indicators characterizing the commercial demand for the implementation ofinnovative technologies are the operational and technological parameters.

The fourth criterion of innovation is universally significant effect is obtained when reproducing innovative technologies. Determination of the effect of the innovative

technology is implemented by the system of indicators of scientific and technical and techno-economic effects. A assessment of scientific-technical and technical-economic effect is carried out in two directions, which are the effects in the sphere of production and the effects in operation.

The cost of manufacturing products by the innovative technology, percentage of cost reduction, the level of technology according to the cost of production, cost savings by reducing the cost, etc. are indicators of technical and economic effect in production. Indicator of cost saving in operation can be used as an indicator of the technical and economic effect in operation. In the early stages of the design, assessment of costs of production has well-known difficulties (Irzaev, 2010). At the same time, a complex economic analysis, both in production and in operation, needs to make decisions about the feasibility of innovative technologies.

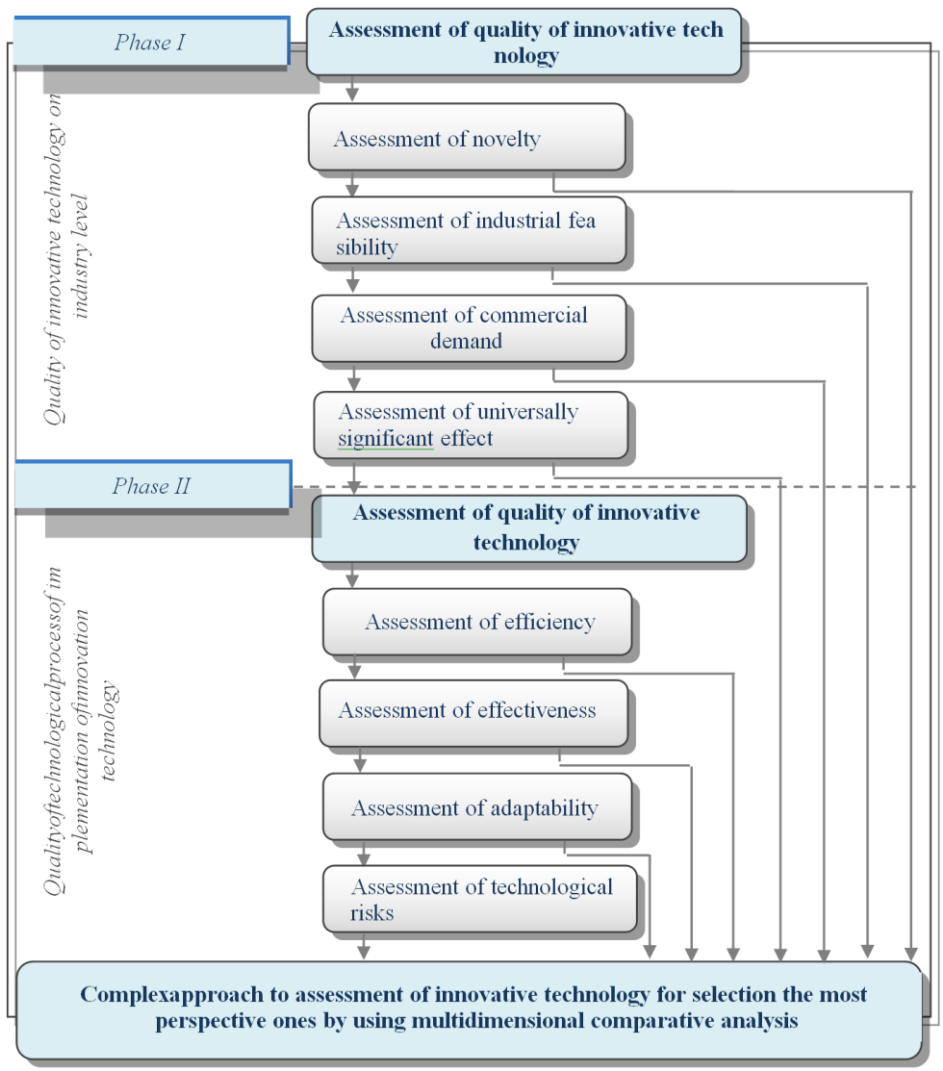

Figure 3. Model of complex assessment of quality of innovative technology

The result of the analysis is a value judgment, containing the value of the criteria that characterize the level of quality alternatives innovative technologies and the level of quality of technological processes of their implementation.

4. Assessment of quality of innovative technology of producing a hollow wide chord fan blade

The developed model of assessing the quality of innovative technology isused for comparative assessment of technologies in design and production of a hollow wide chord fan blade (HWCFB) of aircraft engine is shown on a Figure 4.

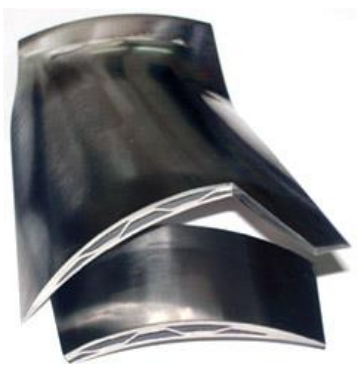

Figure 4. Hollow wide chord fan blade

The innovative technology of producing the HWCFB is based on using the methods of diffusion welding (DW) and super plastic deformation (SPD).

On phase of industry level of assessing the innovative technology quality with the SPD and the DW methods, the assessment is realized by comparison with prototype technology. The prototype technology is the technology of producing the titanium solid blade.

The innovative technology novelty assessment is realized in commercial, scientific and technical aspects. The level of commercial novelty of innovative technology is determined by expert methods according to such valid indicators as prospects of using the results, scope of results implementation and results completeness.

Engineering estimate of innovative technology novelty is higher by 45.8% than the similar assessment of novelty of prototype technology. Thus, prototype technology is less perspective in respect to innovative technology novelty assessment.

The assessing industrial feasibility of innovative technology of producing the HWCFB is realized by the level of complexity of manufacturing and materials for producing theHWCFB.

Despite the high complexity of manufacturing and labor-intensive production of the blade, the labor-intensity of innovative producing the HWCFB is reduced by 14,64%, the material consumption of innovative producing the HWCFB is reduced by 40%.

Assessment of commercial demand of innovative technology of producing the HWCFB is realized by achieving the operational and technological indicators required in conceptual modeling (Figure 5).

The results of calculation of the operational and technological indicators of implementation of prototype technology and innovative technology of producing the HWCFB with the SPD and the DW methods is shown on Figure 6.

Engineering estimate of the commercial demand of innovative technology is higher by 22.8% than the commercial demand assessment of prototype technology.

Assessment of universally significant effect of technology of producing the HWCFB is realized by the system of indicators shown on Figure 7.

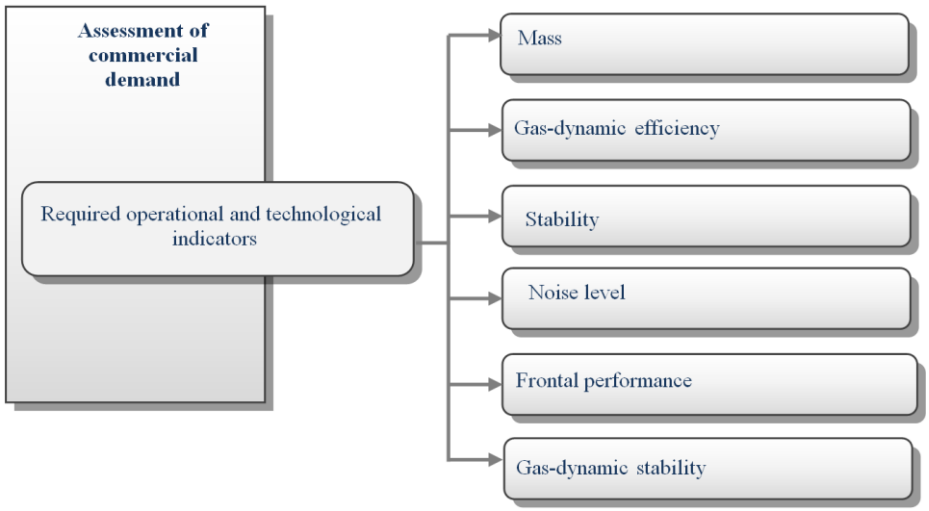

Figure 5. System of indicators of assessing the commercial demand of HWCFB production technology

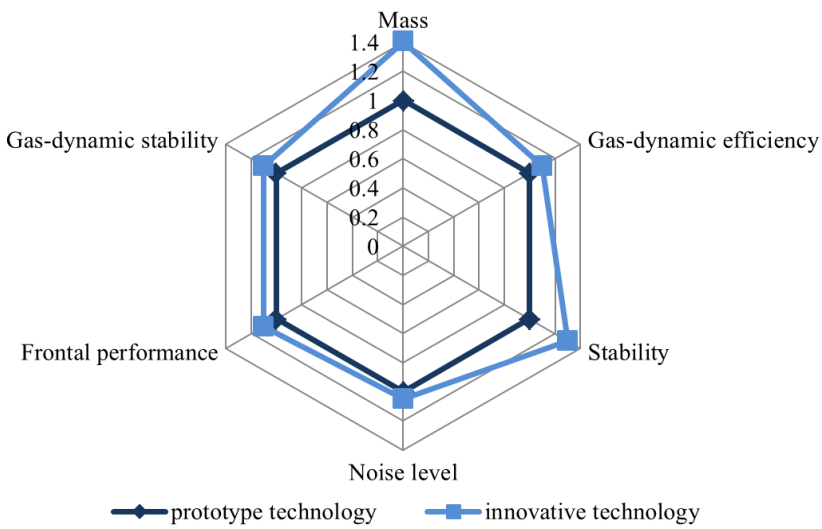

Figure 6. Comparison the operational and technological indicators of technologies of producing the HWCFB

Assessing the effect of technology of producing the HWCFB with the SPD and the DW methods in manufacture and operation shown the possibility of reducing costs by 5-15% in manufacture and by 24% in operation with respect to prototype technology.

Thus, according to all indicators for assessing the quality on industry level, innovative technology of producing the HWCFB with the SPD and the DW can be recommended for distribution in aviation industry enterprises.

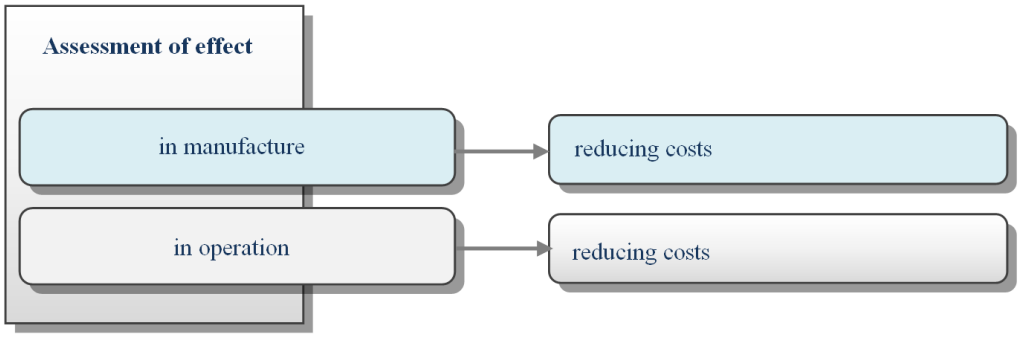

Figure 7. System of indicators for assessing the effect of technology implementation

In phase II of model of assessing the quality of innovative technology, the quality assessing is realized according to efficiency, effectiveness, adaptability and technological risks. The efficiency of technological process is assessed by the technical level of process and operational indicators of product. The effectiveness of technological process is estimated by time and resources. The technological risks of implementing the technology of producing the HWCFB are estimated by indicator, which is reverse to total probability of release of nonconforming products.

The assessment procedure compares two versions of innovative technology implementation process, which differs in the order of operations and their number. Results of this assessment are presented in Table 1.

Table 1. Assessment of technical level of process of producing the HWCFB

Indicators of technical level of process	**Value of indicator**	
	process 1 (TP 1)	**process 2 (TP 2)**
The level of progressive technological operations	0,58	0,57
The level of progressivity of the parts	0,12	0,085
The level of progressive equipment	0, 705	0,667
The level of progressivity snap	1	1
The technical level of the technological process*	0,60	0,58

*The numerical value of indicator of unit properties group is obtained by differential method of quality control, i.e., as the average value of their values.

Table 2. Assessing the quality of technological process of producing the HWCFB

Quality indicators	**Valueofindicator**	
	process 1 (TP 1)	**process 2 (TP 2)**
Efficiency		
Technical and operation indicators (TOI)	0,97	0,62
Technical level of processТП (TLTP)	0,60	0,58
Effectiveness	0,83	0,56
Adaptability	0,70	0,10
Technological risks*	0,52	0,32

*The indicator, which is reverse to total probability of release of nonconforming products

Results of assessing the quality of technological process of producing the HWCFB are presented in Table 2.

Results of assessing the quality of technological process for the most perspective technology selection using the multidimensional comparative analysis of innovative technology of producing the HWCFB with the DW and the SPD methods are presented on Figure 8.

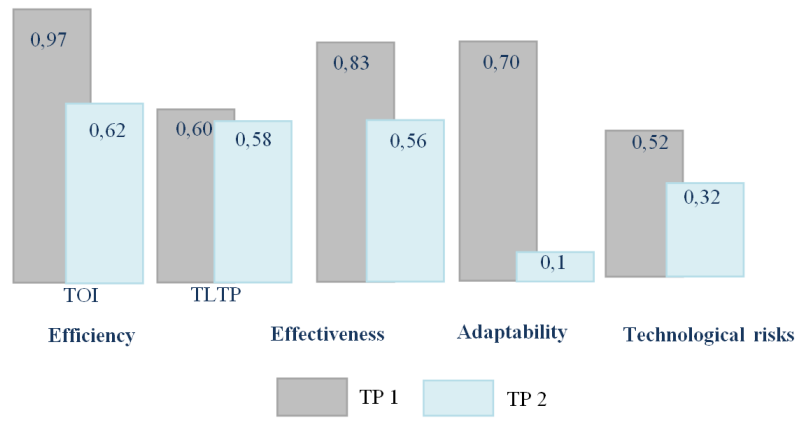

Figure 8. Comparison of alternative processes of implementation of innovative technology of producing the HWCFB

The set of characteristics of quality of technological processes of innovative technology implementation reflects the effectiveness of the complex of research, development, technological and management problems of creating the new product of required scientific and technological level in required output and by a target date in conditions of existing resource constraints.

5. Conclusions

The article discusses the results of assessing the innovative technology quality in aircraft engine manufacture. Innovative technology quality assessment is a complex characteristics of coordination of conflicting requirements to processes of different level of management and different target orientation. The selection of innovative technology from the stand point of industry innovative efficiency can be carried out using the suggested model of innovative technology quality level assessment. The developed model is especially important as a method of managing the innovative efficiency of high-tech aircraft engine manufacturing industry.

The feature of suggested approach is the use multidimensional comparative analysis including the indicators of innovative technology quality and the indicators of technological processes quality. The set of indicators of the quality of innovative technologies reflects the technological properties of the system as a whole, including the infrastructure, system control and management of business processes and the level of competence of staff.

The developed model of assessment of quality of innovative technology is based on the system of indicators that characterize the novelty, feasibility, commercial demand and universally significant effect. The segeneralized indicators assess the overall innovative effectiveness of processes of design and manufacturing the products of aviation industry.

Calculations for the assessing the quality of innovative technology of producing the hollow wide chord blade with using the diffusion welding and the super plastic deformation and calculations for comparison of quality of alternative technologies are presented.

The obtained data confirm the importance end effectiveness of developed model for management of production and business processes, for design and manufacture of aircraft engines to achieve the industry innovative efficiency. Further empirical evidence on lifecycle quality, implementation methodology, relationship between manufacturers and customers for different types of the products and sectors will be the areas where future research should concentrate to enhance the development of the concept. Moreover, practical application of this principle may also be a future research direction to be considered.

References:

AS9100C (2009). *AS 9100C/EN 9100:2009 - Quality Management Systems - Requirements for Aviation, Space and Defense Organizations*. SAE International.

Fedyukin, V. (2013). *Management of quality of technology processes* (1st ed.). Moscow, Russia: KNORUS.

Fonseca, L. (2015). From Quality Gurus and TQM to ISO 9001:2015: A review of several quality paths. *International Journal for Quality Research, 9*(1), 167-180.

Irzaev, G. (2010). *Expert control techniques of manufacturability of industrial products*. Moscow, Russia: Infra-Engineering.

Ismagilova, L., & Gileva, T. (2003). Control of development of modern enterprises: problems and prospects. *Economics and Management, 2*, 16-22.

ISO 9004 (2009). *Managing for the sustained success of an organization – A quality management approach*. Geneva, Switzerland: International Organization for Standardization.

Krivokapic, Z., Vujovic, A., Jovanovic, J., Pekovic, S., & Petrovic, S. (2012). The influence of QMS on development of innovation. In *7th International conference ICQME 2012 (Quality, Management, Environment, Education, Engineering)* (pp. 265-274). Tivat, Montenegro: Faculty of Mechanical Engineering, University of Montenegro.

Larson, P., & Kerr, S. (2007). Integration of Process Management Tools to Support TQM Implementation: ISO 9000 and Activity-based Costing. *Total Quality Management & Business Excellence, 18*(1-2), 201-207.

Pekovic, S., & Galia, F. (2009). From Quality to Innovation: Evidence from French Employer Survey. *Technovation, 29*(12), 829-842.

Perdomo-Ortiz, J., González-Benito, J., & Galende, J. (2006). Total quality managementas a forerunner of business innovation capability. *Technovation, 26*(10), 1170-1185.

Prajogo, D.I., & Sohal, A.S. (2004). The multidimensionality of TQM practices in determining quality and innovation performance—an empirical examination. *Technovation, 24*(6), 443-453.

Russian State programme: Aviation Industry Development, 2. (2012). State programme: *Aviation Industry Development, 2013-2025. Government.ru*. Retrieved 7 November 2016, from http://government.ru/en/docs/3347/

Seth, N., Deshmukh, S.G., & Vrat, P. (2005). Service Quality Models: a Review. *International Journal of Quality & Reliability Management, 22*(9), 913-949.

Singh, P.J., & Smith, A. (2004). Relationship between TQM and innovation: An empirical study. *Journal of Manufacturing Technology Management, 15*(5), 394-401.

Stadnicka, D., Antosz, K. (2015). Continuous Improvement Practice in Large Enterprises: study results. *International Journal for Quality Research, 9*(1), 9-26.

Vasilkov, Y., & Gushina, L. (2014). Analysis of the effectiveness and efficiency of management systems based on system analysis methodology. *International Journal for Quality Research, 8*(3), 347-356.

Weinstein, L., Vokurka, R., & Graman, G. (2009). Costs of quality and maintenance: Improvement approaches. *Total Quality Management & Business Excellence, 20*(5), 497-507.

Yuriev, V., Starochkina, S., & Sukhova, N. (2013). *Control of the manufacturability of aviation gas turbine engines* (1st ed.). Moscow, Russia: Mashinostroenie.

Zivkovic, Z., Nikolic, S., Doroslovacki, R., Lalic, B., Stankovic, J., & Zivkovic, T. (2015). Fostering creativity by a specially designed Doris tool. *Thinking Skills And Creativity*, 17, 132-148.

Larisa Alexejevna Ismagilova
Ufa State Aviation Technical University,
Russia
ismagilova_ugatu@mail.ru

Nadegda Aleksandrovna Sukhova
Ufa State Aviation Technical University,
Russia
nad_suhova@mail.ru