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CORPORATE RESOURCES IN INSTRUMENT MAKING

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PROBLEMS OF INCREASING LABOR PRODUCTIVITY IN THE RUSSIAN FEDERATION AND WAYS TO SOLVE THEM

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To guarantee its economic security, the company uses a set of corporate resources. These are, in essence, all the factors of the company's activity that can be used by owners and managers to achieve the goals set for the organization. In turn, the global digital transformation has led to the spread and widespread use of innovative digital resources in all areas of production. At the same time, every state interested in creating and implementing competitive domestic digital innovations began to pursue a policy that would ensure the achievement of this goal. For example, our country has adopted a number of strategic regulatory legal acts aimed at creating conditions for the digital transformation of the economy. In particular, the creation and implementation of such digital technologies is a key focus of the national technology initiative, including in the instrument industry.

The main part

The domestic instrument-making market is characterized by a high level of import dependence. Meanwhile, there have been certain trends to reduce the share of imported products of this segment in the market. So, if in 2019 the share of imports was about 73%, then by 2021 this indicator has decreased to 69%. The low share of domestic industrial instrumentation should be explained by the following reasons:

- quite extensive volumes of the nomenclature of manufactured types of products of the instrument industry;
- high duration of the production cycle;
- rather low technical level of production. in our country, the production of devices is still accompanied by outdated technologies, and the level of depreciation of fixed assets for various enterprises can reach up to 75%;
- the existing contradictions between the level of complexity of the manufactured types of products, due to market needs, and the lack of highly qualified trained design engineers and specialists (these may be assemblers, installers, etc.);

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- insufficient stimulation of creative and inventive activity and legal protection of inventions;

Low level of profitability (as a rule, less than 15%) of manufactured products. The reason is the high material and energy consumption of products; the life cycle of devices decreases and it becomes necessary to improve them according to market requirements.

To date, it is a very high priority and strategically important to focus on the production of complex types of products in the instrument industry, and ideally on end–use products.: these are complex instrument complexes, coordinated with each other in time and space, performing many local functions in such areas as measurement, control and automatic control of technological processes and entire production facilities. It is also required to endow the products with additional functionality. This can be achieved through the digital transformation of the instrument industry through the effective use of corporate digital resources.

Modern digital technologies (this includes, for example, 3D printing, knowledge-based automation and digital assistants, big data analysis and robotic systems) contribute to the emergence and development of innovations and are able to speed up production processes. The latest digital technologies can increase the complexity of products and processes for their manufacture, contribute to the growth of the competitiveness of enterprises, but, at the same time, the enterprises of the instrument industry using advanced digital resources may face the following difficulties:

1. The need to reduce deadlines. Minimum deadlines for the release of new products to the markets may make it difficult to pre-check the degree of operability of technological processes, and an increase in the volume of output cannot leave room for error.
2. The complexity of the transition from mass production to mass customization. The reason for the inflexibility of existing production systems may not allow switching to full-scale individual production.
3. Strict level of data and documentation requirements. For example, in the automotive or medical equipment industries, as well as in the supply of components to customers who require the highest level of quality and standardization, it is required to document the conformity of products with standards.
4. The impact of globalization on the state of labor and material resources.

Meanwhile, the decision-making processes about the place of production have become more complicated: some regions with low costs have simply been unable to meet the growing level of demand and (or) avoid cost increases. For this reason, the profit margin has decreased, transportation costs can exceed the savings received from the low cost of labor resources. Global outsourcing is able to reduce costs, but optimizing the supply of material resources has become noticeably more complicated.

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Many manufacturers of the instrument industry have already digitalized certain stages of production preparation processes. At the same time, the following approaches are used in different combinations

✓ integrated development of processes for the assembly and testing of printed circuit boards;

✓ production start-up management, virtual tests for the control of design and technological design solutions;

✓ optimization of production facilities using integrated tools for the development

✓ model-driven processes for the manufacture of parts and molds;

✓ cooperation with suppliers in the transfer of printed circuit board production to third-party enterprises;

✓ implementation of production management systems (MES) in the manufacture of printed circuit boards

All these approaches can be combined into a general concept of "digital enterprise". It assumes an integrated platform that integrates the processes for the design, manufacture and supply of modern smart products. Digital enterprises are based on two concepts: a digital thread and a digital twin.

5. The digital thread consists of information transfer processes that unite all participants in the processes of designing, manufacturing and technical support of products. The platform for supporting collaborative work makes it possible to implement data transmission processes in digital form across all engineering disciplines, fields of application, tools and systems.

6. The digital twin is a fairly accurate virtual model of either products or technological processes. These models are used for numerical simulation of real phenomena even before the start of manufacturing products or designing technological operations. The goal is to maximize optimization with the help of computer systems, when, with a minimum level of expenses, many scenarios of the form "what will happen if ..." are considered. The data coming from the digital environment is constantly updated by digital doubles, while guaranteeing their maximum level of accuracy. For example, information received from customers about operations are transferred to the design and testing stage of future products. Similarly, when collecting data on the performance of real technological processes, the quality of numerical modeling of technological operations increases. And this, in turn, will help to create more efficient technological processes. Digital doubles are an excellent way to capture and disseminate optimal approaches to production activities.

Smart manufacturing in the instrument industry is a new production model, which makes it possible to further increase the level of efficiency by combining the virtual and real worlds.

In functional terms, the means of smart production as digital resources offer the following advantages.

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1. Control of the manufacturability of printed circuit boards and mechanical components. The analysis of the manufacturability of printed circuit board designs assumes an average of 950 checks of manufacturing, assembly, testing and reliability capabilities. The digital double of the product helps to identify possible problems. Dimensional deviation analysis calculates and predicts the quality at the assembly stage based on the geometric and dimensional tolerances of parts and assemblies. At the same time, the most important design and technological information is determined.
2. Virtual development, modeling and optimization of technological processes. When designing the manufacturing processes of printed circuit boards, a digital twin of the technological process is created based on the approach "we design, anywhere, we manufacture everywhere". At the same time, the technology for the production of a new product is being developed, the consequences of design changes for production lines are being identified and updated technological documentation is being prepared. Control of technological processes provides visualization and analysis of all assembly operations (manual, automatic or joint) in order to identify possible deviations and introduce advanced technologies. Numerical modeling of equipment performance and utilization simplifies capital investment planning and forecasting of current expenses. Optimization of production leads to an increase in equipment utilization and a reduction in the cost of products.
3. Management of materials and technological operations. Materials management tools ensure just-in-time (JIT) deliveries, which eliminates excess inventory of unfinished products and increases inventory turnover. Special software solutions manage the data coming from all resources (tools, operators, machines), which ensures complete traceability. They also integrate perfectly with enterprise resource management (ERP) and product lifecycle management (PLM) systems.
4. The collection of technological information brings real benefits. Solutions for the Internet of Things collect all the data created during the technological process (including consumption material, quality indicators and progress information). Then a digital twin of the production is created, and the processed technological information is provided to all services of the enterprise in real time. Business intelligence tools support intelligent decision-making based on real-time information analysis, analysis of the main causes of failures, as well as forecasting future quality and cost indicators.

Smart electronics manufacturing allows you to abandon prototypes, eliminate information storage. As a result, a continuous integrated process "design – technological preparation – manufacture of products" is created.

At each stage of pre-production, it is easy to notice the difference between such an approach, when accurate and proven models of products and processes are created and distributed throughout the enterprise, and the current patchwork digitalization. Among the main differences:

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- ✓ constructions are becoming more reliable and technologically advanced;
- ✓ the joint work of design, technological and production departments is improving;
- ✓ data redundancy is reduced;
- ✓ the number of errors in technological processes is reduced;
- ✓ the volume of manual data entry, fraught with errors, is reduced;
- ✓ stocks are optimized, and materials are consumed according to the "just in time" system;
- ✓ advanced technological processes are being implemented;
- ✓ ensures the accuracy and relevance of technological documentation;
- ✓ data collection and monitoring of key indicators is carried out;
- ✓ the root causes of problems are quickly identified;
- ✓ the transition to a more diverse release program is underway without reducing production efficiency.

Thanks to the digitalization of the entire product development process - from design to production – and the creation of a digital thread that unites all its stages, the smart electronics manufacturing strategy allows you to check the possibility of manufacturing a product in advance, and also guarantees the relevance and synchronization of technological documentation, optimization of production and production of products in exact accordance with the plan.

Compared with partial digitalization, the new approach gives a lot of competitive advantages, among which: shortening the time to market, more frequent launches of new products, pre-production tasks that previously took weeks to solve, when creating a digital thread are completed in a matter of hours. Numerical modeling and calculations using digital doubles guarantee the successful release of products from the first time. Overall strategysmart manufacturing is able to reduce the time for products to enter the market by half. This is the way to success in an environment where there is a demand for constant innovation.

5. Quality improvement by transferring a number of tasks to earlier stages. The so-called "left shift" is the transfer of a number of tasks to earlier stages of design. An example in the development of electronics is the analysis of the manufacturability of printed circuit boards, performed regularly at the early stages, and not after the completion of the design. Every time the analysis is carried out, there is a general improvement in the design. The stronger the "shift to the left", the more benefit it brings.

6. Increase the flexibility of production. In the presence of a digital thread that combines the stages of design and technological design, the development of technological processes can be carried out much earlier, and by the time the design development is completed, production can begin immediately. And this paves the way for the mass production of unique, personalized products.

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7. Smart decision-making. The availability of complete information about the course of production and the use of means of analyzing this information makes informed decision-making possible.

8. Cost management. The smart manufacturing strategy in the electronics industry leads to an increase in the efficiency of technological processes and the use of materials (both at individual plants and throughout the company as a whole). In addition, such a strategy reduces the technological cost, which ultimately makes the manufactured products affordable.

In the short and medium term, three technologies will become particularly important.

1. Artificial intelligence. There are hundreds of potential applications of artificial intelligence (AI) in industry. This technology has become one of the most popular among the global venture capital. AI has led to the emergence of so-called cognitive technologies. Among them are computer vision, natural language processing, speech recognition, robotics, optimization, expert systems based on production rules, volume and calendar planning tools and machine learning (the ability of machines to improve performance based on data analysis).

2. 3D printing on an industrial scale. It is estimated that by 2020, 75% of the global industry will use 3D-printed tools and equipment. A number of analysts believe that these technologies will be most widely used in the automotive, aerospace and defense industries, and to a certain extent in the electronics industry.

3. Modern robotic systems. Today, robots easily perform such operations of assembling electronic products, which until recently were considered impossible. The flexibility of robotic complexes is being brought to a new level, industrial complexes are being developed robots-manipulators suitable for the production of small batches of products and functioning within the framework of constantly changing technological processes.

Changes in the modern field of instrument engineering, which implies "digital production", are taking place and will continue to take place in the following key areas:

1. Digital modeling - the concept of a digital twin is being developed, that is, the manufacture of a product in a virtual model that includes equipment, production process and personnel of the enterprise.

2. "Big data" (big data) and business analytics that arise in the production process.

3. Autonomous robots that will receive greater industrial functionality, independence, flexibility and efficiency compared to the previous generation.

4. Horizontal and vertical integration of systems - most of the huge number of information systems currently in use are integrated, but it is necessary to establish closer interaction at various levels within the enterprise, as well as between different enterprises.

5. Industrial Internet of Things, when information coming from production from a large number of sensors and equipment is combined into a single network.

6. Cloud technologies, additive manufacturing and additional reality will also influence the development of digital production. The main changes will occur thanks to these listed technologies.

Conclusion

Thus, the "digitization" of production processes in instrumentation has its own differences from classical mechanical engineering. A separate task is the organization of an import-independent information environment where it is required by legislation, internal standards of the enterprise, cooperative relations. As a result, smart manufacturing will appear in the instrument industry – a full-featured line of solutions, including means of controlling the manufacturability of projects, virtual design, modeling and optimization of technological processes, generation and control of control programs and technological documentation, optimization of schedules and resource allocation. In order for any company to succeed in a diversifying market that requires rapid innovation and personalization of its products, it is extremely important to create a flexible, cost-effective and responsive product development environment - smart manufacturing of the instrument industry.

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