Model to improve the quality of additive production by forming competencies in training for high-tech industries

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Abstract. Modern trends and technologies of high-tech production are aimed at the active application and use of additive technologies in the production of complex industrial products of non-standard shape. The problem of complicating the design of products is acutely felt. Working with additive technologies requires special competencies of personnel capable of working in high-tech industries in modern digital production.

1. Introduction
Increasing automation of production lines and the proliferation of new digital tools. Change the nature of the work. Not only do production workers see that their field of activity goes beyond the main job, but they also need to be able to intervene in different processes within the same job. An industry 4.0 employee will have to solve accessibility, security, and quality issues. This will require addressing the challenges of improving skills in areas such as system design and IT infrastructure, software, and data protection. But in addition to "more knowledge", the main task of training within Industry 4.0 is to develop interdisciplinary or even hybrid profiles. A prime example is maintenance activities. Factories are already equipped with sensors that track and record the performance of production operations. They can, for example, predict breakdowns and maintain equipment autonomously, or signal the need for intervention. Therefore, in the future, employees will no longer only participate in maintenance work.

2. Development of high-tech industries of domestic enterprises
In 2019, Russia moved up one place to 47th place. Russia's strong points are the large number of employees engaged in science-intensive work, many patent applications, and others. The weak points include high taxes, high interest rates on loans, and unstable political and economic conditions. The current political and economic conditions in the Russian Federation have a dual character: on the one hand, it is a unique probability for Russian companies to occupy a niche of sanctioned foreign goods, on the other hand, Russian enterprises are faced with the problem of import substitution of foreign equipment that allows them to increase production.

Thus, the introduction of new technologies and innovations is very important for the Russian economy and Russia as a whole. The analysis of innovative activity of Russian enterprises in the period from 2010 to 2019 revealed trends in the development of knowledge-intensive industries.
Figure 1. Shares of innovative potential of a high-tech enterprise.

The study of many situational features of the implementation of innovative development plans for various enterprises in the industrial sector shows that the main focus of the development of innovative potential is the renewal of fixed assets and, above all, the material and technical Park. However, increasing the production and technological potential of the enterprise without a corresponding increase in its other components will not lead to a significant increase in the enterprise's potential. In the process of managing the enterprise's potential, it is necessary to assess the adequacy of the innovative potential in order to develop an adequate strategy for its implementation and development and then make a decision on the implementation of the scenario for the deployment of innovative projects.

3. Model of improving the quality of additive production taking into account the competences of staff and taking into account the requirements of additive installations

It is necessary to consider that industrial enterprises and personnel are constantly influenced by various factors that can be represented in the form of a diagram. One of them is the competence of the staff figure 2.

Figure 2. Staff competencies.

The applicability analysis also implies a risk assessment. A hierarchical risk structure has been developed figure 4 to form a complete picture of risk as an integral part of production.

To improve the quality of additive manufacturing, the equipment is evaluated according to the criteria and requirements specified in the product specification and in accordance with the qualification of the personnel (table 1).
Table 1. Identified indicators of additive manufacturing.

| Option                        | Build accuracy | Layer thickness | Element resolution | Print speed | Output       |
|-------------------------------|----------------|-----------------|--------------------|-------------|--------------|
| Types of printers             |                |                 |                    |             |              |
| Picasso 3d designer pro 250   | 5              | 1               | 3                  | 3,00        | Norm         |
| 3D printer                    |                |                 |                    |             |              |
| Formlabs The Form 2           | 1              | 5               | 3                  | 1           | 2,50 not satisfactory |
| Hercules Mini 3D printer      | 5              | 5               | 1                  | 1           | 3,00 Norm    |

The obtained data allows you to visualize the quality of additive installations and, depending on the qualification of the staff, give work to an employee on the installation figure 3 [6,1].

Figure 3. Visual image of performance ratings.

Considering the performance of the equipment and the qualification of the personnel interacting with it, the following risks can be identified in additive manufacturing figure 4.

Figure 4. Hierarchical structure of emerging risks in additive manufacturing.
Based on the results of the equipment tests and personnel training, additive products were produced in the form of a component base of radio-electronic equipment of complex shape, shown in figure 5.

![Image of additive products](image)

**Figure 5.** Products made using additive technologies.

The requirements of the technical specification are set, each of which must be met. Due to the complex technological process, high-quality training of personnel is necessary, considering the requirements of the equipment and technical characteristics of polymers used in additive manufacturing [2,3].

![Image of training process](image)

**Figure 6.** Additive technology products.

Thus, at the moment, the training of personnel consists in timely meeting the quantitative and qualitative needs of the organization in highly qualified personnel capable of working on additive equipment.

It is important that domestic enterprises understand that if they want to remain competitive, they must provide quality training to all their employees throughout their working life.

**References**

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