Artículo de investigación

Simulation of production processes at aircraft building enterprises

Моделирование производственных процессов на предприятиях авиастроения

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Abstract

The effective development of productive capacities of the domestic aircraft industry was analyzed. A methodology for calculating general indicators for assessing the feasibility of production programs of the aviation industry at the level of technological limits and types of aircraft manufacturing was developed.
The application of this methodology will allow making more meaningful determination of the material consumption of new types of aviation products and the productivity of new equipment and ultimately assessing the feasibility of prospective production plans. Monitoring of the performance indicators of the domestic aircraft industry will give new impetus to research in the sphere of development, production and maintenance of science-intensive products according to their specificity. Despite the great value of scientific studies of the works of many scientists in the sphere of organization of production at enterprises, there are currently unresolved issues of an industrial and technological nature.

Keywords: Aircraft manufacturing, high-technology manufacturing, key indicators, monitoring of production processes, optimization, organization of production, production program, science-intensive products.

Аннотация

Проведен анализ эффективного развития производственного потенциала отечественной отрасли авиастроения. Разработана методика расчета обобщающих показателей оценки реализуемости производственных программ авиационной промышленности на уровне технологических переделов и видов авиационного производства.
Применение такой методики позволит более обоснованно определить материалоемкость новых видов авиационной продукции и производительность нового оборудования, и, в конечном счете – оценить реализуемость перспективных производственных планов. Мониторинг производственных показателей отечественной отрасли авиастроения сможет дать новый импульс к исследованиям в области организации разработки, производства и обслуживания наукоемкой продукции с учетом ее специфики. Несмотря на большую ценность научных исследований трудов целого ряда ученых в области организации производства на предприятиях, в настоящее время имеются нерешенные проблемы промышленно-технологического характера.

Ключевые слова: авиастроение, высокотехнологичное производство, ключевые показатели, мониторинг производственных процессов, наукоемкая продукция, оптимизация, организация производства, производственная программа.

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Introduction

Currently, the development of methods for monitoring the development of productive capacities is an urgent problem for any aircraft manufacturing enterprise. According to the authors, it is important to introduce a set of estimated figures that are calculated with a high degree of accuracy and should be used to analyze enterprises' effectiveness. An important step in optimization of the organization of production in creating science-intensive products at aircraft manufacturing enterprises is improvement of the quality of performance indicators, which include a set of indicators of production and output volumes of science-intensive products. The introduction of such indicators at enterprises and their monitoring will enable to timely determine the need for industrial transformations in science-intensive industries in order to optimize enterprises. The application of methodology for assessing the feasibility of production programs at aircraft manufacturing enterprises will enable determining the dynamics and ranges of competitiveness of science-intensive products and increasing the level of productive capacities of these enterprises.

In order to develop an assessment of the feasibility of production programs at aircraft manufacturing enterprises, it is necessary to use a common conceptual framework and methodological tools to assess their competitiveness. The range of its definitions indicates the complexity of this economic category and the possibility of the diverse study (Adler, 2007; Kim, MacDuffie, Pil, 2010; Batkovsky, Kalachanov, 2017). Much attention in the world literature is now paid to the issues of improving the competitiveness of aircraft manufacturing enterprises and the aviation industry as a whole.

Materials and methods of tasks, accepted assumptions

Today aviation industry provides the intellectual content of aircraft weapons and military equipment, which makes up a significant share in the total value of produced aircraft products.

The main problems characterizing the current state and operating conditions of aircraft manufacturing enterprises may include the following: insufficient budget funding for state defense orders, underutilization of production capacities, and significant restriction of the enterprises' autonomy on the international market by the state.

Today, the main strategic objectives of the development of the aviation industry, including aircraft manufacturing, are as follows:

1. Implementation of systemic planning of design and production processes of science-intensive defence products, including military equipment and its components, of industrial technologies design and rational production cooperation.

2. Significant reduction of the accumulated technological lag, including through comprehensive technical re-equipment of existing modern industries and the creation of new ones (Manturov, Efimova, 2012; McNamara, 2018).

3. Decreasing unit costs by reducing excess capacities, rational specialization of enterprises, including through creation of intersectional holding technology centers, additional capacities loading through civilian products and creating a cooperative cost management system.

4. Phased transition to modern information technology of design, organization of production and maintenance of products made by aircraft manufacturing enterprises (De Sousa Damiani, 2016; Morrissey, Guarraia, Pauwels, Sampathkumar, 2016).

To achieve these objectives, it is necessary to solve the following tasks:

- Contribution to the development of globally competitive products in the aircraft industry;

- Promotion of aircraft industry products in the world market.

In modern works dedicated to the analysis of the feasibility of current and prospective production plans at the level of a separate machine-building enterprises and manufactures, it is suggested that the following model should be used (Panahifar, Byrne, Heavey, 2014; Knutstad, Ravn, 2014; Nikezić, Dželetović, Vučinić, 2018). Suppose an enterprise can produce types of products indicated by indices $i = 1, 2, \dots n$. Various types of productions (e.g. blank production, mechanoprocessing manufacture, welding, etc.) indicated by indices $j = 1, \dots m$, participate in the output of products. Let us introduce the following notation keys: $q^i(t)$ is the output of the production of q type in a year t, a_j^i, $i = 1, 2, \dots n$, $j = 1, \dots m$ is a technological factor of material consumption that indicates how many units of a j production (e.g. tons of casting, square meters of coatings, etc.) are needed to output a unit of product of an i type. It is supposed to be stable for a long time, since its value is conditioned by the design and production technology of this type of product. Thus, with given final outputs it is possible to estimate the total output of separate production of a given enterprise in a year $t\{q_j(t)\}$; $j = 1, \dots m$ by summing up the production volumes necessary for the production of all types of final products:

$$q_j(t) = \sum_{i=1}^{n} a_j^i \cdot q^i(t), j = 1, \dots m. \quad (1)$$

For any high-technology production, this total output is subject to a capacity limit:

$q_j(t) \le V_j(t), j = 1, \dots m$, where $V_j(t)$ is the capacity of a j production in a year t.

We can estimate the capacity utilization of a j production of a given machine-building enterprise in a year t by the following formula:

$$k_j(t) = \frac{q_j(t)}{V_j(t)}, j = 1, \dots m. \quad (2)$$

For any type of production of a given aircraft building enterprise at any moment of time, the factor of capacity utilization cannot exceed 100%.

The following restrictions are imposed on the output program for various types of products (assuming the linearity of the technology, i.e., the constancy of technological factors they are a system of linear inequalities):

$$\sum_{i=1}^{n} a_j^i \cdot q^i(t) \le V_j(t); j = 1, \dots m. \quad (3)$$

Let $N_j(t)$ be the number of equipment units of a j production in a year t. We can estimate the average natural productivity of an equipment unit of a j production:

$$v_j = \frac{V_j(t)}{N_j(t)}, j = 1, \dots m. \quad (4)$$

On the basis of investment programs for the development of the material and technical base of the enterprise we can estimate the increase in the production capacity of a j production in a year t :$V_j^+(t) = v_j \cdot N_j^+(t); j = 1, \dots m$, where $N_j^+(t)$; $j = 1, \dots m$ is the planned increase in the number of equipment units of a given production type in a year t.

Values of the average productivity of an equipment unit can be obtained in practice by taking one of the past years t as the base (or by averaging the corresponding data for several past years), and assuming that in the future these specific values will not change significantly:

$$v_j \approx \frac{V_j(t_0)}{N_j(t_0)}, j = 1, \dots m. \quad (5)$$

In projecting the dynamics of production capacities estimating the volumes of fixed assets disposals poses a difficult issue. As a rule, the following simplifying hypothesis is accepted: the output of new types of products is possible only on a new physical infrastructure, due to more stringent requirements for the quality of production processes, the need to implement progressive technologies, etc. Thus, the current production capabilities of enterprises for the output of new products are determined precisely by availability of new equipment (with a period of use for a maximum of five years, according to the most frequently used accounting rules). At the same time, during the planning period typical for medium-term prospective production plans of the industry (within 10 years), a massive disposal of new equipment is unlikely. With regard to long-term plans (for more than 10-15 years), a detailed forecast for such a duration is unlikely to be reliable, an estimate of the total planned investment volumes for physical infrastructure provision would suffice (Pokrajac, Nikolić, Filipović, 2016; Radu, 2018).

So, without taking into account the disposal of new equipment, the balances of its quantity and capacity for each type of production and for each next year of the planning period $t = 1,2,3,\ldots T-1$ (year t = 1 is current) can be written as follows:

$$N_j^{new}(t+1) = N_j^{new}(1) + \sum_{s=1}^{t} N_j^{+}(s), \qquad (6)$$

where $V_j^{new}(t+1) = V_j^{new}(1) + \sum_{s=1}^{t} V_j^{+}(s), j = 1,\ldots m, t = 1,2,\ldots \mathrm{T}-1.$

Next, it is necessary to estimate the capacity level of each type of production of a given type of high-technology machine-building enterprise for each year of the planning period required to implement a prospective program for new products. It is determined by the planned labour intensity of the production program for a given production in a year t, $q_j^{new}(t)$ (in terms of the output of new generation products). This, in turn, can be estimated on the basis of the aggregated material consumption of new productsa_j^{new}, which can be approximately determined by comparison of the following values in the selected base yeart_0:

- Output of new generation products $q^{\mathrm{new}}(t_0)$;
- Labour intensity of the production program for a *j* production in terms of the output of new generation products $q_j^{new}(t_0)$.

The latter value cannot be determined on the basis of an enterprise data. It can be estimated approximately by multiplying the total labour intensity of the production program for a *j* production $q_j(t_0)$by the share of new products (which is considered as an aggregate) in the general production program of the enterprise in the base year. Based on an enterprise data, this share can be estimated as follows:

$\alpha_{\mathrm{new}}(t_0) = \frac{q^{new}(t_0)}{q^{\Sigma}(t_0)}$ – in physical terms, or $\alpha^{new}(t_0) = \frac{Q^{new}(t_0)}{Q^{\Sigma}(t_0)}$ – in value terms, which is probably more correct due to the variety of products and the possible incomparability of their natural volumes. Here, $q^{\Sigma}(t) = \sum_{i=1}^{n} q^i(t)$; $Q^{\Sigma}(t) = \sum_{i=1}^{n} Q^i(t) = \sum_{i=1}^{n} p^i(t) \cdot q^i(t)$ are total production volumes, where $q^i(t)$and $p^i(t)$, respectively, are the natural output and unit price of a unit of product of an *i* type in a year *t*.

Thus, the labour intensity of the production program for a *j* production in terms of the output of new generation products in a base year can be determined as follows:

$$q_j^{\mathrm{new}}(t_0) = \alpha^{\mathrm{new}}(t_0) \cdot q_j(t_0) = \frac{q^{\mathrm{new}}(t_0)}{q^{\Sigma}(t_0)} \cdot q_j(t_0), j = 1,\ldots m, \qquad (7)$$

So, the required level of new equipment capacities of a *j* production in a year *t* can be estimated by the following formula:

$$a_j^{new} = \frac{q_j^{new}(t_0)}{q^{new}(t_0)} = \alpha^{new}(t_0) \cdot \frac{q_j(t_0)}{q^{new}(t_0)} = \frac{q_j(t_0)}{q^{\Sigma}(t_0)},$$

$$j = 1,\ldots m. \qquad (8)$$

So, the required level of new equipment capacities of a j production in a year t can be estimated by the following formula:

$$V_j^{req}(t) = a_j^{new} \cdot q^{new}(t), j = 1,\ldots m, t = 1,2,\ldots T. \qquad (9)$$

By comparing the planned level of production capacity in a year *t* (with a given program for commissioning of the new equipment$\{N_j^{+}(t)\}$) with the level of production capacity required for the production program$V_j^{req}(t)$, we can conclude on the sufficiency of the capacity level of specific productions of a given enterprise for the successful implementation of production plans (Rolfsen, Langeland, 2012; Sparrow, Cooper, 2014).

In fact, all of the above estimates of the required number of equipment fleets and the feasibility of production programs of enterprises are based on the following important assumptions: the basis of prospective production plans is formed by the new generation products; new products are produced only with the new equipment which is in working order within the planning period; the productivity of new equipment, as well as the aggregate material consumption of new generation products, are reasonably estimated on the basis of the current data and extrapolated to the entire planning period (Lee, 2011; Li, Bai, Xiang, Xie, 2017).

At the same time, the estimation of the current volume, cost, capacity and productivity of new equipment is a particular problem. At first glance, it is enough to estimate the share of relatively modern production equipment in the total fleet of equipment on the base of an enterprise data, compare it with the current production capacity in general and determine its capacity by the following formula:

$$V_j^{new}(1) = V_j(1) \cdot \frac{N_j^{new}(1)}{N_j(1)} = \frac{q_j(1)}{k_j(1)} \cdot \frac{N_j^{new}(1)}{N_j(1)} = v_j^{new} \cdot N_j^{new}, j = 1, \dots m. \quad (10)$$

The productivity of new equipment for a given production is accordingly defined as the ratio of the capacity of new equipment to its number:

$$v_j^{new} = \frac{V_j^{new}(1)}{N_j^{new}(1)} = \frac{V_j(1)}{N_j(1)} = \frac{q_j(1)}{k_j(1)} \cdot \frac{1}{N_j(1)} = v_j, \quad (11)$$

$j = 1, \dots m$, that is, the average productivity of new equipment is considered to be equal for the entire fleet of equipment of a given production in general (and it is impossible to make other estimates without information on the load on the equipment, differentiated by age groups). However, such estimates will be incorrect, or rather, understated for the following reasons (Vonortas, Zirulia, 2015; Efimova, 2015):

1) New technologies and types of equipment increase labour and capital productivity and it is quite possible to provide greater output of the products with fewer equipment units.

2) Industry is fundamentally restructuring, and this process has not yet been completed. As a result, specialized high-technology industries should be formed that produce individual components or perform certain technological operations to create final products. Such subject or technological specialization also increases the efficiency of equipment use, as shown above (Lyu, Wang, Ren, Feng, Zhao, 2016).

Similarly, in the methodology described above, it is considered that the material consumption of the production of a new generation products for each type of production are equal to the average ones for the entire range of products. Since the labour intensity of the production program for a j production in terms of the output of new generation products was estimated as the product of the total labour intensity of the production program for a given production and the share of new products:

$$a_j^{new} = \frac{q_j^{new}(t_0)}{q^{new}(t_0)} = \alpha^{new}(t_0) \cdot \frac{q_j(t_0)}{q^{new}(t_0)} = \frac{q_j(t_0)}{q^{\Sigma}(t_0)} = a_j, j = 1, \dots m \quad (12)$$

However, such an assumption can also be fundamentally incorrect. The transition to the output of new science-intensive equipment is associated with significant structural changes in terms of the technologies used and the relative contribution of various productions. It would be possible to estimate the aggregate material consumption of new generation products more correctly (without recourse to the assumption $q_j^{new}(t_0) = \alpha^{new}(t_0) \cdot q_j(t_0)$, described above, which heavily distorts the results) if information were available on the labour intensity of the production program for each production of a given enterprise in terms of new product output $q_j^{new}(t_0)$. Theoretically, if there are reported data for the past few years, and the material consumption factors for each product group ("transitional" and new generation) are stable, their values can be estimated using the following linear regression model (Batkovskiy, Fomina,, Batkovskiy,, Klochkov,, Semenova, 2016; Chursin, Drogovoz, Sadovskaya, Shiboldenkov, 2017):

$$q_j(t_{base}) = a_j^{new} \cdot q^{new}(t_{base}) + a_j^{trans} \cdot q^{trans}(t_{base}) + e_j(t_{base}), \quad (13)$$

where $\{t_{base}\}$ are years of the base period, $q^{new}(t_{base})$, $q^{trans}(t_{new})$ are aggregated outputs of "transitional" and new generation products, respectively, in a year t_{base}; $e_j(t_{base})$ is the error (discrepancy) of the *j* production model in a year t_{base}; a_j^{new}, a_j^{trans} are the factors of material consumption (of the *j* production) of new generation products and "transitional" types, respectively.

As shown above, it is possible to estimate the share of new generation products $\alpha^{new}(t)$ in the production program of the enterprise on the base of this enterprise data. It is also possible to estimate the share of relatively modern equipment (e.g. not beyond the age of 5 years) in the total number of equipment of a *j* production at a given enterprise:

$$\beta_j^{new}(t) = \frac{N_j^{new}(t)}{N_j(t)}, j = 1, \ldots m. \quad (14)$$

A comparison of these shares, as well as equipment load factors for each type of production of a given enterprise, allows drawing some conclusions regarding the production technologies of products of various types, as well as the efficiency of equipment use (De Sousa Damiani, 2016).

Supposing that the entire production program of a given enterprise for this type of production is already implemented exclusively on new equipment, it is possible to get an upper estimate of its productivity as follows:

$$\hat{v}_j^{new} = \frac{q_j(t)}{N_j^{new}(t) \cdot k_j^{new}(t)}, j = 1, \ldots m. \quad (15)$$

On the contrary, supposing that the new equipment is used only for the production of new generation products, it is possible to get a lower estimate of its productivity:

$$\breve{v}_j^{new} = \frac{q_j(t) \cdot \alpha^{new}(t)}{N_j^{new}(t) \cdot k_j^{new}(t)}, j = 1, \ldots m. \quad (16)$$

However, in both cases, it is necessary to know the load factors of the new equipment $\{k_j^{new}(t)\}$. As a matter of principle, with a fixed value of such an averaged factor, the load factor of new equipment can fall in a wide range – generally, from 0 to 100% (Chursin, Drogovoz, Sadovskaya, Shiboldenkov, 2017).

It is economically feasible to develop and implement standard forms for assessing the feasibility of production programs at aircraft building enterprises. Monitoring of the proposed assessment will enable to determine the level of capacities of separate production and make timely adjustments within the investment and production programs of enterprises. It is proposed to combine all types of products in two larger groups: products of a new technological level, requiring new technologies and equipment and other products.

The form 1 "Output of the products and its change" (Table 1) indicates the actual values of the output of the products of each above category (in value and physical terms) for 2015 and the planned values of output for each year of the planning period from 2017 to 2020.

Table 1. Proposed form 1 "Production output and its change"

products category (i = 1, 2)	*year (t)*	2015	2016	2017	2018	2019	2020
products of a new technological level *(i = 1)*	physical output, in units ($q^1(t)$)						
	value output, in thousands of RUB ($x^1(t)$)						
other products *(i = 2)*	physical output, in units ($q^2(t)$)						
	value output, in thousands of RUB, ($x^2(t)$)						
Relative change in output compared to 2017							
products category (i = 1, 2)	*year (t)*	2015	2016	2017	2018	2019	2020
products of a new technological level *(i = 1)*	physical output						
	value output						
other products *(i = 2)*	physical output						
	value output						

Equipment can be grouped by the type of production or combined into larger groups: main production equipment, ancillary production equipment, experimental and test-bench equipment, etc.

In its turn, the equipment within each group should be divided into the following categories: A is the equipment that allows the implementation of advanced technologies necessary for the production of a new technological level products, B is the obsolete equipment that cannot be used for the production of a new technological level products, C is the other equipment that can be used both for the production of a new technological level products and for the production of other products (Morrissey, Guarraia, Pauwels, Sampathkumar, 2016).

The actual number of equipment fleet of the above categories in 2015, as well as the integrated utilization factor of equipment of each category in 2015 are indicated in the Form 2 "Use and required number of equipment fleet" (Table 2). The integrated utilization factor of equipment includes the total one and the factor within the production program for each product category (new technological level products and other products). On the basis of this data, the minimum required number of equipment fleet of each category for each year of the planning period, from 2017 to 2020, can be calculated.

Table 2. Proposed form 2 "Use and required number of equipment fleet"

Equipment group (main production equipment, ancillary production equipment, experimental and test-bench equipment, etc.)			
equipment category (j = A, B, C)	A	B	C
number of equipment fleet in 2015, in units ($N_j(2015)$)			
integrated utilization factor of equipment in 2015 ($k_j(2015)$)			
Including within the production program:			
- new technological level products ($k_j^1(2015)$)			
- other products ($k_j^2(2015)$)			
Minimum required number of equipment fleet (for the implementation of the production program) ($N_j^{req}(t)$; *j = A, B, C; t = 2015,…2020*), in units			

year (t = 2015,…2020) \ equipment category (j = A, B, C)	A	B	C
2015			
2016			
2017			
2018			
2019			
2020			

The dynamics of the change in the number of equipment fleet is projected on the basis of the data on its condition and the adopted investment program of the enterprise. Actual volumes of launching of the equipment of each above category in 2015 (in physical terms and in value) are indicated in Form 3 "Dynamics of investments and the amount of fixed assets" (Table 3). Hereinafter, major repairs are considered for the obsolete equipment, since the purchase and launching of new equipment of a given category is impossible or ineffective.

Table 3. Proposed form 3 "Dynamics of investments and the amount of fixed assets"

Group of the equipment (main production equipment, ancillary production equipment, experimental and test-bench equipment, etc.)							
Launching of the equipment							
equipment category (j = A, B, C)	*year (t)*	2015	2016	2017	2018	2019	2020
A	in physical terms, in units ($\Delta N_A^+(t)$)						
	in value, in thousands of RUB ($\Delta F_A^+(t)$)						
B	in physical terms, in units ($\Delta N_B^+(t)$)						
	in value, in thousands of RUB ($\Delta F_B^+(t)$)						
C	in physical terms, in units ($\Delta N_C^+(t)$)						
	in value, in thousands of RUB ($\Delta F_C^+(t)$)						
Disposal of equipment in physical terms, in units ($\Delta N_j^-(t)$; *j = A, B, C; t = 2015,…2020***)**							
equipment category \ year		2017	2018	2019	2020		
A							
B							
C							
Projected number of equipment fleet ($N_j^{project}(t)$; *j = A, B, C; t = 2016,…2020*), **in units ***							
equipment category \ year		2015	2016	2017	2018	2019	2020
A							
B							
C							

Results

On the basis of the required and projected number of equipment fleet of each category obtained in Forms 2 and 3, it is possible to get an objective assessment of feasibility of the production program of the enterprise

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(in terms of providing the physical infrastructure), as well as an assessment of the need for additional investments to provide its feasibility. Form 4 "Assessment of the provision of production programs implementation and the amount of required additional activities" (Table 4) compares the required and projected number of equipment fleet and draws the conclusion on the provision of production programs implementation with a production base for each year of the planning period from 2019 to 2020 and for each of the above categories of equipment.

It is done as follows:

- If the required number of fleet of all equipment categories in a given year does not exceed the projected number, it is concluded that "the implementation of the production program is being provided";
- If the required number of fleet exceeds the projected number for at least one equipment category, it is concluded that "capacity shortage is possible".

Next, the additional amount of fixed assets required for the implementation of the production program is estimated in value terms for each year of the planning period from 2017 to 2020 and for each of the equipment categories $\Delta F_j^{+dd}(t)$:

$$\Delta F_j^{+add}(t) = \frac{\Delta F_j^{+}(2015)}{\Delta N_j^{+}(2015)} \times \left[N_j^{req}(t) - N_j^{project}(t)\right]; \ t = 2016,\ldots 2020, \qquad (17)$$

where $\Delta N_j^{+}(2015)$ and $\Delta F_j^{+}(2015)$ are physical (in units) and value (in thousands of RUB) amounts of launching of *j*-category equipment in 2015, respectively.

Table 4. Proposed form 4 "Assessment of the provision of production programs implementation and the amount of required additional activities"

equipment group (main production equipment, ancillary production equipment, experimental and test-bench equipment, etc.)						
Accounting estimate of the provision of production programs implementation with the industrial-processing base						
equipment category (j = A, B, C) \ year (t)	2015	2016	2017	2018	2019	2020
A						
B						
C						
Additional amount of fixed assets required for the implementation of the production program ($\Delta F_j^{+add}(t)$; *j = A, B, C; t = 2016,…2020*)						
equipment category / year		2016	2017	2018	2019	2020
A						
B						
C						
Integrated expert assessment of the provision of production programs implementation (in terms of the industrial-processing base)						
rate of provision / year		2016	2017	2018	2019	2020
production program for a new technological level products						
production program for other products						

The procedure for assessing the feasibility of the production program (in terms of the industrial-processing base) ends with an integrated expert assessment of the provision of production programs implementation. The assessment is carried out for each year of the planning period from 2017 to 2020 and for each of the above product categories (new technological level products and other products).

The rate of provision is indicated at the following possible levels: sufficient (even with the existing fleet of equipment, taking into account its disposal by the respective year); conditionally sufficient (subject to the implementation of the adopted investment program); low (additional activities beyond the adopted program are required; actual activities stating the amount of required additional expenses should be indicated); critical (adopted production program cannot be implemented even taking into account additional investments and adjustments are required; the reason and the necessary reduction in the production program per cent should be explained).

Discussion

1. Since the processes of technological re-equipment of production and the introduction of new technologies and equipment are crucial for the potential development of domestic aircraft manufacturing, it can be concluded that the existing structure of the statistical reporting of the enterprise does not allow determining productivity of new types of equipment correctly and accurately, and therefore, it is impossible to determine the number of the equipment fleet required for the implementation of prospective production programs and the required volumes of investment in the development of the physical infrastructure for various types of production in specific enterprises. Ultimately, this structure does not allow drawing a clear conclusion on the feasibility of production plans (in terms of provision with physical infrastructure).

2. In relation to the discovered discrepancy between the required and available volumes of the source data, it is appropriate to recommend the following: the introduction of a differentiated recording of the availability, age and acquisition of equipment by the type of production; separate record of the load factor of new equipment (not beyond the age of 5 years); separate record of the planned labour intensity of the production program for the output of new products. These data will allow determining the material consumption of new types of products and the productivity of new equipment more reasonably and, ultimately, to assess the feasibility of prospective production plans.

3. To do this, it is advisable to reduce the initial information and initial calculations to the following forms: “Production output and its change”; “Use and required number of equipment fleet”; “Dynamics of investments and the amount of fixed assets”; “Assessment of the provision of production programs implementation and the amount of required additional activities”. It is advisable to introduce the proposed standard forms of monitoring at aircraft building enterprises in the future.

Conclusion

The modern development of the Russian economy is accompanied by a globalization and increasing competition in the international markets of high-technology products. Under these conditions, the strategic vectors of Russian economic progress focus on the problem of increasing the competitiveness of science-intensive industries.

Currently, there is a development of methodological tools for effective management of production organization in high-technology industries. According to the authors, it is important to introduce a set of estimates, which are calculated with a high degree of accuracy and should be used to analyze the outcomes of the aircraft building enterprise. Improving the quality of production indicators, which include a set of indicators of production volumes and production capacities, should be an important step in optimizing the organization of production in high-technology industries. The introduction of such indicators at enterprises will provide timely determination of the need for industrial transformations in the aircraft industry in order to modernize enterprises and to reduce excess production capacities. On the basis of the methodology applied for assessing the provision of the implementation of production programs at the enterprises it can be concluded that the competitive properties of the aircraft manufacturing enterprise are increasing. It is also possible to determine the dynamics and ranges of competitiveness of science-intensive products.

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References

Adler P.S. (2007). The future of critical management studies: A Paleo-Marxist critique of labour process theory. Organization Studies. 28(9), 1313-1345.
Batkovskiy A.M., Fomina A.V., Batkovskiy M.A., Klochkov V.V., Semenova E.G. (2016). Implementation risks in investment projects on boosting high-tech business production capacity: analysis and management. Journal of Applied Economic Sciences, 6(44), 1200-1209.
Batkovsky A.M., Kalachanov V.D. (2017). Modeling the innovative development of economic systems. Electronics Issues, 2015, 258-279.
Chursin A., Drogovoz P., Sadovskaya T., Shiboldenkov V. (2017). A linear model of economic and technological shocks in science-intensive industries. Journal of Applied Economic Sciences 6(52), 1567–1577.
Chursin A., Drogovoz P., Sadovskaya T., Shiboldenkov V. (2017). The dynamic model of elements' interaction within system of science-intensive production under unstable macroeconomic conditions. Journal of Applied Economic Sciences. 5(51), 1520–1530.
De Sousa Damiani J.H. (2016). Regional development in Brazil and the challenges facing technology-intensive cities: A proposal for a framework of a municipal innovation system. Portland International Conference on Management of Engineering and Technology: Technology Management for Social Innovation. 510-522.
Efimova N.S. (2015). The formation of methods of information support for the development of high technology products in the conditions of information security of the enterprise. Bulletin of the Moscow Aviation Institute, 2, 214-220.
Kim J., MacDuffie J.P., Pil F.K. (2010). Employee voice and organizational performance: Team versus representative influence. HumanRelations. 63, 371-394.
Knutstad G.J., Ravn E. (2014). Technology Utilization as Competitive Advantage - A Sociotechnical Approach to High Performance Work Systems. Advanced Materials Research, 1039, 555-561.
Lee B.H. (2011). The political economics of industrial development in the Korean automotive sector. International Journal of Automotive Technology and Management. 11, 137-151.
Li C., Bai Y., Xiang X., Xie X. (2017). To mine coordinated development degrees of high-tech equipment manufacturing industry and logistics industry via an improved grey hierarchy analysis model. Journal of Grey System. 29, 105-119.
Lyu J., Wang W., Ren Y., Feng W., Zhao J. (2016). An evaluation method for use phase affordability of aviation equipment. International Conference on System Reliability and Science. 16599734, 42-45.
Manturov D.V., Efimova N.S. (2012). Implementation of information support systems for high technology products in the organization of production in the aircraft industry. Military Economics and Finance. 3(19), 50-55.
McNamara C. (2018). Organizational Performance Management. Evaluating and Improving Organizations. Guidelines about achieving stronger organizational performance. 15, 220-225.
Morrissey R., Guarraia P., Pauwels V., Sampathkumar S. (2016). Building Efficient Organizations. Bain & Company. Available at: http://www.bain.com/publications/articles/building-efficient-organizations.aspx.
Nikezić S., Dželetović M., Vučinić D. (2018). Chester Barnard: Organisational-Management Code for the 21st Century. Procedia - Social and Behavioral Sciences. 221(2016), 126-134.
Panahifar F., Byrne P.J., Heavey C. (2014). ISM analysis of CPFR implementation barriers. International Journal of Production Research. 52, 5255-5272.
Pokrajac S., Nikolić M., Filipović M. (2016). Industrial competitiveness as a basis of Serbian reindustrialization. Journal of Applied Engineering Science. 14(2), 248-259.
Radu C. (2018). Modern Instruments For Measuring Organizational Performance. Modern Instruments ForMeasuring Organizational Performance. 14(2), 349-367.
Rolfsen M., Langeland C. (2012). Successful maintenance practice through team autonomy. Employee Relations. Employee Relations. 34, 306-321.
Sparrow P., Cooper C. (2014). Organizational effectiveness, people and performance: new challenges, new research agendas. Journal of Organizational Effectiveness: People and Performance (Lancaster University). 1, 2-13.
Vonortas N., Zirulia L. (2015). Strategic technology alliances and networks. Economics of Innovation and New Technology. 24, 490-509.