ATLAS OF NEW PROFESSIONS AND COMPETENCIES OF KAZAKHSTAN

ATLAS
OF NEW
PROFESSIONS
AND COMPETENCIES
IN KAZAKHSTAN

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# MECHANICAL ENGINEERING

MINISTRY OF LABOR
AND SOCIAL PROTECTION
OF THE REPUBLIC OF KAZAKHSTAN

THE WORLD BANK
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DEVELOPING
WORK SKILLS
AND STIMULATING
JOBS

# ATLAS OF NEW PROFESSIONS AND COMPETENCIES IN KAZAKHSTAN

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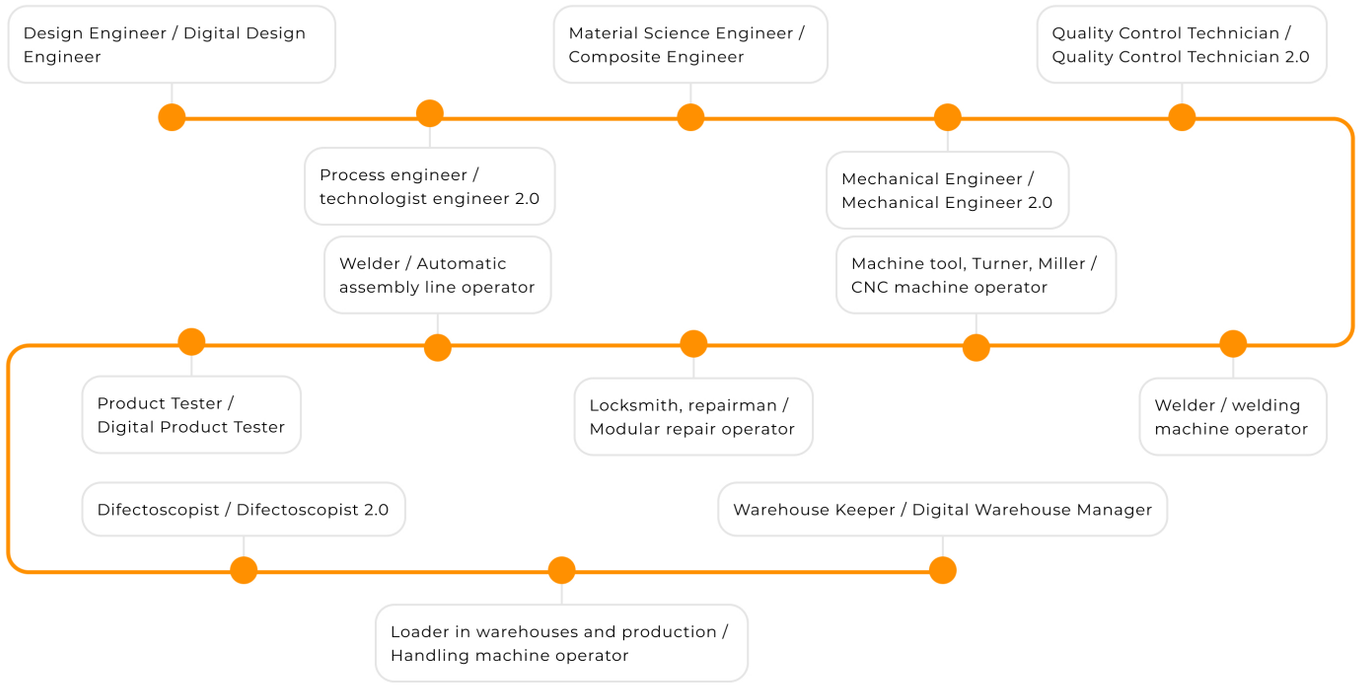
# LIST OF ABBREVIATIONS

- **3D – Three-Dimensional.**
- **AM – Additive Manufacturing.**
- **ANP – Atlas of New Professions.**
- **AR – Augmented Reality.**
- **CIS – Commonwealth of Independent States.**
- **CNC – Computer Numerical Control.**
- **EAEU - Eurasian Economic Union.**
- **ERP – Enterprise Resource Planning.**
- **EU – European Union.**
- **ICT – Information Communication Technologies.**
- **IFR – International Federation of Robotics.**
- **IoT – Internet of Things.**
- **IT – Information Technology.**
- **JSC – Joint-Stock Company.**
- **LLP – Limited Liability Partnership.**
- **MIIR RK – Ministry of Industry and Infrastructure Development of the Republic of Kazakhstan.**

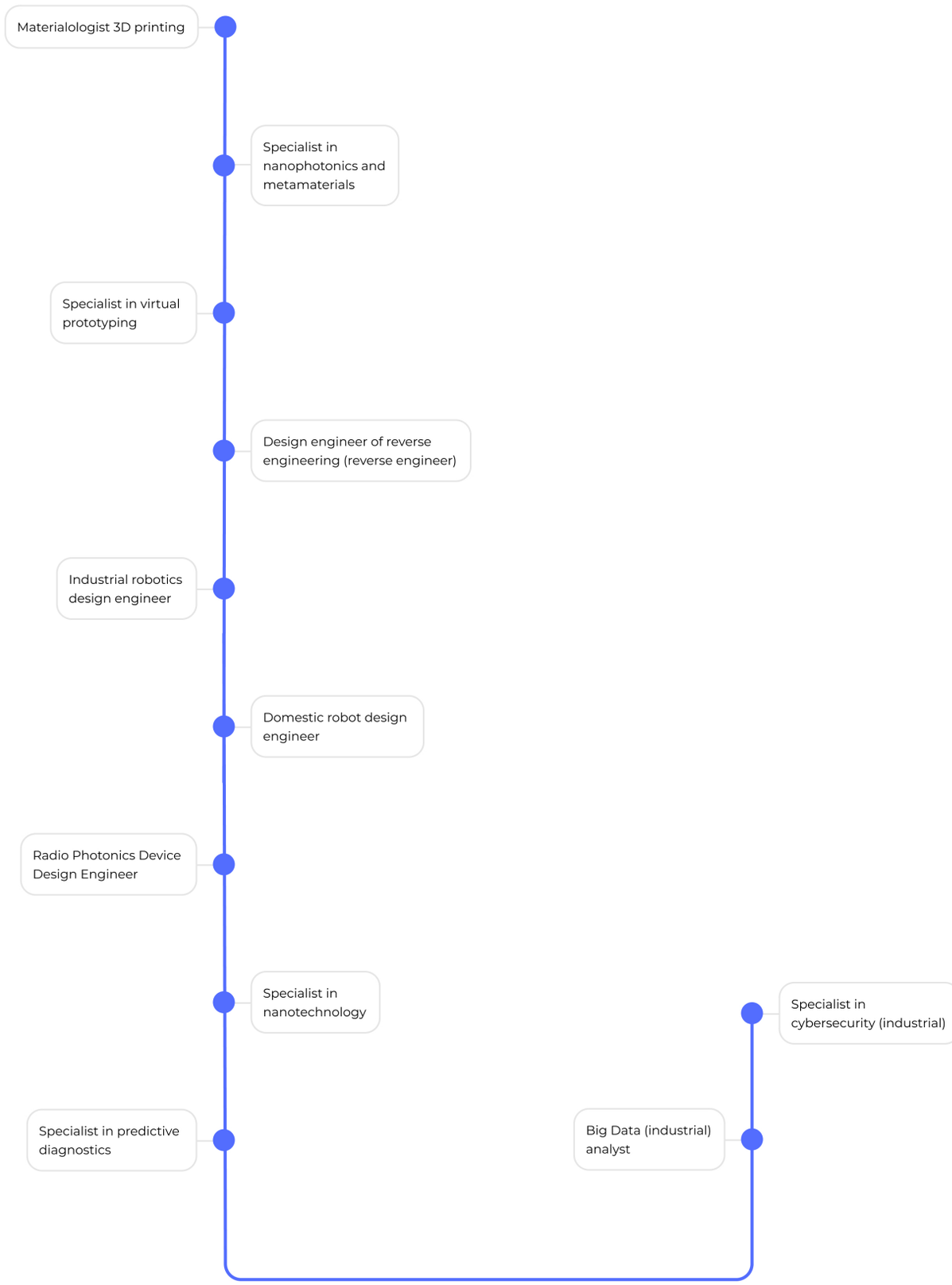
- MNE RK – Ministry of National Economy of the Republic of Kazakhstan.
- MR – Mixed Reality.
- NCE – National Chamber of Entrepreneurs.
- R&D– Research and Development.
- RFID – Radio Frequency Identification.
- RI - Research Institute.
- RK – Republic of Kazakhstan.
- TVE - Technical and vocational education.
- USA – United States of America.
- VR – Virtual Reality.

## **Transforming** Professions in Mechanical Engineering




## **Disappearing** Professions in Mechanical Engineering

# **New** Professions in Mechanical Engineering



# NAVIGATING THE ATLAS OF NEW PROFESSIONS

# 1.


STRAITS TRADING
STRAITS TRADING

# NAVIGATING THE ATLAS OF NEW PROFESSIONS

## Dear Readers!

You've probably noticed how rapidly the world around us is changing lately. What used to seem like a pipe dream and even fantasy is now taking on real shape. Global trends of recent decades have changed not only cities, our homes, ourselves, but also the labor market - the professions that we choose.

Remember, not long ago we were impatiently awaiting the arrival of the postman with the long-awaited letter. Now, to send a letter to another continent, just one click of a button is enough, and the addressee receives it at the same moment. And what happened to this large army of previously demanded postmen, where are they now? In the same place as chimney sweeps, skittles distributors, cabbies...

And today there is a possibility that the most promising professions at the moment, at the most unexpected moment, will also cease to be relevant.

Therefore, already now, in order not to replenish the army of unclaimed specialists, it is necessary to approach with particular seriousness the choice of one's future profession or obtaining a new specialty when changing jobs.

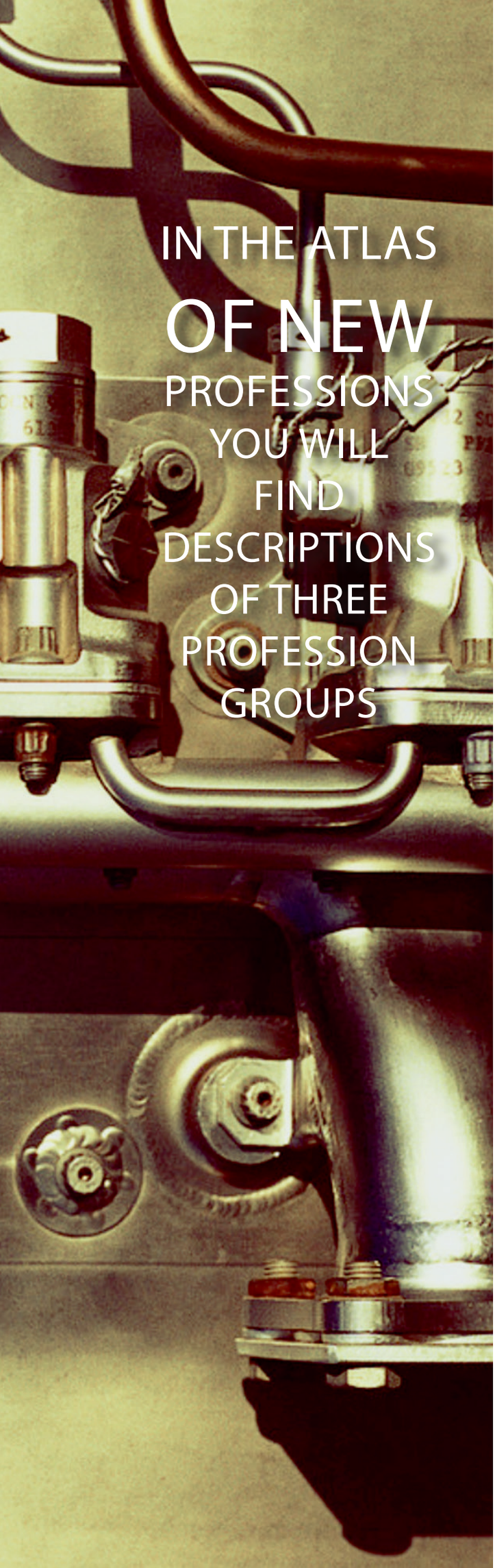
## CHOOSING A PROFESSION — WE CHOOSE THE FUTURE.

Choosing a profession is one of the most difficult issues in our lives. Of course, we all want our future profession to bring pleasure, financial well-being, and benefit to others. And I also want not to be mistaken - to choose a profession that would be relevant in ten or twenty years.

It is for this purpose that the Atlas of New Professions has been developed, based on materials that employ the methodology for predicting the future based on technological Foresight methotology.

The purpose of the Atlas of new professions is to help you understand what trends are driving changes in various industries, as well as what changes are forecast in the labor market.

Our Atlas will help you figure out which professions will appear, and which ones will change or even disappear in the next 10-15 years. And you will also have the opportunity to determine the list of skills that are most in demand for building a successful career in the future.



# IN THE ATLAS OF NEW PROFESSIONS YOU WILL FIND DESCRIPTIONS OF THREE PROFESSION GROUPS

***NEW PROFESSIONS***

— professions that do not exist now or they are just emerging and will become relevant in the near future.

TRANSFORMING PROFESSIONS

— already existing professions and specialties, the qualification requirements for which are significantly changing under the influence of new technologies.

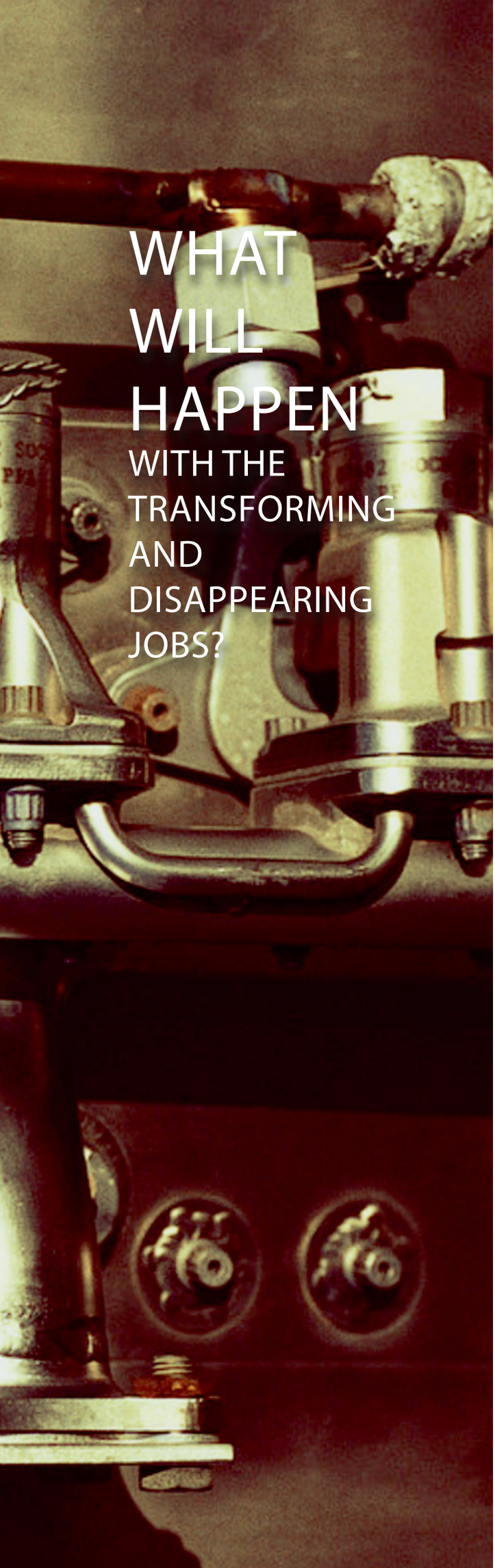
DISAPPEARING PROFESSIONS

— professions and specialties that will not be in demand in the near future.

# STRUCTURE OF THE ATLAS

To make it easier to navigate the sections of the magazine, we will briefly introduce you to what information you will find in each of them.

| | |
|---|---|
| Mechanical engineering in the economy of Kazakhstan. | This section gives<br>▶ assessment of the role of mechanical engineering in the development of the country's economy,<br>▶ analysis of the current state of the industry and major achievements over the past 10 years. |
| The future of mechanical engineering through the eyes of industry experts. | Here you will familiarize yourself with<br>▶ excerpts from interviews with leading industry experts,<br>▶ industry development forecasts for the next 10-15 years. |
| Trends and technologies shaping the future of mechanical engineering in Kazakhstan. | An important section of the magazine from which you can learn about<br>▶ leading trends that have the greatest impact on the development of the industry,<br>▶ results obtained through the introduction of advanced technologies at production sites. |
| The future is not far off. What will it be for mechanical engineering? | ▶ A very interesting section for those who want to look into the future of mechanical engineering.<br>▶ Most importantly, this section will help you decide whether you want to be a part of this future or not. |
| How to prepare for the future? | ▶ Here you will find the answer to how competencies differ from skills.<br>▶ Understand what competencies you first need to develop in order to be successful in the profession. |
| Where should I go to study? | A key section of the magazine that provides detailed information on<br>▶ new<br>▶ transforming<br>▶ and disappearing professions. |



# WHAT WILL HAPPEN WITH THE TRANSFORMING AND DISAPPEARING JOBS?

## WHY DO PROFESSIONS CHANGE OR DISAPPEAR?

- This happens under the influence of scientific and technological progress. New technologies, automation and digitalization can replace not only the profession of hard manual labor, but also mental labor.

## HOW SOON WILL THIS HAPPEN?

- The process of transformation of professions has already started and its scale will only grow. And professions will disappear gradually. Therefore, such specialists have time to decide on the choice of their future profession.

## WHAT WILL IT LEAD TO?

- There will be a reduction in jobs and an increase in the requirements for existing professions. It will be necessary to make a choice: mastering additional professional competencies or retraining in a new profession.

## HOW DO I STAY IN DEMAND AS A SPECIALIST?

- It is necessary to constantly improve your professional level, master new skills and competencies, as well as monitor trends in the labor market.

## WHAT ARE THE ADVANTAGES OF THIS PROCESS?

- Professions associated with monotonous, routine work will disappear. They will be replaced by new jobs, where specialists with the competencies and skills of the future will be in demand.

To make it clear to you how to use the Atlas of New Professions, we have built its structure for each industry according to a universal model.

For the convenience of working with Atlas materials, you can use filters that will help you quickly find and choose the desired profession.

PROFESSIONAL GROUP FILTERS:

1. industry (nine industries);
2. new / transforming / disappearing professions;
3. trends;
4. skills and competencies.

Forecasting the professions of all sectoral Atlases is based on six leading trends that have the greatest impact on the development of the industry and the country's economy as a whole.

LEADING TRENDS:

1. The spread of the introduction of robots and smart systems.
2. Expanding the scope of digitalization and big data.
3. Improving the efficiency of industry resource management.
4. Increasing requirements for environmental friendliness of production and products.
5. Changing requests and requirements of a new generation of employees.
6. Changing consumer preferences.

Nine supra-professional competencies are used to describe new professions, which are necessary for building a successful career.

SUPERPROFESSIONAL COMPETENCES:

1. Lean manufacturing.
2. Customer focus.
3. Multilingualism and multiculturalism.
4. Cross-industry communication.
5. Artistic creativity.
6. Programming / Robotics / Artificial Intelligence.
7. Systems thinking.
8. Project and process management.
9. Environmental thinking.

# ATLAS OF NEW PROFESSIONS AND COMPETENCIES IN KAZAKHSTAN

## MMC

A set of related industries and stages of the production process from the extraction of raw materials to the production of finished products: ferrous and non-ferrous metals and their alloys

## Energy

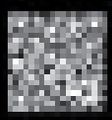
The economy sector that generates, converts, distributes and uses all types of energy resources.

## Oil and gas

The economy sector engaged in the extraction, processing, storage and sale of natural minerals - oil and related petroleum products.

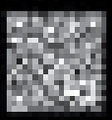
## Mechanical engineering

The economy sector that designs, manufactures, maintains and disposes all kinds of machines, technological equipment and their parts.



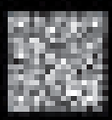
## Agriculture

Economic sector that focuses at production, storage and processing of food (food products) and raw materials for a number of industries.



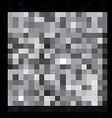
## IT

The economy sector aimed at finding, collecting, storing, processing, transmitting and providing useful information through technical means.



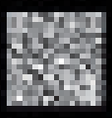
## Transport and logistics

The economy sector carrying passengers, as well as the management system for the purpose of optimization.



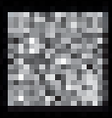
## Tourism

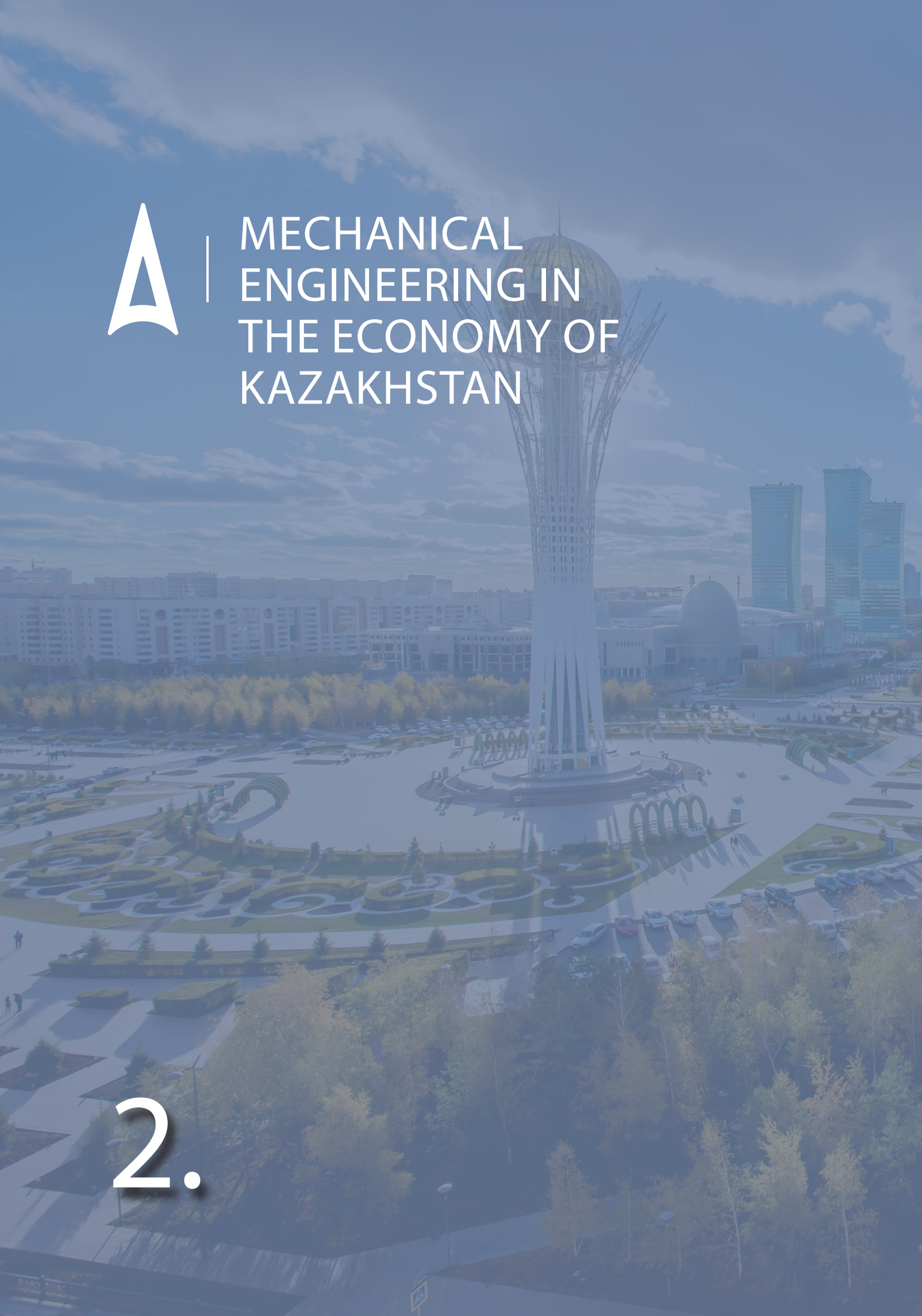
An industry that organizes trips (travels) to another country or area other than the place of residence to get acquainted with the lifestyle, gastronomy, nature, etc.



## Construction

The economy sector that designs, creates buildings, structures, as well as performing their major and current repairs.





# MECHANICAL ENGINEERING IN THE ECONOMY OF KAZAKHSTAN

# 2.


Евразийский Банк

## PROFESSIONS CAN BE OBTAINED IN 7 BASIC SPECIALTIES

ANNUALLY STUDY IN 11 COLLEGES AND 11 UNIVERSITIES OF THE RK

**2200** in metallurgical field

**9500** in mining

## THERE ARE APPROXIMATELY 2394 OPERATING ENTERPRISES IN KAZAKHSTAN

OF WHICH: 85 LARGE, 79 MEDIUM AND 1900 SMALL

**85** **79** **1900**

**1472,3** BILLION TENGE

**ANNUAL PRODUCTION VOLUME**

Share in industrial output

Share of manufacturing production volume

Total number of production employees of Kazakhstan

## KAZAKHSTAN IS CONCENTRATED FROM WORLD RESERVES

| Cr | Zn | Mn | Fe,Cu,Pb |
|---|---|---|---|
| 30% | 13% | 25% | 10% |

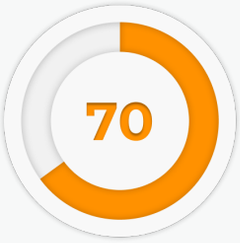
30% - chrome ore
25% - manganese ores
13% - zinc
10% - iron ores, copper and lead

**~20%** of global uranium mining

**40%** Kazakhstan's uranium concentrate provides more than 40% of the world's nuclear power industry

## IN THE DEPTHS OF KAZAKHSTAN OF 105 ELEMENTS OF THE MENDELEEV TABLE


Involved in production




Explored reserves


Inventories were identified

# MECHANICAL ENGINEERING IN THE ECONOMY OF KAZAKHSTAN

Mechanical engineering is a priority branch of the country's industrial and innovative development, and the level of its development affects the country's economic independence and its security.

Picture 1

***The main results of the implementation of the State Program of Industrial and Innovative Development of Mechanical Engineering of the Republic of Kazakhstan for 2010-2019.***[1]


[1] Press service of the Prime Minister of the Republic of Kazakhstan. — URL: https://primeminister.kz/ru/news/naibolshuyu-dinamiku-rosta-sredi-otrasley-mashinostroeniya-demonstriruet-avtomobilestroenie-miir-rk-1954037.

Mechanical engineering has always be mechanical engineering has always been distinguished by a high level of manufacturability and science intensity. At the same time, while the 20th-century industry was based on large factories with a large number of employees, modern mechanical engineering is increasingly relies on robotic production with a smaller number of operating personnel.

Mechanical engineering is characterized by a high level of multiplier return on related sectors of the economy. One created job in mechanical engineering stimulates the creation of about 7-8 jobs in related industries.

Enterprises producing electrical equipment and vehicles have the greatest multiplier effect on other sectors of the economy among machine builders in Kazakhstan.[2]

A distinctive feature of Kazakhstan's mechanical engineering is the predominance of enterprises for the repair and installation of machinery and equipment, as well as assembly plants in the automotive industry, railway and agricultural engineering.

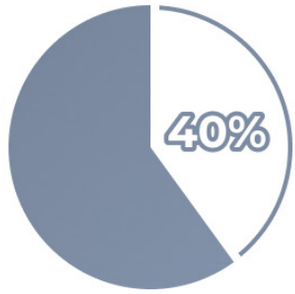
[2] Press service of the Prime Minister of the Republic of Kazakhstan. — URL: https://primeminister.kz/ru/news/reviews/odno-rabochee-mesto-v-mashinostroitelnoy-otrasli-stimuliruet-sozdanie-7-8-rabochih-mest-v-smezhnyh-otraslyah-2821350.

# AUTOMOTIVE

## AUTOMOTIVE DEVELOPMENT RESULTS FOR 2010-2019

**Investment growth by 14.4 times**

**Production growth by 24.5 times**




**Localization is 40%**

The highest growth dynamics among the engineering industries is demonstrated by the automotive industry. The products of the domestic auto industry have entered the export markets.

The main exporting countries for the industry are Russia, Belarus, Kyrgyzstan, Tajikistan and Uzbekistan. In March 2020, the first stage of the Hyundai Trans Kazakhstan passenger car plant with a capacity of 45 thousand passenger cars per year was launched in Almaty.

A number of domestic enterprises, together with foreign manufacturers, are implementing large investment projects for the production of passenger cars and tires for them, as well as buses.

## Key companies in the sector

SaryarkaAvtoProm

Hyundai Trans Auto

Asia Auto

KAMAZ-Engineering

Daewoo Bus Kazakhstan

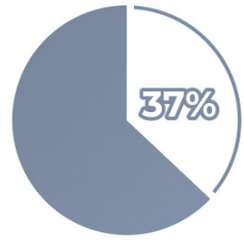
SemAZ

# AGRICULTURAL MACHINERY

## RESULTS OF DEVELOPMENT OF AGRICULTURAL MACHINERY FOR 2010-2019

**Investment growth by 3.4 times**

**Production growth by 5 times**




**Localization is 37%**

Agricultural machinery manufacturing enterprises show a stable trend of growth in production. It should be noted that 65% of 153 thousand units of working tractors and and 46% of 42 thousand units of combines, have been in operation for more than 17 years.

The machine builders plan to increase the level of localization of products, expansion of production, export, while the introduction of new technologies allowed the enterprises of the industry to increase production volumes by releasing new products for them: diesel locomotives, electric locomotives, axles and wheels for trains. The leading manufacturers of railway engineering have been involved in joint activities - Alstom, General Electric, AGRICULTURAL MACHINERY RAILWAY MACHINERY mastering the production of spare parts and components.

In May 2019, AgromashHoding KZ JSC, together with the largest Chinese corporation, launched the production of Lovol tractors with a production capacity of up to 3000 tractors per year. In October 2019, a plant for assembling tractors «Kirovets'' was opened on the basis of the Kostanay Tractor Plant. The plant's capacity is approximately 700 tractors per year.

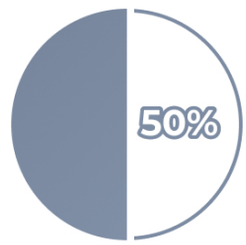
## Key companies in the sector

- SaryarkaAvtoProm
- Hyundai Trans Auto
- Asia Auto
- KAMAZ-Engineering
- Daewoo Bus Kazakhstan
- SemAZ

# RAILWAY MECHANICAL ENGINEERING

## RESULTS OF DEVELOPMENT OF RAILWAY MECHANICAL ENGINEERING FOR 2010-2019 GG.

**Production growth by 3.8 times**




**Production localization is over 50%**

The introduction of new technologies allowed the enterprises of the industry to increase production volumes due to the release of new products for them: diesel locomotives, electric locomotives, axles and wheels for trains. Leading manufacturers of railway engineering - Alstom, General Electric, Transmashholding - are involved in joint activities. Over the past 10 years of implementation of the State Program of Industrial and Innovative Development of Mechanical Engineering, the following plants were put into operation: JSC Lokomotiv Krastyru Zauyty, LLP Elektrovoz Krastyru Zauyty, LLP Prommashkomplekt, and Carriage Works Tulpar, whose production is oriented to export.

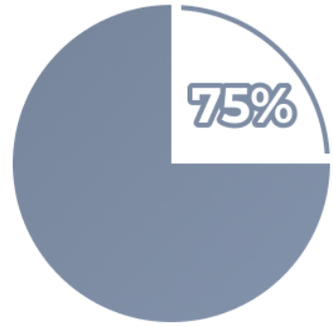
## Key companies in the sector

- Lokomotiv kurastyru zauyty
- Carriage Works «Tulpar»
- Elektrovoz kurastyru zauyty
- ZYXTO
- Prommashkomplekt
- Kazakh. wagon building company
- Format Mach Company

# ELECTRICAL MECHANICAL ENGINEERING

## RESULTS OF DEVELOPMENT OF ELECTRICAL ENGINEERING FOR 2010-2019

**Production growth by 3 times**




**Production localization is over 75%**

The products of the industry are in demand in the foreign markets of the country. For example, batteries are exported to Russia, Belarus, Uzbekistan, Kyrgyzstan, Tajikistan, Germany, China. The main importers of the products of the Kentau Transformer Plant are Russia, Tajikistan, Kyrgyzstan and Turkmenistan. Currently, in the special economic zone of Petropavlovsk, Alageum Electric is building a plant whose products will be export-oriented.

### Key companies of the sector

- Kainar-AKB
- Kentau transformer plant
- Saiman Corporation
- Kazenergocable
- EvrazCable
- Kazcentrelectroprovod

# MINING MECHANICAL ENGINEERING

## RESULTS OF DEVELOPMENT OF MINING MECHANICAL ENGINEERING FOR 2010-2019.

**Production growth by 3 times**

**Export volume growth by 1.8 times**

Over the past 10 years, mining engineering has mastered such types of products as full-revolving machines, mine trolleys, self-propelled drilling rigs, crushing and grinding equipment, as well as the production of spare parts for mining machinery and equipment. As part of the modernization of production processes and adaptation to new conditions, one of the first enterprises in the country to introduce Industry 4.0 technologies was the Karaganda enterprise Maker LLP.

## Key companies of the sector

- Almaty Heavy Engineering Plant
- Kazzincmash
- Karaganda foundry and mechanical plant
- Kurylysymet
- Kaz Carbon
- Karaganda Machine-Building Plant named after Parkhomenko

# OIL AND GAS MECHANICAL ENGINEERING

## RESULTS OF DEVELOPMENT OF OIL AND GAS MECHANICAL ENGINEERING FOR 2010-2019.

**Production growth by 4.2 times**

**Export volume growth 1.1 times**

Since 2010, the industry enterprises have launched new production of the following products: valves, power plants, gas filtering equipment, pumping equipment, etc. In the near future, industry enterprises will have the opportunity to obtain international certificates for standards such as ISO, API, OHSAS. Major global players such as the German leader in the production of valves «Böhmer Armaturen», the Canadian leading manufacturer of full-compact screw pumping systems «Kudu Industries» were involved in the joint activities of the industry enterprises.

### Key companies of the sector

- Petropavlovsk Heavy Machine Building Plant
- Belkamit
- KARLSKRONA LC AB
- Muynamash
- AtyrauNefteMash
- Ust-Kamenogorsk Valve Plant

In 2019, four machine-building enterprises were included in the top 50 largest private companies in the non-financial sector of the Forbes Kazakhstan rating: BIPEK Auto-Asia Auto Group of Companies (12th place), Kazakh Motor Company Astana-Motors LLP (14th place), JSC "Group of Companies" Allur "(27th place) and GC" Alageum Electric "(35th place).[3]

[3] 50 largest private companies — 2019: Forbes Kazakhstan rating. When ranking companies, revenue, the amount of taxes paid for the year and the number of employees were taken into account. — URL: https://forbes.kz/leader/50_krupneyshih_chastnyih_kompaniy_-_2019_1578881268/?utm_source=forbes&utm_medium=mlt_news.

# CURRENT INDUSTRY CHALLENGES

The development of mechanical engineering is hindered by the shortage of qualified personnel, the outdated material and technical base of enterprises and the lack of interest of young people in working specialties.

Mechanical engineering is a critical industry with global goals. But, like any other industry, mechanical engineering faces a number of problems that lead to an insufficient level of competitiveness of the industry's products both in the domestic and foreign markets.

According to industry experts, the greatest influence on the development of mechanical engineering is exerted by two groups of problems: personnel and technical equipment of enterprises.

***Current problems of the industry***

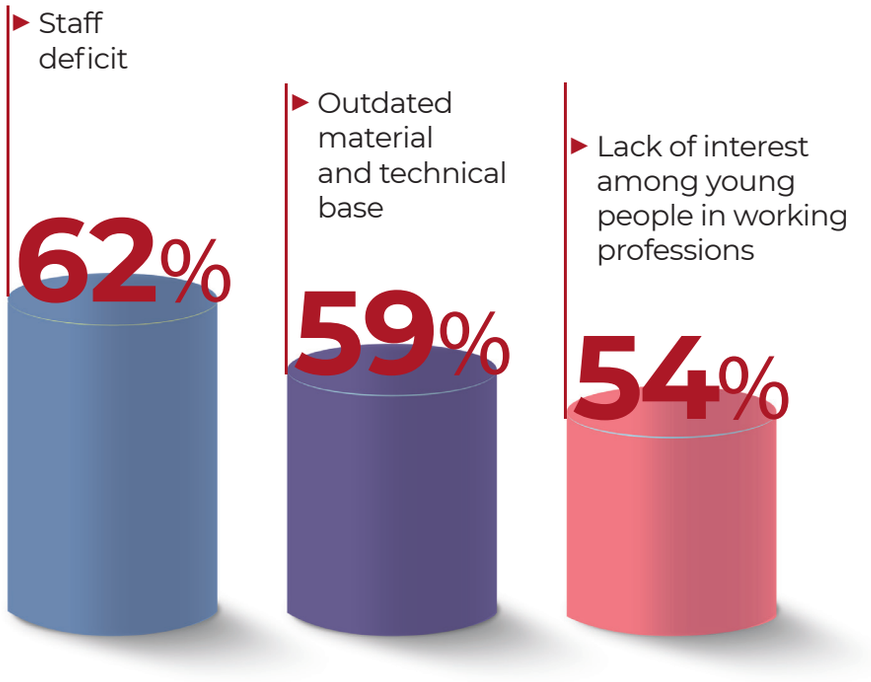
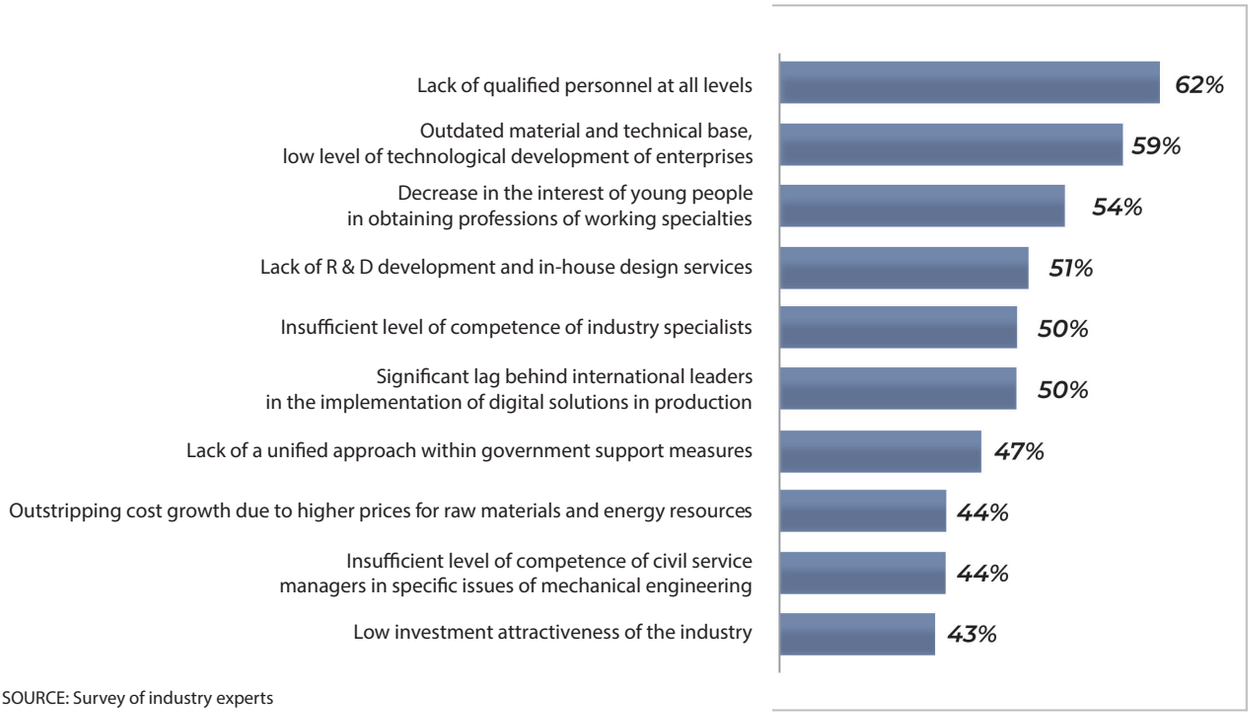


Diagram 2.1

***Top 10 problems of the current development of mechanical engineering in Kazakhstan, which have the greatest impact on its***




SOURCE: Survey of industry experts

## STAFF

Mechanical engineering enterprises are acutely aware of a shortage of personnel, both engineering and blue-collar workers, both experienced, who know all the subtleties and specifics of production, and young personnel who can quickly understand the latest technologies. But, as experts note, young people do not want to go to work in factories, especially to master blue-collar professions, so the tendency of aging of the staff is becoming more noticeable.

The number of young people working in mechanical engineering decreases by an average of 9% per year. If at the end of 2015 the share of industry personnel under the age of 29 was 21%, then at the end of 2019 it was only 18%. At the same time, the share of personnel aged 50 years and older is 28%, and working pensioners of them - 3.4%.[4]

Experts are also concerned about the low level of staff qualifications. One of the reasons for this as they see, is the insufficiently high level of training of specialists in higher and secondary vocational educational institutions, the isolation of their training programs from the real needs of the industry.

## THE TECHNICAL EQUIPMENT OF ENTERPRISES

Industry experts note the serious obsolescence of the material and technical base of enterprises.

[4] Information and analytical system «Taldau» of the Committee on Statistics of the Ministry of National Economy of the Republic of Kazakhstan.

The equipment installed at the production sites lags far behind the world leaders in the penetration of Industry 4.0 advanced tech. At the beginning of 2018, «more than 80% of manufacturing enterprises were at the Industry 2.0 level (semi-automated operations) or at the stage of transition to automated production.[5]

Innovative technologies, robots and robotic complexes are slowly being introduced to production sites, artificial intelligence technologies are not fully used. First of all, this is due to the still high cost of advanced technologies, as well as to the underestimation by manufacturers of the scale of the opportunities that open up to them.

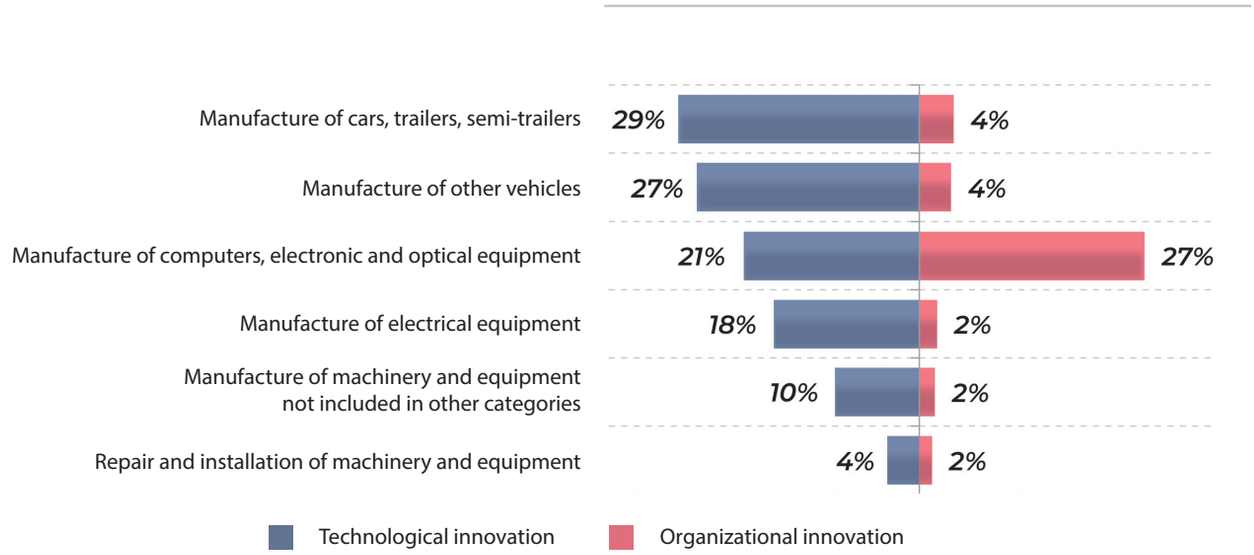
At the end of 2019, the average republican level of use by enterprises of various technological innovations was 7.5%, organizational innovations - 3.6%.[6]

IN AVERAGE IN MACHINE ENGINEERING, TECHNOLOGICAL INNOVATIONS ARE USED BY 9% OF ENTERPRISES, ORGANIZATIONAL - 3% OF ENTERPRISES.

Diagram 2.2

***The share of engineering enterprises using technological and organizational innovations***

*(in % of the number of enterprises in the sample survey industry).*




SOURCE: Committee on Statistics of the Ministry of National Economy of the Republic of Kazakhstan

[5] Report of the Minister of MIID RK at the international forum «Digital Agenda in the Era of Globalization», https://www.zakon.kz/4902665-doklad-ministra-mir-rk-na.html

[6] Selective study «On the innovative activity of enterprises in the Republic of Kazakhstan», Information and analytical system «Taldau» of the Committee on Statistics of the Ministry of National Economy of the Republic of Kazakhstan. In 2019, 773 engineering enterprises participated in the survey.

The highest level of use of technological innovations is noted in enterprises that are engaged in the production of cars, trailers and semi-trailers (29% of enterprises) and other vehicles (27%).

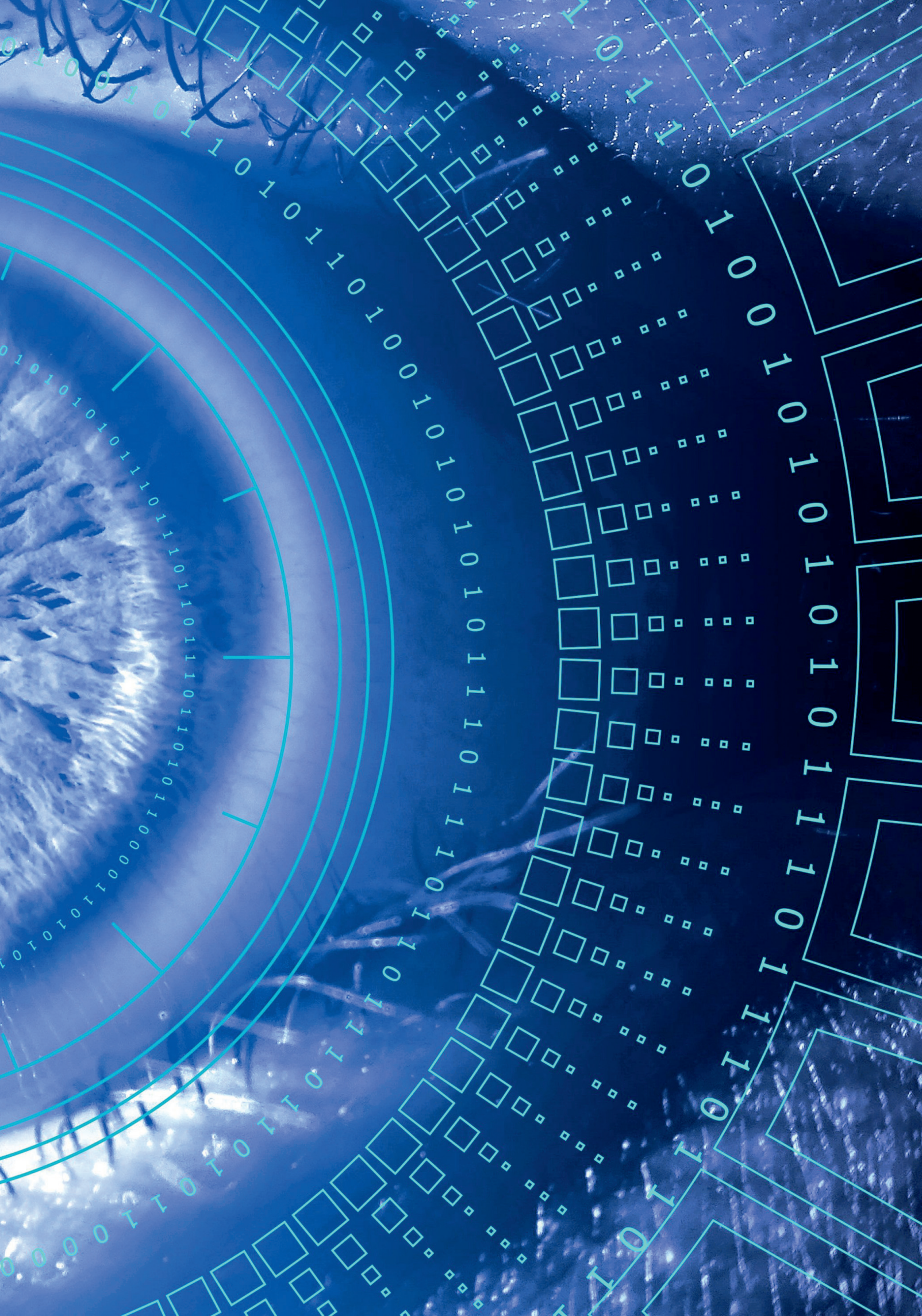
The industry leader in the implementation of organizational innovations among machine builders is the «Production of computers, electronic and optical equipment» - 27% of the enterprises in the industry use this type of innovation.

Today, under the influence of global technological trends, the machine-building complex is undergoing a significant transformation. Kazakhstani manufacturers have the opportunity to compete with other enterprises not by expanding production, but by robotization and digitalization, customized product offerings, and widespread use of the latest technologies and materials.

The introduction of these areas will contribute to the gradual transition of the industry from large vertically integrated machine-building plants to compact production sites.

The current situation in the industry can be improved by effective support from the state for those enterprises that will introduce advanced technologies on a large scale.

# 3. THE FUTURE OF MECHANICAL ENGINEERING IN THE EYES OF INDUSTRY EXPERTS



# 3.1.
## EXPERT OPINIONS

YERZHANOV
UMIRSERIK
KUZTAEVICH

Executive Director
of the Association
of the Union
of Mechanical Engineers.

The crisis of 2008-2009 turned out to be favorable for the industry - devaluation and customs problems made it possible to focus attention on the domestic market.

The situation is similar today. Large companies such as KazMunayGaz, Kazatomprom, Kazakhstan Temir Zholy, as well as the quasi-public sector and will try to focus on the products of the domestic market.

As a result of the adoption of the State Program of Industrial and Innovative Development of Mechanical Engineering of the Republic of Kazakhstan, six branches of mechanical engineering were declared priority. It was decided to provide these industries with benefits on a priority basis and create conditions for their development.

This contributed to the fact that, for example, the railway sector was successfully launched. The manufacturing of final products - locomotives, passenger cars, freight cars - began in Nur-Sultan, Ekibastuz and Petropavlovsk. Covering the needs of the domestic market, the products also began to be successfully exported to foreign markets. Now almost the entire mobile fleet of old locomotives on the railway has been replaced. New enterprises are opening in railway engineering, which contribute to the development of the industry. For example, the Prommashkomplekt plant in Ekibastuz has mastered the production of wagon wheels.

If we consider electrical

engineering, then Kazakhstani enterprises produce transformers, capacitors, batteries, cables and wires, etc. The industry began to develop in a more technological direction, in the future we will be able to produce final products from our ore.

A striking example is batteries. If in the 90s there was a dream to produce about 200 thousand accumulators, in the early 2000s - a million accumulators, then today the output reaches already three million. At the same time, the main raw material for production is Kazakhstani lead. Batteries are used not only domestically, but are also successfully exported to China, Europe, Russia, Belarus and other countries.

Low and high power transformers are produced at factories located in the cities of Kentau, Shymkent and Uralsk. These enterprises manufacture products using modern technology and meeting the standards of European countries.

In Kazakhstan, there is a unique and unparalleled production of capacitors in the city of Ust-Kamenogorsk, which has no analogues on the territory of the CIS countries. Capacitors are reactive power compensators, energy-saving equipment that is in demand among energy-saving organizations. More than 70% of products are exported.

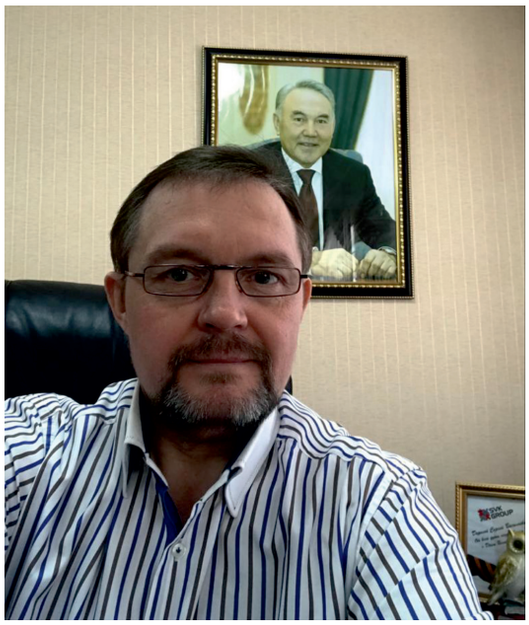
I have worked at the factory for many years. I constantly noticed that graduates of universities and colleges have to retrain directly on the job. For this, mentors are involved who help young people to take their first steps. In those enterprises where the work of mentoring is well organized, there are no problems with young personnel.

**But the professionalism of young specialists in the first place still depends on them. Whether he wants to work and master a new profession or not. And necessarily young personnel, and not only young ones, all must constantly improve their level of professional qualifications and master the skills of working on new equipment.**

And the enterprises themselves should send their employees for training, so that they have an incentive to stay at the plant. I believe that in enterprises with a high level of staff turnover, management does not care enough about their employees, and as a result, industrial equipment is idle and not used at full capacity.

It is necessary that employees feel cared for in relation to themselves, so that they have the mood to go to work with a desire. I would like the specialist to come to the plant, change into clean overalls, have lunch on time, and wash after the shift.

THE ENTERPRISES THAT IMPROVE THEIR TECHNOLOGIES, TAKE CARE OF THE CLEANLINESS AND COMFORT OF THE WORKPLACES, TODAY WORK EFFICIENTLY - WITHOUT PRODUCTION STOPPING AND STAFF FLOW. PEOPLE WHO WORK IN SUCH CONDITIONS HAVE AN OPPORTUNITY TO DEVELOP, AND, THEREFORE, THE RETURNS FROM THEM ARE MUCH HIGHER. UNDER THESE CONDITIONS, I THINK, IT WILL BE POSSIBLE TO SOLVE THE PROBLEM OF STAFF SHORTAGE IN MACHINE BUILDING.



# KAMAEV SERGEY VASILIEVICH

Director of Kazgidromash LLP,
Director of KazPolymer LLP

**Sergey Vasilievich, how do you assess the current development of mechanical engineering in Kazakhstan? Name three key events over the past five years that, in your opinion, have had the most significant impact on the industry in Kazakhstan.**

After a difficult situation in the 90s, we stabilized the situation and made a good start for the development of the industry in the future. I believe that we are at the stage of transition to sustainable development. Of the significant events for us, I would like to note the organization of industry events and sites, such as «AMM» - Mining and Metallurgical Congress and «Creating Kazakhstani». Of the real instruments, the programs of NPP «Atameken» and the Entrepreneurship Development Fund «Damu» are significant.

**In your opinion, under the influence of what trends is the development of mechanical engineering currently taking place in the world? Name three trends that will have the greatest impact on the development of domestic mechanical engineering in the next 10-15 years? What changes in the future will take place in the industry under the influence of these trends?**

Since the world is now moving towards digitalization of processes and automation of production, I believe that these trends will have the greatest impact on mechanical engineering. Thanks to the virtualization of production preparation, automated control and systematization of processes, changes will occur both within machine-building enterprises (the production process and the emergence of new specialties) and will affect the manufactured

products (accuracy, cost price, production time).

**Please name three technologies that, in your opinion, will have a greater impact on the development of domestic mechanical engineering in the near future? How will the industry change with the introduction of these technologies?**

3D production technologies and quality control have great prospects. I believe that the domestic mechanical engineering needs the development of new methods for obtaining workpieces for small-scale production (precision casting or deformation), which will ensure the avoidance of additional processing. Replacing metals with composites and new methods of hardening materials also have prospects, in my opinion.

**Sergey Vasilievich, how do you see Kazakhstan's mechanical engineering in 10-15 years? In what direction will it change? What level of technological development will it reach, what products will be produced, etc.?**

I believe that in Kazakhstan we must develop the use of the most modern technologies of high-precision mechanical engineering, as well as secondary use of raw materials. The mandatory introduction of digitalization and automation (robotization) should become the norm and ensure high production standards. It is necessary to focus on import substitution. This is especially true for the development of the production of precise, complex units of equipment for the extraction and processing of minerals. At the same time, to create a reserve for the future production of robots for domestic use.

**Please tell me, the absence of which specialists are currently holding back the development of your company and the industry as a whole? What is the reason for the absence of these specialists?**

The difficulties today concern engineering workers. These are designers, technologists, etc. Also, there are not enough CNC machine operators who are ready to learn over time and move on to new systems of machine tools. I believe that one of the possible reasons is the decline in the popularity of blue-collar occupations. Now is the time of office workers. It is necessary to raise the status and prestige of the person producing the product.

**In your opinion, which new professions may appear in the mechanical engineering industry in the next 10-15 years, and which ones will lose their relevance or transform in the future? What employee competencies will be most in demand?**

With the advent of new technologies, of course, professions will also change. In my opinion, there will be specialists in the design and maintenance of robotics. Virtual design, Big Data, reuse of materials will ensure the emergence of new specialties. At the same time, the work of welders, machine operators and operators will change. And such professions as bookkeepers, some warehouse workers, controllers and markers may disappear.

Workers should not worry about this, this is a normal evolution of technologies and specialties. The main thing is that a person is inclined to learn and master new things, as well as have the ability to work with Big Data.

# YERMENOV DAMIR GIZATULLAEVICH

Deputy Director
of the Department
of Civil Production and MTC
of JSC «NC» Kazakhstan Engineering»

**Damir Gizatullaevich how do you assess the current development of mechanical engineering in Kazakhstan? What three key events over the past five years, in Your opinion, have had the most significant impact on the domestic engineering industry?**

In 2020, the pandemic made certain adjustments. The demand for medical technology, equipment and products grew. At a subsidiary of our company, work began on the development of medical equipment and products, in particular, artificial lung ventilation devices, including modern stationary ones, which in the recent past were unclaimed.

For five years, Kazakhstan has been implementing the Preferential Car Loan Program, which has allowed domestic machine-building enterprises to increase the sale of vehicles.

The dependence of Kazakhstan's economy on world oil prices reduces the budgets of oil operators, which in turn reduces the need for engineering products for the oil and gas industry.

At the same time, the systematic development of the energy sector is observed in Kazakhstan. In particular, work is underway to convert a number of CHPPs to gas, which makes it possible for machine-building enterprises to master various equipment, including non-standard equipment.

There is also a rise in the development of agricultural engineering due to the implementation of the state program for subsidizing interest rates on loans and leasing, as well

as investment subsidies, which provides for reimbursement of 25% of the cost of purchased equipment. It was thanks to investment subsidies that the most problematic issue of the lack of an initial payment for machinery was solved by farmers.

**In your opinion, under the influence of what trends is the development of mechanical engineering currently taking place in the world? What are the main trends that will have the greatest impact on the domestic engineering industry in the next 10-15 years? What changes in the future will take place in the industry under the influence of these trends?**

The EU countries, as well as some successfully developing countries, usually specialize in the production of certain types of engineering products.

Specialization involves the production of goods and the provision of services in amounts significantly exceeding the own needs of the producing country. Thus, the EU countries specialize in the production of machine tool products and equipment for light industry; The USA, Japan and Germany are focused on the production of energy and chemical equipment; large machine tool building is developed in Germany, Japan and China; nuclear and metallurgical equipment is produced in the USA, Japan, Germany, France and Russia.

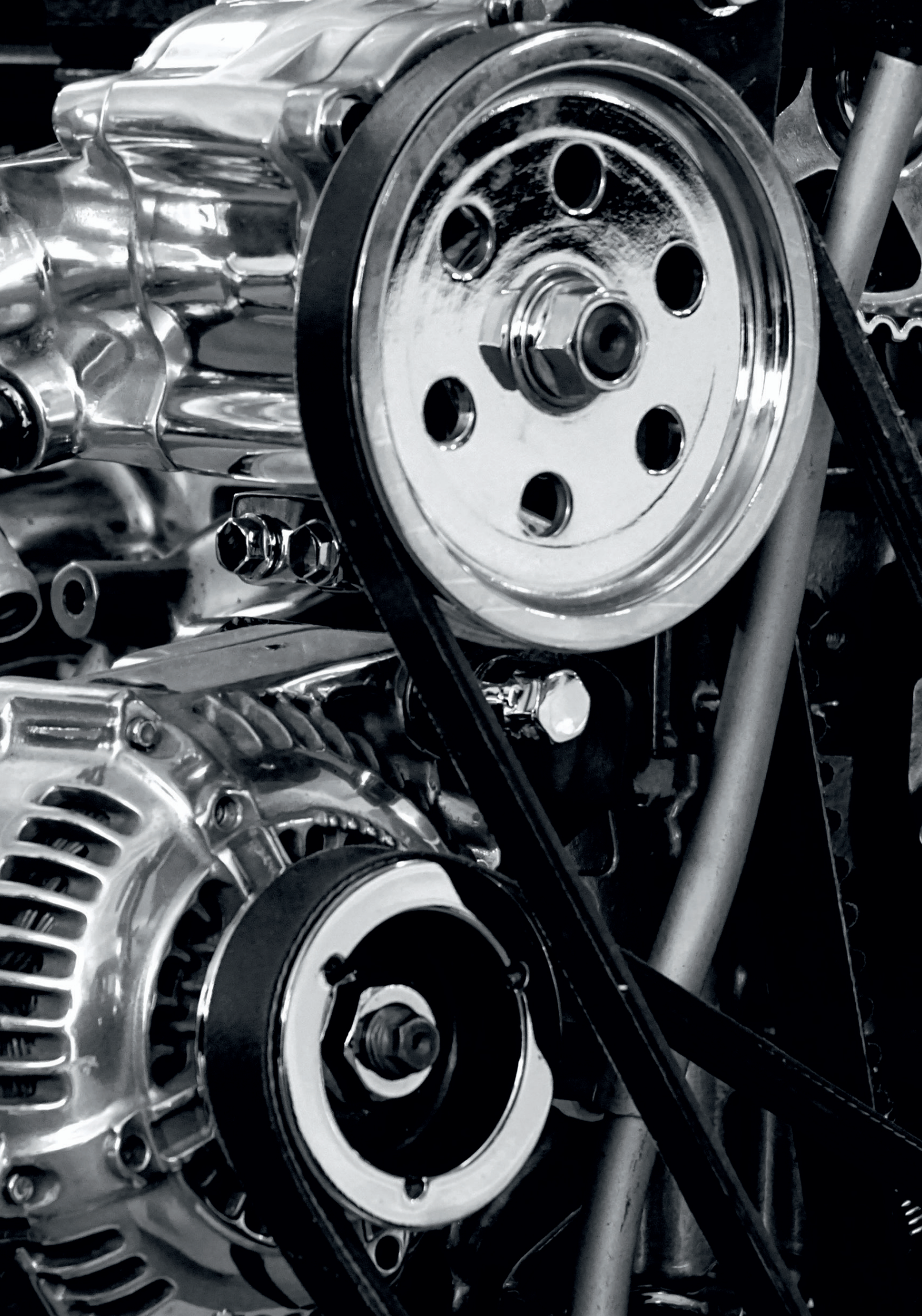
The country's powerful industry is innovative production, primarily in the engineering industries, with a high share of added value in the output to meet the needs of both the domestic and foreign markets.

Leadership in the world market of mechanical engineering products is ensured by specialization, concentration and cooperation of production, innovative product and pricing policy, government support in conquering new markets when selling products of domestic producers.

The growing needs of citizens of the state can be satisfied only on condition of highly productive and meaningful work in all spheres of life, including mechanical engineering. At the same time, it is important to study, generalize, introduce and improve the advanced foreign and domestic experience of the functioning of traditional branches of mechanical engineering, as well as the advanced development of science-intensive, innovative technological processes for the production of products with a high share of added value. An example is the state policy of industrial development in China, USA, Germany, France, Japan, Russia, Brazil, India, Singapore and a number of other countries.

**What technologies, in your opinion, will have a greater impact on the development of domestic mechanical engineering in the near future? How will the industry change with the introduction of these technologies?**

In my opinion, in the near future the following technologies will have an impact on the development of domestic



mechanical engineering: robotics; Information Technology; electronic industry.

However, given the presence of a small market, due to the small number of the population of the Republic of Kazakhstan, high competition, the engineering industry will not change much.

Damir Gizatullaevich, how do you see Kazakhstan's mechanical engineering in 10-15 years? In what direction will it change?

In 10-15 years, given the low attractiveness to the mechanical engineering industry due to its long payback period, the crisis, Kazakhstan's mechanical engineering will not change much and will remain in the third or fourth technological order. Perhaps a small part of domestic machine building companies will reach the fifth technological level.

Please tell me, the absence of which specialists are currently holding back the development of your company and the industry as a whole? What is the reason for the absence of these specialists?

The biggest constraint on the development of the company and the industry as a whole is the lack of top managers who are able to bring the machine-building industry to a new technological level.

In your opinion, which new professions may appear in the mechanical engineering industry in the next 10-15 years, and which ones will lose their relevance or transform in the future? What competencies of employees will be most in demand.

The following professions will lose their relevance in connection with the introduction of automation or are transformed, for example, a gas welder, a gas cutter, a mechanic of mechanical assembly works.

Since 2010, the development of the sixth technological order began in the world, according to which there is a need for the emergence of new professions.

For example, a designer of future technologies, a developer of IT interfaces in mechanical engineering, an interface designer in robotics, a designer of nanotechnological materials.

High-tech equipment at machine-building plants will become more and more modular and distributed, thereby ensuring a quick transition to the development of a new product line. Employees of such factories will quickly form highly effective teams, including people with the necessary knowledge and skills, who are able to quickly solve specific production problems. The most demanded competence will be the ability to implement the convergence of nano-, bio-, info- and cognitive technologies.

# 3.2.
# INDUSTRY DEVELOPMENT FORECAST

Can the future be predicted? Especially in such a complex industry as mechanical engineering? Of course, this is not easy to do.

Nevertheless, industry experts, representatives of research organizations and personnel training, tried to look 10-15 years ahead and assess how Kazakhstan's mechanical engineering will develop in the near future. As a result, a number of forecasts related to the most important aspects of the industry's development were formed.

# FORECAST # 1

## MECHANICAL ENGINEERING OF KAZAKHSTAN HAS OPPORTUNITIES FOR SUCCESSFUL DEVELOPMENT IN THE NEXT 10-15 YEARS, BUT NOT ALL ENTERPRISES ARE READY FOR THE FUTURE CHANGES

**60 %**

- Experts are positive about the future of the industry.

**41 %**

- Of these believe that the industry will develop successfully.

**19 %**

- We are confident that everything will be stable and the situation will not change.

**31 %**

- Experts found it difficult to unequivocally assess the future

**9 %**

- Experts see a negative scenario for the development of the industry.

Despite the existing problems in the industry, 41% of experts believe that mechanical engineering in Kazakhstan will develop successfully in the next 10-15 years. And the positive attitude of machine builders is not unfounded.

Indeed, even in such a difficult period, when the economies of all countries were in a fever from the pandemic caused by the coronavirus infection COVID-19, when enterprises could not work at full capacity, the domestic mechanical engineering in 5 months of 2020 showed an increase in production by 18.5% compared to with the same period last year.

And in order to effectively support manufacturers, work is being carried out in Kazakhstan to introduce Industry 4.0 technologies.

For example, the Ministry of Industry and Infrastructure Development of the Republic of Kazakhstan is implementing a project to create 7 model digital factories, three of which relate to the mechanical engineering industry:

- JSC «Kentau Transformer Plant»;
- Karlskrona LC AB LLP;
- and Almaty Ventilator Plant LLP.

The results of individual enterprises are certainly encouraging. But what about the readiness of the industry's enterprises for the large-scale introduction of the latest technologies?

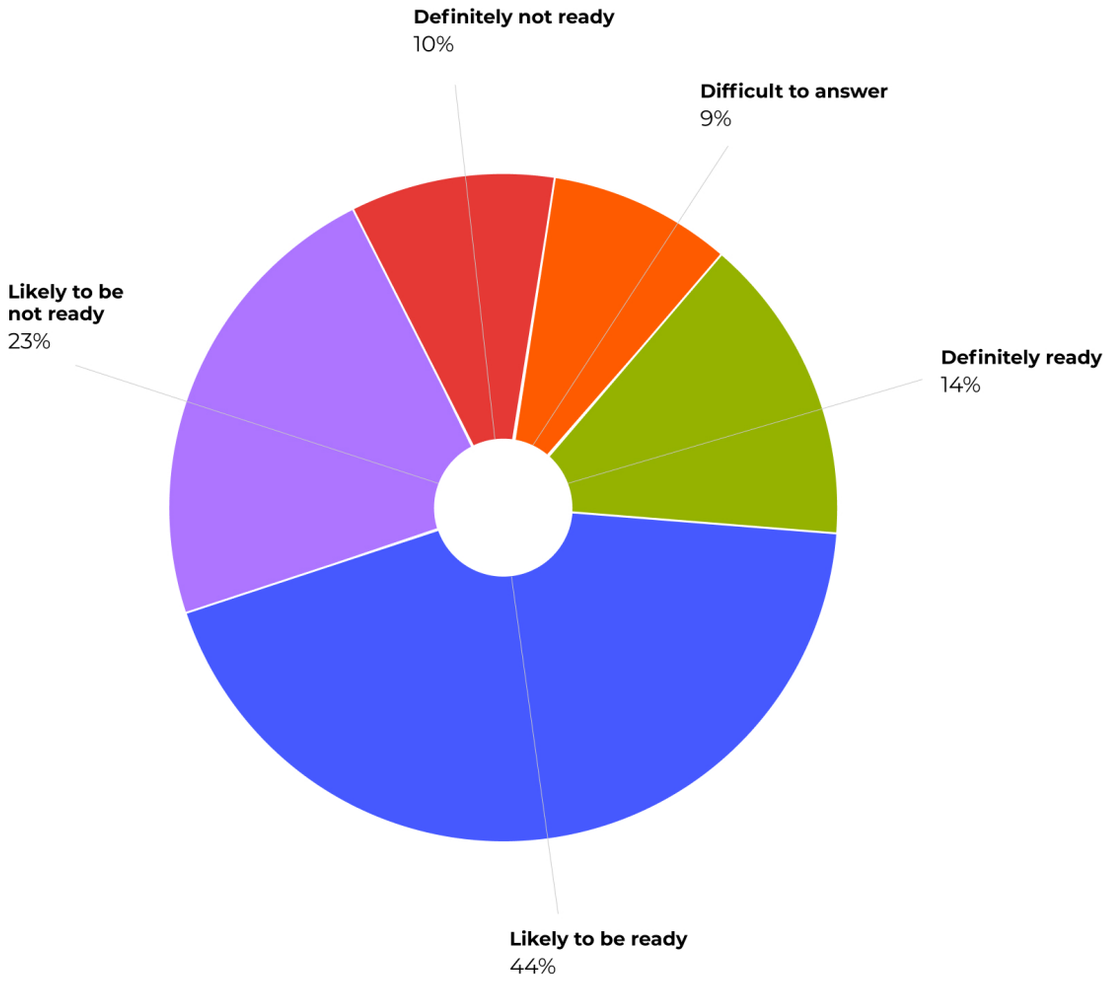
According to 58% of industry experts, enterprises are already ready for the upcoming changes,

and 14% of them are unequivocally sure of this.

However, a third of experts doubt the industry's readiness for changes, and 10% of them are sure that enterprises are definitely not ready for this. At the same time, it should be understood that the readiness of enterprises to transform the industry is not only the introduction of robots and intelligent equipment at production sites. It is also a set of measures to change approaches to enterprise management, retraining of working personnel and training of young personnel.

Diagram 3.1

***Assessment by experts of the readiness of industry enterprises for the upcoming changes***

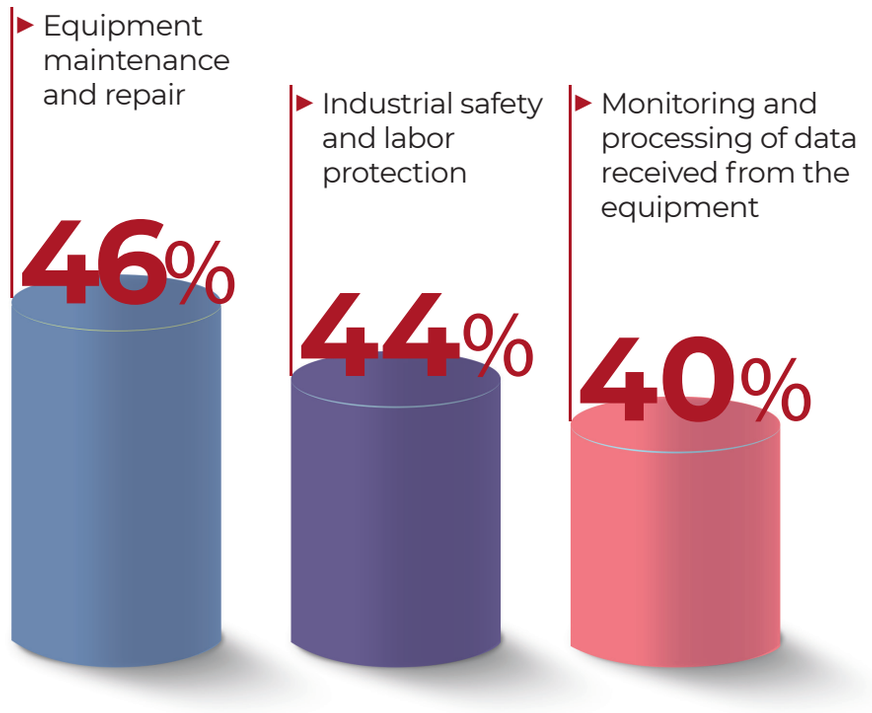



Source: Survey of industry experts.

# FORECAST #2

## TECHNOLOGICAL BREAKTHROUGH LEADERS WILL BE THE SPHERES OF MAINTENANCE AND REPAIR, INDUSTRIAL SAFETY AND DATA MONITORING

Industry experts suggest that the greatest technological breakthroughs can be expected in the following business areas:




## EQUIPMENT MAINTENANCE AND REPAIR

Machine tools and machines are the foundation of mechanical engineering enterprises. They must be constantly maintained in working order. Today, the field of maintenance and repair of equipment is developing under the influence of the following trends:

- the complication of industrial equipment designs, which in turn increases the

requirements for sensors controlling the course of their operation;

- transition to comprehensive equipment maintenance;
- reduction of time costs for equipment repair;
- demand for logistic support and maintenance of the automated lines and robots being introduced before the end of their application;
- an increase in the scale of implementation of CALS technologies, with the help of which industrial automated enterprise management systems are integrated into one common multifunctional system;
- ▸ demand for personnel of a new formation, with less clear boundaries for specialization, but a higher level of professional training.

Considering that obsolete equipment is still used in mechanical engineering, that not all enterprises in the industry can afford to introduce modern robotic systems, then the issues of maintenance and repair are of paramount importance. And without a technical breakthrough in this area, it will be difficult to create competitive products.

## NDUSTRIAL SAFETY AND LABOR PROTECTION

The trend of the proliferation of robots and automated systems facilitates the hard work of machine builders, but at the same time creates new requirements for organizing the safety of the workplace for personnel.

There is an increase in the share of industry workers working in hazardous working conditions that do not meet sanitary and hygienic standards from 12% in 2015 to 15% in 2019.[7]

At the same time, if in 2015 the number of workers working on equipment that did not meet safety requirements was 122 people in mechanical engineering, then in 2019, all equipment of enterprises was brought in line with these requirements.

The statistics of industrial injuries, although in general, show a relative improvement in the situation - the number of injured in accidents related to work-related disability, in 2019 compared to 2015 in the manufacturing industry decreased by 17.8%.

[7] Information and analytical system «Taldau» of the Committee on Statistics of the Ministry of National

However, the rate of severe injury and fatality remains the same.

Therefore, the enterprises of the industry cannot avoid the introduction of modern technologies for ensuring the safety of personnel and methods of organizing this work at their production sites..

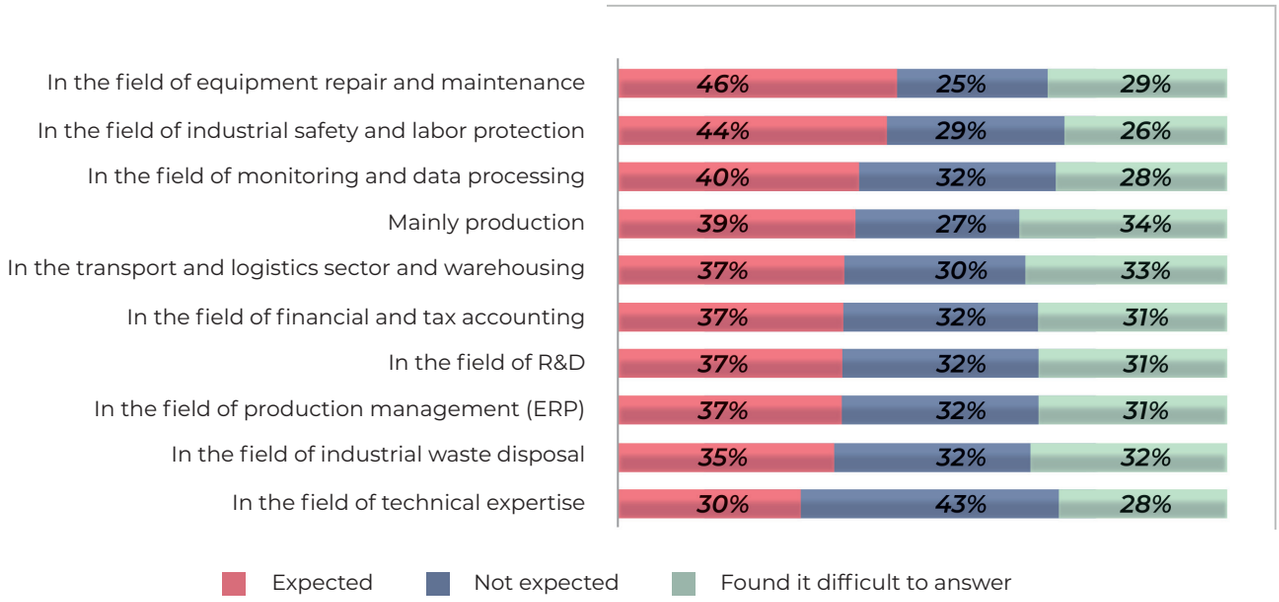
## MONITORING AND DATA PROCESSING

In order to quickly detect malfunctions in the operation of industrial equipment and prevent injuries in the workplace, manufacturers are introducing intelligent equipment at production sites.

Since the volume of collected data on the current state of equipment tends to grow rapidly, machine builders need to constantly monitor trends in technology development in the field of monitoring and processing data from various reading devices. After all, a technological breakthrough in this area will lead to a decrease in injury rates, a reduction in equipment downtime, a decrease in the loss of working time, and, as a consequence, to an increase in the efficiency of enterprises.

Diagram 3.2

***Assessment of the likelihood of a qualitative technological breakthrough in various fields of engineering in the next 10-15 years.***




SOURCE: Survey of industry experts.

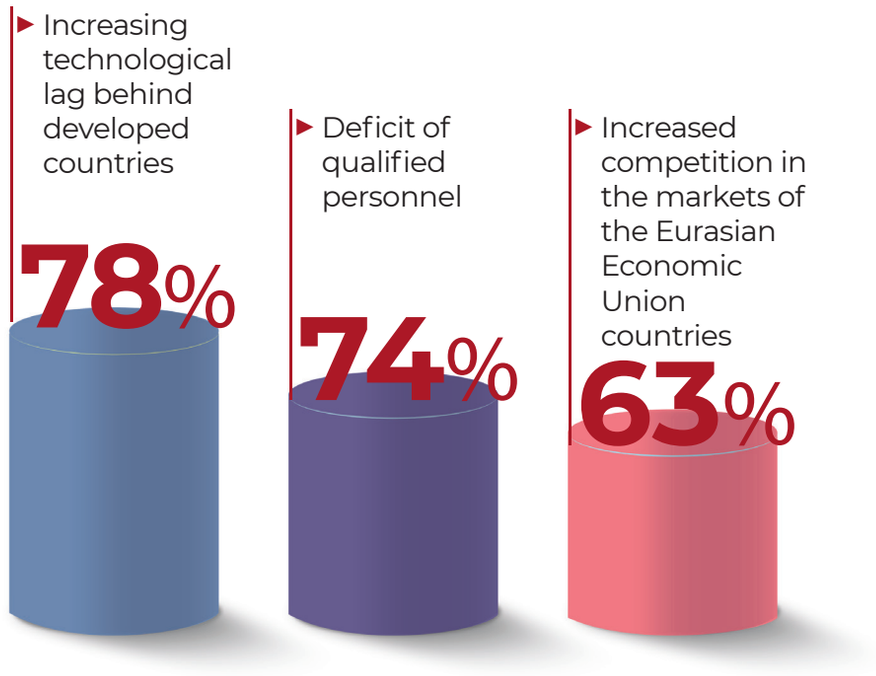
And I would like to draw your attention to one more point. During the survey, from 26% to 34% of industry experts showed some uncertainty in assessing the likelihood of large-scale implementation of advanced technological solutions in various fields of engineering.

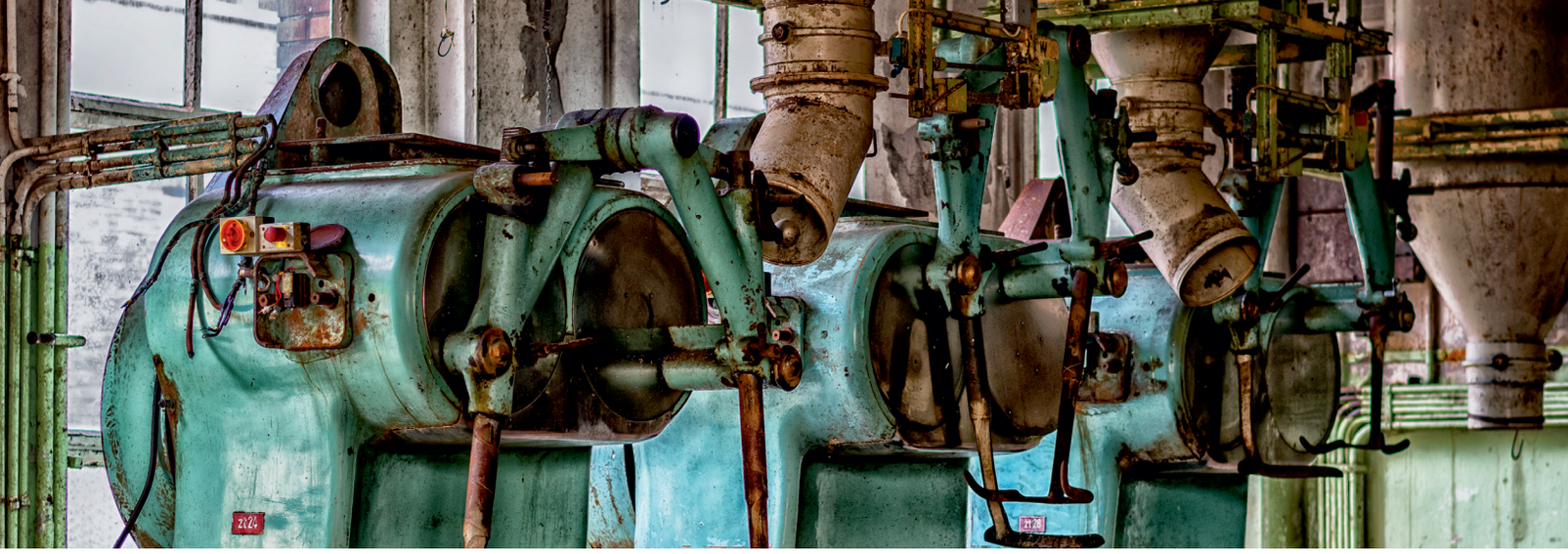
It is worth noting, however, that most of the experts who found it difficult to give an unambiguous answer to this question are experts in the field of support services and training. On the one hand, this is understandable - these experts are not directly involved in production processes. On the other hand, it is alarming. After all, if the system of our education does not see what the mechanical engineering of the future will be like, in which direction it will develop, then the question is brewing: to what extent are the curricula of universities and colleges focused on the needs of the industry for the next 10-15 years, and are they ready to train a new generation of mechanical engineers?

## FORECAST #3

THE MAIN PROBLEMS OF FUTURE MACHINE BUILDING MAY BE INCREASED TECHNOLOGICAL LACKING FROM DEVELOPED COUNTRIES, LACK OF QUALIFIED STAFF, AS WELL AS INCREASED COMPETITION IN THE MARKETS OF THE EURASIAN ECONOMIC UNION COUNTRIES

***The main problems of mechanical engineering identified by experts***





There have always been problems in the sectors of the economy, some have an insignificant effect on the development of enterprises, others, on the contrary, have a significant impact. Experts in the field of mechanical engineering have formed a rating of the problems that, in their opinion, they are more likely to face in the next 10-15 years.

To increase the information content of the obtained results, we used the index of the likelihood of risk occurrence.[8]

The index shows the percentage of the number of experts assessing the possibility of future risks as "high" or "medium", more or less than the number of experts assessing this probability as "low" ... The higher the index value, the higher the assessment of the likelihood of risk occurrence.

## NCREASING TECHNOLOGICAL LAG BEHIND DEVELOPED COUNTRIES

Industry experts are concerned that the level of development of mechanical engineering is lagging behind developed countries.

Domestic enterprises are already seriously inferior in terms of the implementation of robots, intelligent equipment and digital technologies, as well as the use of construction materials. And over time, if you do not take decisive steps towards the modernization of enterprises, this lag can only increase.

Untimely transition of the industry to Industry 4.0 technologies may negatively affect the competitiveness of the industry not only on the external, but also on the internal markets, as well as on the indicators of production profitability.

[8] The risk probability index shows how pessimistic the experts are about the future of mechanical engineering. The indicator is calculated as the difference between the sum of the answers «high» and «medium» probability and the answer «low probability». The index can take a value from -100 to 100 points. The higher the value of the index, the higher the assessment of the prospects for the emergence of risks. Zero value fixes the balance of optimistic and pessimistic forecasts.

## LACK OF QUALIFIED STAFF

The lack of qualified personnel at mechanical engineering enterprises is already becoming a common phenomenon. The older generation goes on a well-deserved rest, young people strive to get a more prestigious, in their opinion, education in the financial sphere, information technology. But young people are not very interested in obtaining professions of blue-collar specialties. Many people associate professions in mechanical engineering with hard physical labor, increased noise levels, and pollution of workplaces. But the maximum automation of workplaces contributes to the reduction of manual labor and the creation of clean and comfortable workshops and workplaces. The only thing that needs to be conveyed to the younger generation. And this requires close cooperation of machine builders with schools and senior students.

## STRENGTHENING COMPETITION IN THE MARKETS OF THE EURASIAN ECONOMIC UNION COUNTRIES

It is known that Kazakhstan is one of the countries of the Eurasian Economic Union, within which favorable conditions are created for all participating countries.

For Kazakhstan, this is the establishment of uniform customs regulations, duty-free trade, integration into global transport hubs with access to the markets of other countries.

The competitiveness of the industry within the Union is determined by the capabilities of the domestic engineering industry to provide a demanded product to the external market. And each country that is part of this union seeks to use the opportunities obtained to achieve the maximum effect, becoming a competitor for our producers.

Consequently, if the modernization stage at domestic machine-building enterprises is delayed, then the products of other countries may turn out to be more technological, economically beneficial in terms of cost and maintenance costs.

To increase the competitive advantages of the industry, it is necessary to adopt the experience of world leaders in such areas as the management and implementation of innovations, the introduction of the latest technologies, the formation of export potential, as well as the reduction of the time required for the introduction of scientific and design achievements into production.

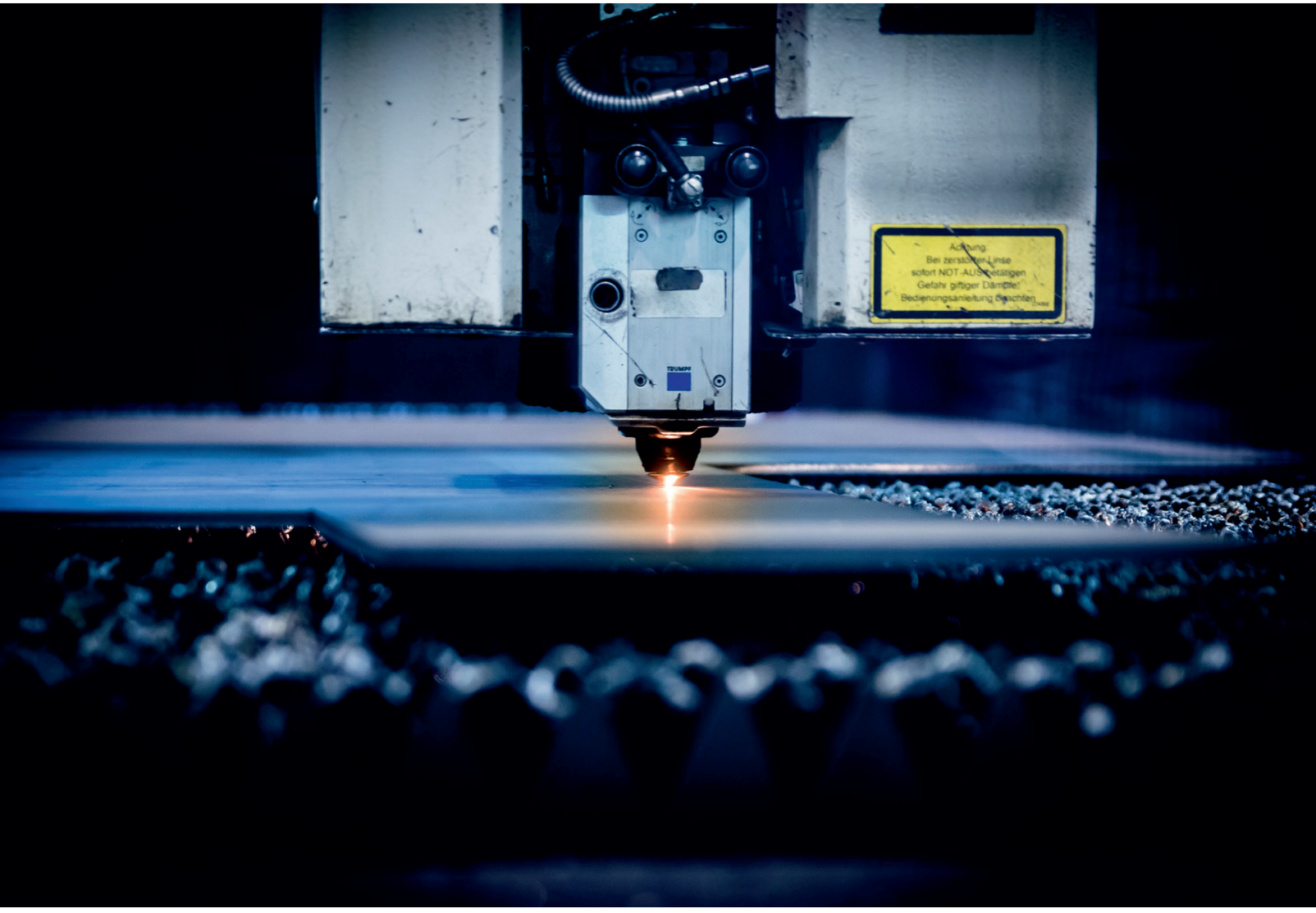
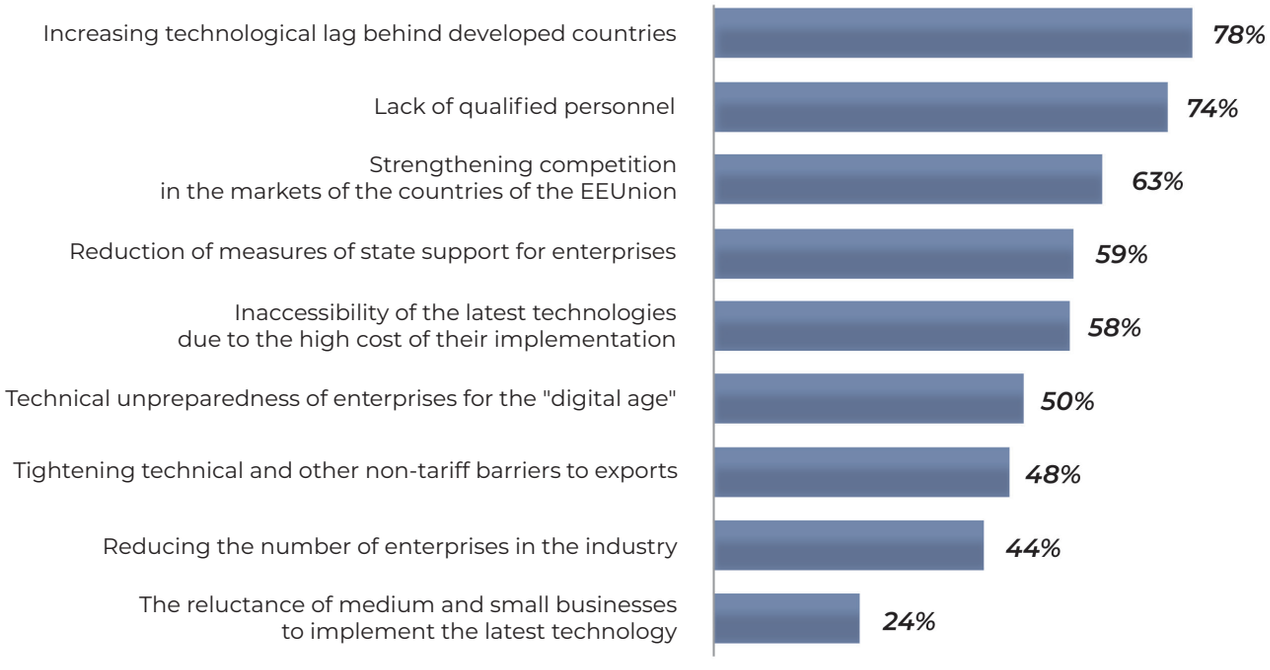


Diagram 3.3.

## *The index of the likelihood of individual risks in the industry in the next 10-15 years*

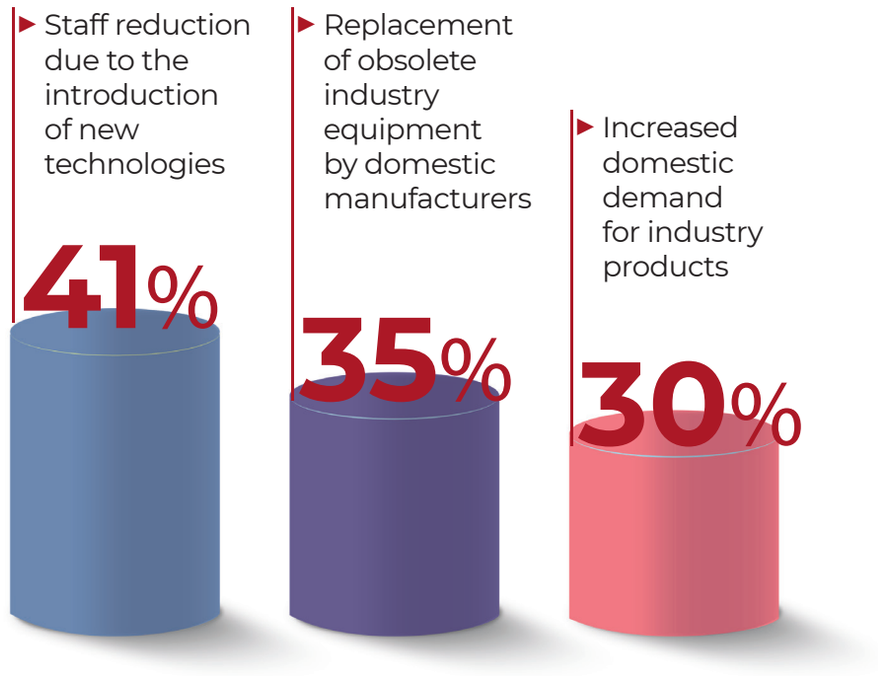



SOURCE: Survey of industry experts.

# FORECAST #4

FUTURE INDUSTRY DEVELOPMENT DRIVERS - SOLVING THE PROBLEM OF STAFF LACK BY THE IMPLEMENTATION OF NEW TECHNOLOGIES, THE DEMAND OF PRODUCTS OF DOMESTIC PRODUCERS

## *Drivers of development of the mechanical engineering industry*




The number of mechanical engineering enterprises has a small but stable growth trend. In the last year alone, the number of operating enterprises increased by 15.4%. This means that manufacturers see opportunities for the development of their enterprises.

Industry experts have formed a rating of potential opportunities, which, in their opinion, are more likely to manifest themselves in mechanical engineering in the next 10-15 years.

To increase the information content of the results obtained, we used the index of the probability of potential opportunities.[9]

The index shows the percentage of the number of experts who assess the possibility of future prospects as "high" or "medium", more or less than the number of experts who assess this probability as "low". The higher the index obtained, the higher the likelihood of an opportunity arising.

## STAFF REDUCTION DUE TO THE INTRODUCTION OF THE LATEST TECHNOLOGIES

Analyzing the answers to all the questions in the questionnaire, we noticed that experts put the questions of personnel in the first place in any situation, be it problems or prospects.

Experts understand that the situation on the labor market will not change dramatically in the next 10-15 years. There will also be a shortage of qualified personnel. And if the technological transformation of the industry makes it possible to reduce the number of working personnel, then the problem of the shortage of personnel will be partially solved. Therefore, in this context, experts consider staff reduction as a potential opportunity. In areas where several specialists worked, it will be possible to use one operator who will monitor the work of several machines or robots at once.

However, in this case, the level of qualification of a specialist should be much higher in order to correctly assess the current progress of the equipment, respond quickly to possible failures and be able to eliminate them. Consequently, already now, and not when the new equipment will be installed, it is necessary to begin to deal with the issues of personnel training, including on-the-job in our own training center.

## DEMAND FOR DOMESTIC ENGINEERING PRODUCTS

At the moment, the products of machine-building plants do not cover the existing demand on the domestic market. It is still difficult for domestic enterprises to compete with Russian, European or Chinese manufacturers in terms of price offer and assortment. At the same time, industry experts see an increase in the demand for their products in the domestic market of the country in the future for 10-15 years. In particular, in the form of replacing an outdated fleet of production equipment in other sectors of the economy.

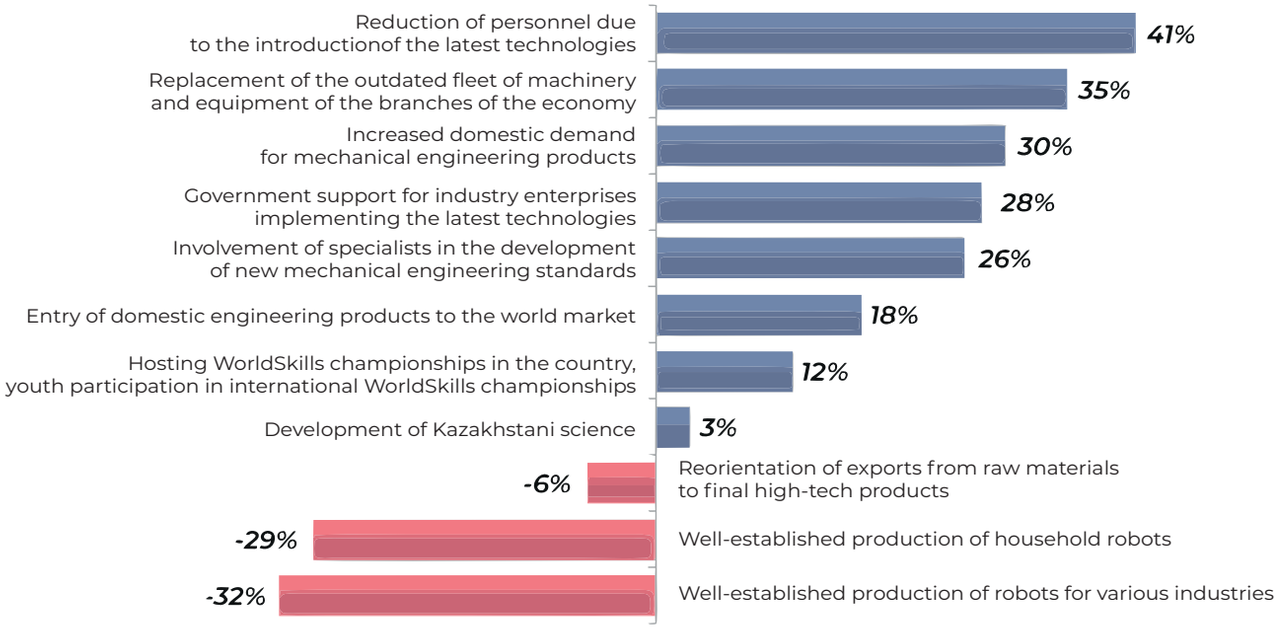
[9] The Potential Opportunity Likelihood Index shows how optimistic the experts are about the future of mechanical engineering. The indicator is calculated as the difference between the sum of the answers «high» and «medium» probability and the answer «low probability». The index can take a value from -100 to 100 points. The higher the index value, the higher the assessment of the prospects for the emergence of opportunities. Zero value fixes the balance of optimistic and pessimistic forecasts, and negative - the prevalence of "low fidelity" answers.


The level of localization of the industry's products may tend to grow with the introduction of tax incentives for enterprises using products of domestic manufacturers. It is worth noting that experts for the next 10-15 years do not see any prospects for the production of industrial and household robots by domestic mechanical engineering, the reorientation of exports from raw materials to the final high-tech products. A larger number of experts chose the "low probability" answer, so the index takes negative values.

There are already significant successes in this direction - enterprises are involved in replacing the rolling stock of tractors and combines in agriculture, railway cars, buses for public transport, and also produce equipment for the mining industry

Diagram 3.4

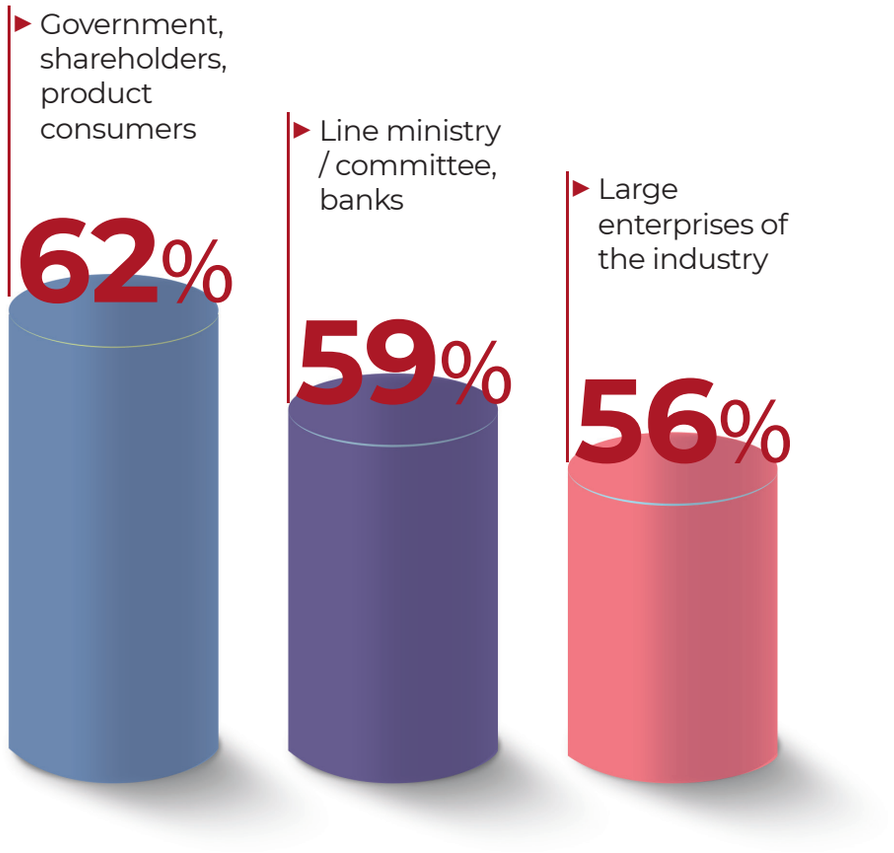
***Probability index of potential industry opportunities in the next 10—15 years***



## FORECAST #5

### FURTHER DEVELOPMENT OF DOMESTIC ENGINEERING WILL DEPEND ON THE POSITION OF GOVERNMENTAL BODIES, SHAREHOLDERS AND OWNERS, BANKS AND LARGE ENTERPRISES OF THE INDUSTRY

Three groups of market participants have the most significant influence on the development of domestic mechanical engineering: government organizations, owners and shareholders of enterprises and major players in the industry, as well as the banking system.



## GOVERNMENT OF THE RK AND LINE MINISTRY

The beginning of the transition to a new round of industrial development, in the near future will lead to the restructuring of a large number of enterprises in the industry.

The large-scale introduction of the latest technologies, digitalization will orient the industry towards the development of new markets.

However, it will be difficult for the enterprises of the industry to master this stage of transformation on their own.

Therefore, the state industrial policy is focused on the development of effective measures to support machine builders.

For example, in 2019, the Roadmap for the development of mechanical engineering for 2019-2024 was approved, according to which tax preferences are provided for enterprises that introduce the latest technologies and increase the production of export products. This increases the investment attractiveness of the industry.

Within the framework of the Productivity 2020 program, mechanisms are being implemented to reimburse the costs of using consulting services, leasing at a reduced interest rate or subsidizing loan rates.

## OWNERS, SHAREHOLDERS AND LARGE ENTERPRISES OF THE INDUSTRY

The influence of this group of market participants on the development of domestic mechanical engineering is highly appreciated by more than half of the survey experts.

Large enterprises set the vector of development for all enterprises in the sector, they try to be equal to them in order to withstand competition in the market of engineering products.

They adopt the experience of introducing automation and robotization. Large enterprises have a great responsibility for the development of the industry in the next decade. The owners and shareholders of the company should also be interested in the technical re-equipment of the domestic engineering industry.

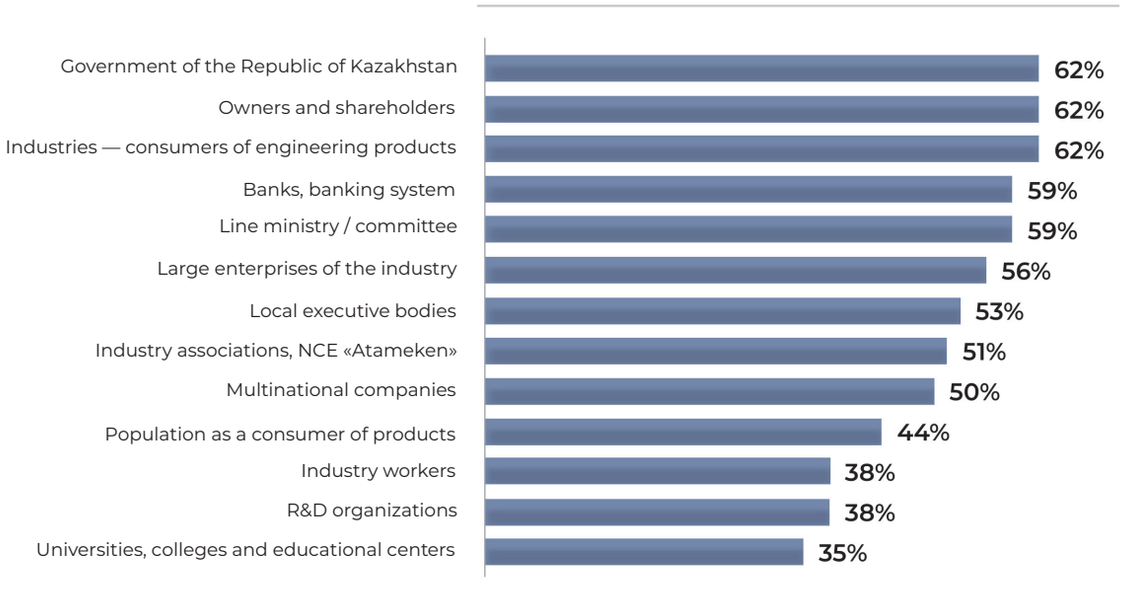
At this stage, without making additional investments in the innovative development of enterprises, it will be more and more difficult to obtain high profits. And without investment, the production of competitive products will be complicated.

## BANKING SYSTEM

The possibility of obtaining loans for equipping enterprises with automation and robotization means on favorable terms, according to industry experts, would give a powerful impetus to the development of mechanical engineering in the country as a whole. In May 2020, at a meeting of the Government, Minister of National Economy R. Dalenov announced a decision to create an industrial development fund, which will deal with issues of providing loans to enterprises in the manufacturing sector at a rate of no more than 3% per annum.[10]

Diagram 3.5

***Rating of the influence of the main market participants on the development of domestic mechanical engineering.***




Source: Survey of industry experts.

[10] URL: https://smkz.kz/kredity-pod-3-godovyx-predostavyat-prompredpriyatiyam/.

# FORECAST #6

## THE FUTURE IS DEVELOPMENT, CONFIDENCE AND POTENTIAL

We all thought at least once about what will happen tomorrow, in five or ten years. What opportunities will open up for us, and what obstacles will appear on the way? Though the future is created collectively, each of us sees it differently.

The experts of the machine-building complex have formed a collective image of the future, in which there are opportunities for the development of personal potential (according to 18% of experts), which gives a feeling of confidence (31%), and most importantly, it is based on constant development (38%). Even though our country lags significantly behind developed countries in terms of the level of technical equipment of enterprises, the experts demonstrated a high level of technological optimism.

Experts want to believe that the level of technology development will significantly change for the better, which in turn will help solve a large number of accumulated problems, including in the machine building itself. Not without pessimistic assessments - 13% of experts still feel a sense of anxiety, looking at tomorrow.

Diagram 3.6

***Vision of the future by industry experts.***


Source: Survey of industry experts.

# TRENDS AND TECHNOLOGIES SHAPING THE FUTURE OF MECHANICAL ENGINEERING IN KAZAKHSTAN

# 4.

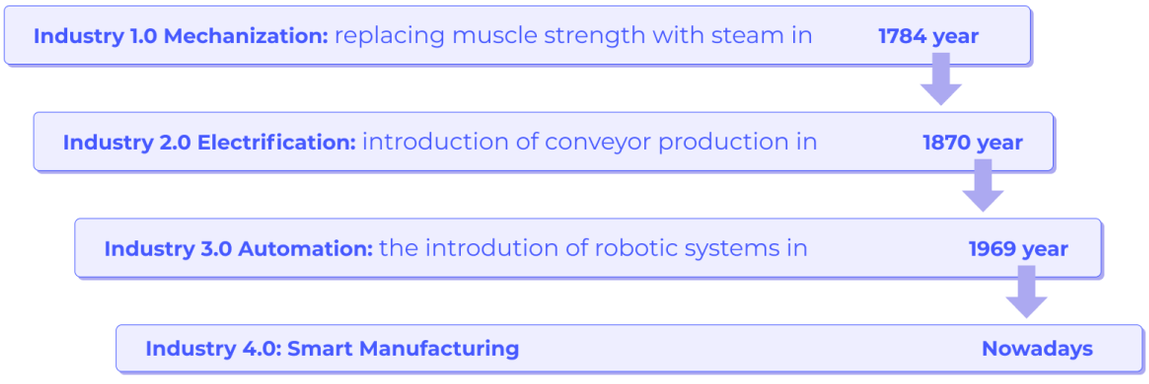
# TRENDS AND TECHNOLOGIES SHAPING THE FUTURE OF MECHANICAL ENGINEERING IN KAZAKHSTAN

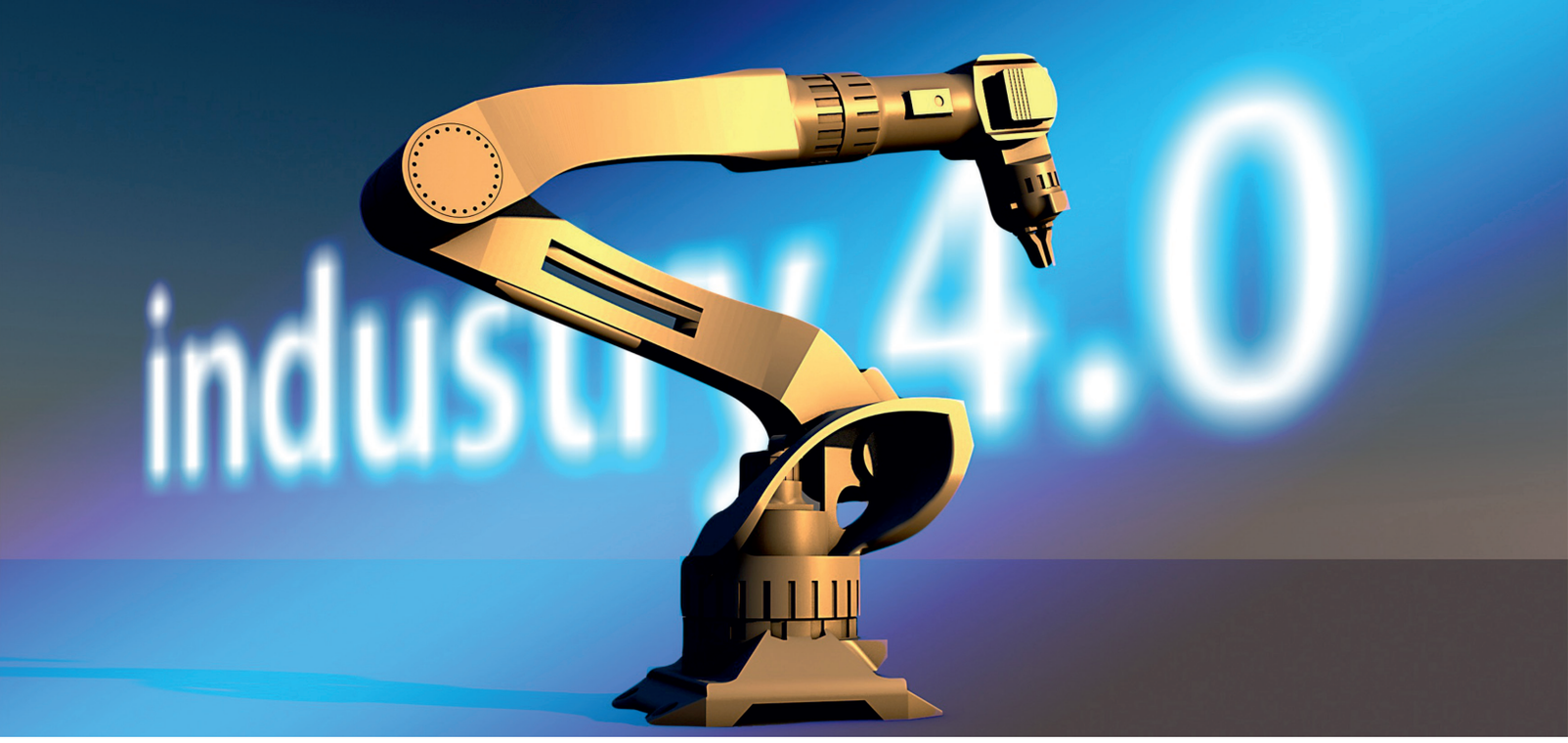
The modern world is characterized by a high rate of implementation of innovative technologies of the fourth industrial revolution and increased competition between companies for bringing a product to the consumer market.

While the first industrial revolution was based on the creation of a steam engine and a mechanical weaving machine, the fourth industrial revolution (Industry 4.0) represents the transition to fully automated digital production, which is controlled by intelligent systems in real time.

Figure 4.1

***Stages of transformation of industrial production.***






The foundation of Industry 4.0 is smart factories that are capable of handling more complex jobs. At such enterprises, not only the share of manual labor is gradually decreasing, but also the number of unskilled personnel released as a result of the introduction of the latest technologies.

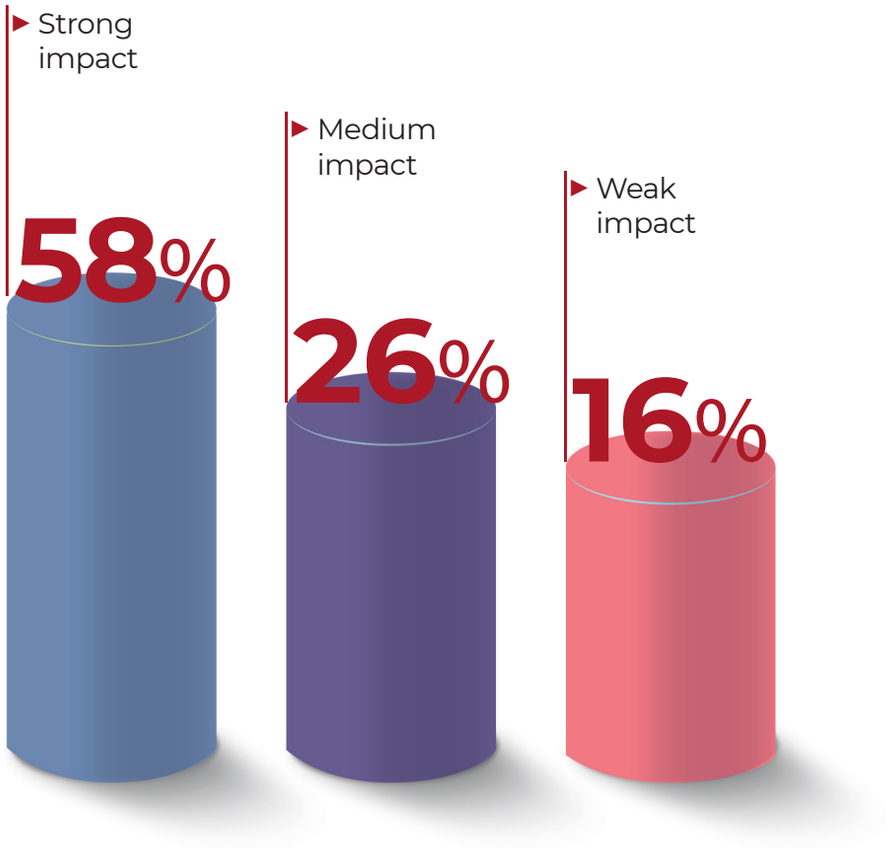
The technological components of the fourth industrial revolution are: the industrial Internet of things, big data analytics, robots with a high level of autonomy and flexibility, composite materials, innovative technologies such as 3D printing, virtual and augmented reality, nanotechnology, etc.

The transformation of mechanical engineering is taking place under the influence of a large number of trends. Industry experts have identified a number of global and industry trends that can be grouped into six leading trends:

- Scaling up the adoption of robots and smart systems
- Expanding the scope of digitalization and big data applications
- Improving the efficiency of resource management in the industry
- Increasing requirements for environmentally friendliness production
- Changing the needs and requirements of the Y and Z generation specialists
- Changing in consumer preferences

# 4.1.
# SCALING UP THE ADOPTION OF ROBOTS AND SMART SYSTEMS

The increase in the scale of implementation of robots and smart systems in the next 10-15 years, according to industry experts, will have a strong impact on the development of domestic mechanical engineering.



Innovative technologies of recent decades have increased the role and scope of application of automated control systems at enterprises of the machine-building complex. Some of the work that was previously performed only manually is now automated and brought to the level of error-free execution.

**By automation and robotization of production sites, manufacturers strive to:**

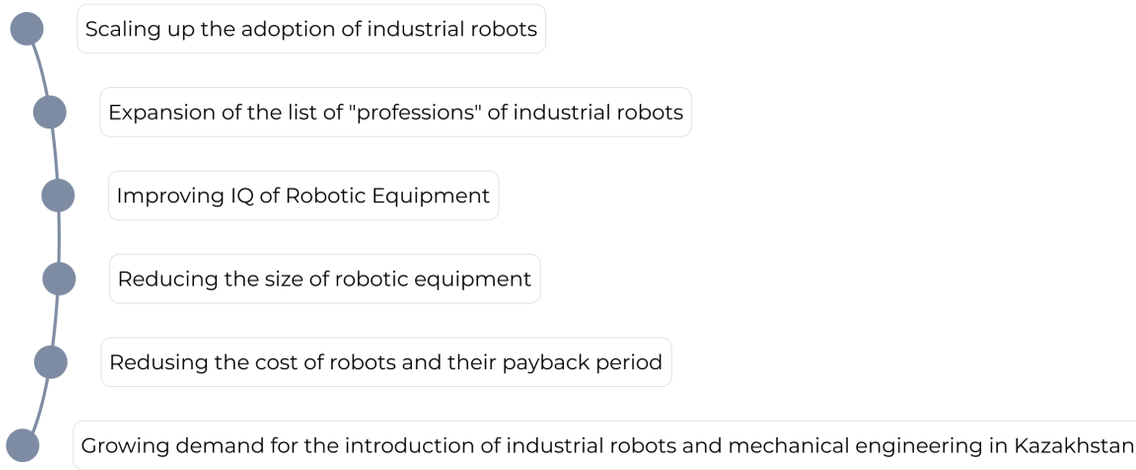
- increase the autonomy of industrial equipment and the safety of personnel interaction with it;
- to increase labor productivity and product quality;
- to reduce the production time of products and the share of manual labor;
- to solve the problem with a shortage of qualified personnel, primarily working specialties.

**The introduction of the new always faces problems, especially when it comes to the latest technologies.**

Most often these are:

- insufficient awareness of insufficient awareness of manufacturers about the potential capabilities of robotic systems and their benefits;
- unfounded concerns about the complexity of implementation and the high cost of not only the equipment itself, but also the cost of its maintenance;
- discrepancy between the functionality of robots and specific production needs.

**In the next 10-15 years, five global trends and one local one will have the greatest impact on increasing the level of robotization of the machine-building complex in Kazakhstan:**



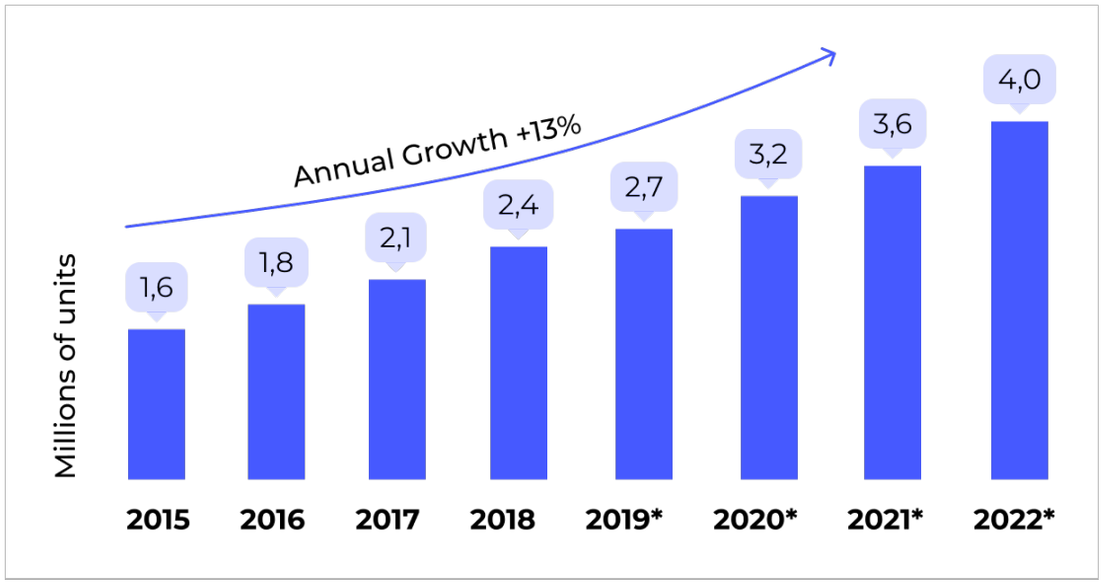
# 1 TREND
# INCREASING THE SCALE OF PRODUCTION AND INTRODUCTION OF INDUSTRIAL ROBOTS

Scientific and technological progress does not stand still. The demand for robotic technology is dictated by the automation of an increasing number of industries, which in turn is a response to increased competition between enterprises for entering both domestic and foreign markets. At the same time, the opposite effect is noted, an increase in the production of robotics and an expansion of the range of functional capabilities, increases the interest of enterprises in using robots at their production sites.

The global market for industrial robots in service reached 2.4 million units in 2018. It is projected to reach 4 million units by 2022, with an annual growth rate of 13%.[11]

Diagram 4.1.

***World market for used industrial robots***




* Forecast

Source: International Federation of Robotics.

[11] IFR, Executive Summary World Robotics 2019 Industrial Robots. — URL: https://ifr.org/downloads/press2018/IFR%20World%20Robotics%20Presentation%20-%2018%20Sept%202019.pdf.

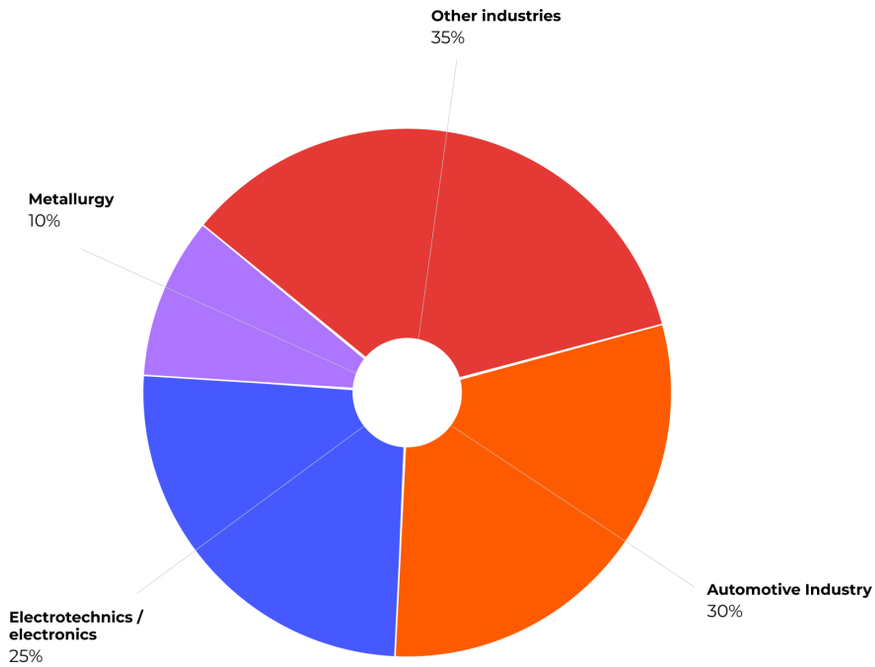
In 2018 alone, according to the International Federation of Robotics (IFR), 422 thousand robots were sold worldwide, and by 2022, sales of industrial robotics will grow by about 12% annually.

In 2018, there were 99 industrial robots for every 10 thousand employees of enterprises in the world. In just four years, this figure increased 1.5 times - in 2015 it was 66 robots per 10 thousand employees. Singapore (831 units) and Korea (774 units) are the leaders in terms of the density of use of robotic technology per 10 thousand workers.

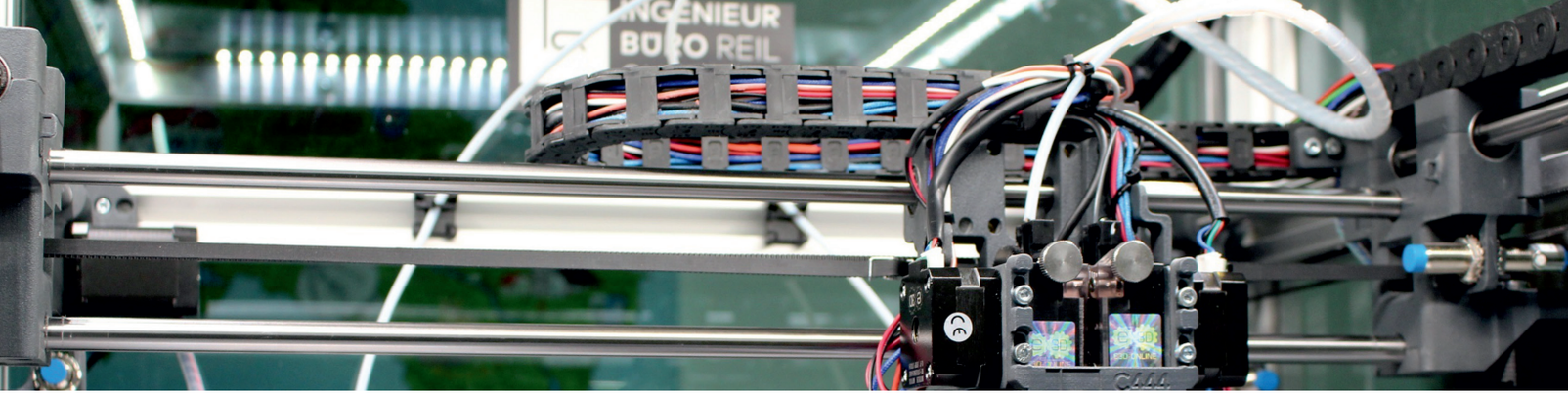
# 2 TREND
# EXPANSION OF THE LIST OF INDUSTRIAL ROBOTICS PROFESSIONS

Three industries account for 65% of all industrial robots used in the world, with the automotive industry - 30%, the production of electrical engineering and electronics - 25%.[12]

Diagram 4.2
***Sectoral distribution of industrial robots***




Source: International Federation of Robotics.



Nowadays, robots are able to successfully replace industrial personnel who are engaged in hard physical labor, and also work in hazardous and harmful working conditions.

The functionality of robots is indispensable at those stages where the work is associated with the performance of monotonous and cyclical operations.

Robotic technology significantly increases the efficiency of personnel in production areas

- welding work;
- mechanical and heat treatment of parts;
- material cutting, gluing and painting works;
- transportation and storage of products;
- product assembly and repair equipments.

This is not a complete list of the fields of application of robots in mechanical engineering, and it is only being replenished every year.

Who could have imagined 20-30 years ago that a robot would independently adjust car fog lights, as the KUKA LBR iiwa robot does at a Ford plant[13], or test the quality of car doors, opening and closing them 45 thousand times in just three days , which the robot Mrs. Doorboto at Nissan.[14]

## TREND EXAMPLE

In Hamburg, the Airbus A320 assembly line employs robots that perform up to 80% of the drilling of the upper fuselage panels. This automation improves work accuracy and optimizes the workspace.[15]

[12] IFR, Executive Summary World Robotics 2019 Industrial Robots. — URL: https://ifr.org/downloads/press2018/IFR%20World%20Robotics%20Presentation%20-%2018%20Sept%202019.pdf.
[13] URL: https://robo-hunter.com/news/na-zavode-ford-poyavilis-roboti-reguliruyshie-svet-far15832.
[14] Robohunter. — URL: https://robo-hunter.com/news/nissan-predstavila-novogo-robota-testiruyshego-dveri-avtomobilei8323.
[15] Robohunter. — URL: https://robo-hunter.com/news/airbus-pokazala-robotov-na-novoi-linii-proizvodstva-lainera-a32011701.

# 3 TREND
# INCREASING IQ OF ROBOTIC EQUIPMENT

Almost 60 years have passed since the world's first industrial robot appeared in 1961. Since then, robotics has changed. Robots and automated systems have become much smarter and more complex in terms of kinematics, the number of tasks to be solved, degrees of freedom and sensors used.

Factories of the future, where robots will produce robots, are already becoming a reality. The construction of just such a plant is currently underway in China by the Swedish-Swiss engineering group ABB. It will be the most technologically advanced plant, equipped with machine learning systems and digital solutions.

The plant itself will be modeled after a digital twin with intuitively configurable control panels.[16]

The main trend in robotics in recent years has been the emergence of robots with elements of artificial intelligence - collaborative robots (cobots) designed to work together with a person on the same work site. According to the International Federation of Robotics, in 2018 the global sales market for cobots amounted to 14 thousand units, which is 23% higher than the level of 2017, when 11.1 thousand units of cobots were sold and installed.[17]

The widespread use of cobots is explained not only by the fact that they are much smaller and designed so as not to endanger the worker who is nearby, but also by the ease of maintenance and the possibility of training in imitation.

Cobots are very easy to use, they don't even need special programs. The operator can simply press the button to record and perform the required actions several times. After that, the cobot independently in autonomous mode can exactly repeat all the operator's movements and then use them in the process.

[16] URL: https://new.abb.com/news/ru/detail/9592/avv-postroit-samuiu-pieriedovuiu-v-mirie-fabriku-robototiekhniki-v-shankhaie.
[17] IFR, Executive Summary World Robotics 2019 Industrial Robots. — URL: https://ifr.org/downloads/press2018/IFR%20World%20Robotics%20Presentation%20-%2018%20Sept%202019.pdf.

TREND EXAMPLE

The Baxter cobot of the German company Rethink Robotics GmbH monitors the efforts and provides feedback on the progress of the process. A feature of Baxter is that there is no need to program each of its actions - the robot is able to memorize and apply in further work even those actions shown by the operator.[18]

# 4 TREND REDUCING THE SIZE OF ROBOTIC EQUIPMENT

As you know, the world's first industrial robot Ultimate was introduced at the General Motors plant in 1961. The control programs for his 1.2 ton hand were then stored on a magnetic drum. And until now, when we mention industrial robots, we imagine a huge object, occupying significant volumes of production areas. Of course, such powerful robotic systems continue to exist, effectively handling the most difficult and difficult areas of work. And one cannot do without them today, and in the next 20-30 years, most likely, too.

However, their smaller brothers appear on the market of robotic technology. First of all, this applies to cobots, which, unlike traditional robots, have less weight, are more compact and mobile, which is especially important in the absence of large production areas at the enterprise.

But even there, progress in further minimizing the size of robots did not stop. For example, researchers at the Wyss Institute at Harvard University have developed a 1.5-gram HAMR (Harvard Ambulatory Microrobot) micro-robot that can move like insects and is considered one of the fastest and most agile at the moment.[19]

Such micro-robots are necessary for working in small or hard-to-reach places , for repair work or monitoring of industrial equipment. Each of the types of robots performs its own range of functional tasks. What type

[18] URL: https://habr.com/ru/company/top3dshop/blog/403323/.
[19] Wyss Institute. — URL: https://wyss.harvard.edu/technology/hamr-versatile-crawling-microrobot/.

of robotic technology to use at their production sites, enterprises decide on the basis of the specifics of production and economic feasibility.

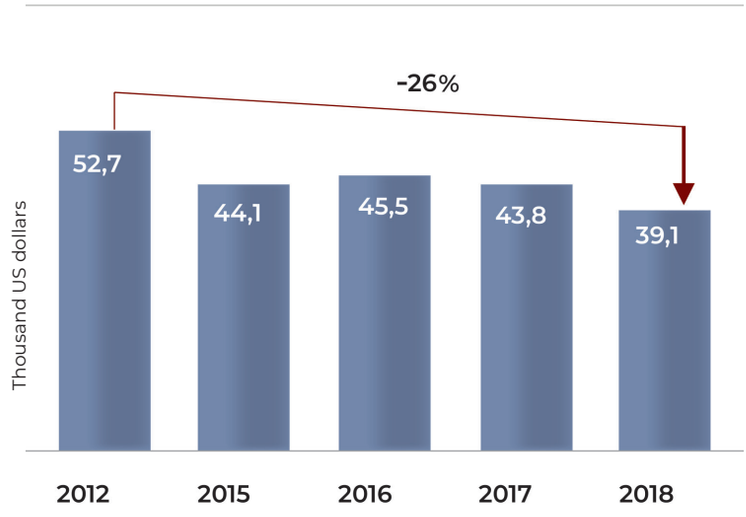
# 5 TREND
# REDUCING THE AVERAGE COST OF ROBOTS AND THE TERMS OF THEIR ROI

It is noteworthy that against the background of expanding the functionality of robots, the average cost of robots is gradually decreasing in the global robotics market.

In 2018, the average price of one industrial robot in the world market was 39.1 thousand US dollars. Compared to 2012, the average cost of robots has decreased by 26%.[20]

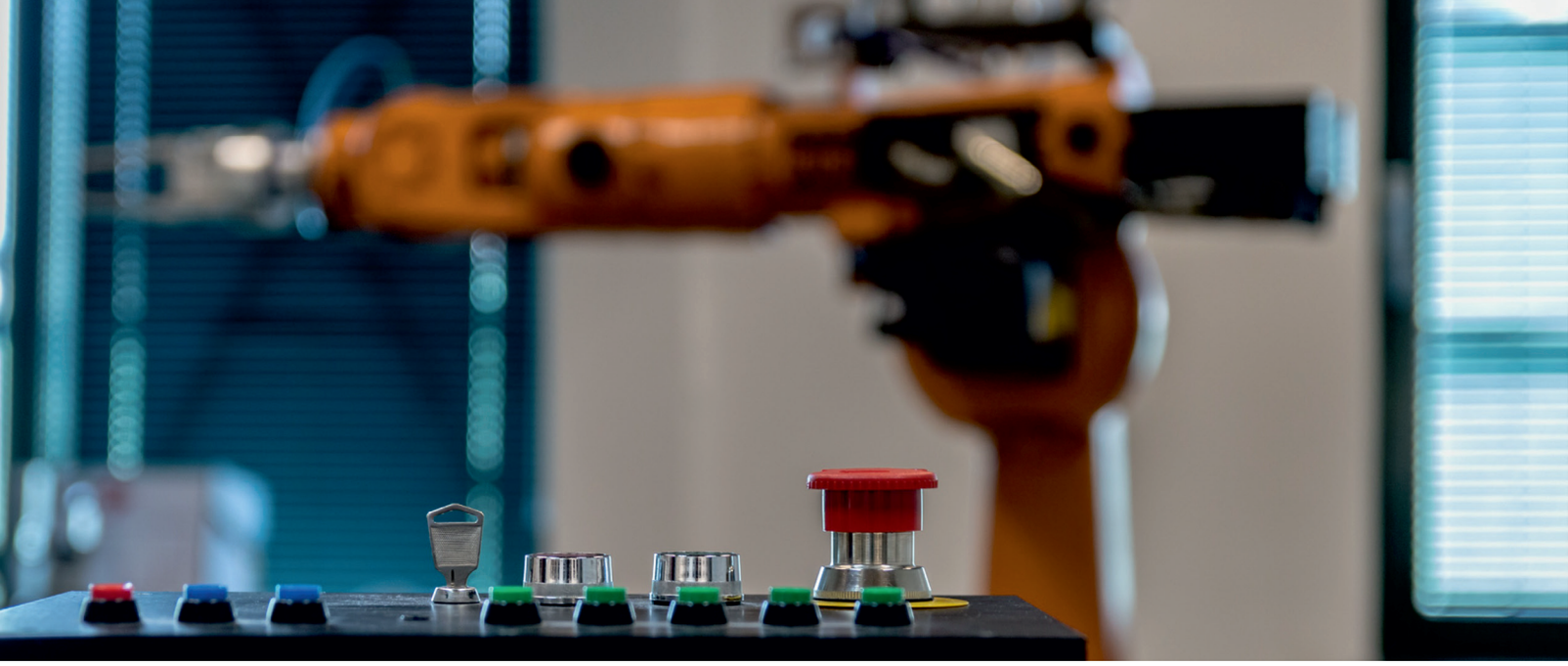
Diagram 4.3

***Estimating the average cost of industrial robots***




Source: Sberbank Robotics Laboratory, Analytical review of the global robotics market 2019.

[20] Sberbank Robotics Laboratory. Analytical review of the global robotics market 2019. — URL: https://adindex.ru/files2/access/2019_07/273895_sberbank_robotics_review_2019_17.07.2019_m.pdf.



However, an increase in demand for robotic equipment is accompanied not only by a decrease in its cost, but also by a payback period for implementation costs.

Many studies have already proved more than once that robotic technology effectively replaces a person and in many countries costs manufacturers less than workers in enterprises. For manufacturers, the introduction of robotization at production sites has a number of advantages:

- reduced labor costs;
- the number of rejects decreases;
- material and energy savings occur;
- Increased production flexibility when introducing new assortments.

All this, ultimately, leads to a decrease in production costs and an increase in the efficiency of the enterprise.

## TREND EXAMPLE

a. At US automobile factories, labor costs are about 15% higher than the cost of purchasing and maintaining robotic equipment. On average, the cost of 1 hour of work of a robot is $ 8, and for 1 hour the employee must be paid $ 25.

b. The Chinese company Changying Precision Technology, replacing 650 workers with 60 robots, in a month was able to triple the volume of parts production and reduce the number of scrap by 80%.[21]

[21] Robotization and wage labor. — URL: https://politsturm.com/naemnyj-trud-i-robotizaciya/.

# 6 TREND
# GROWTHING DEMAND FOR THE IMPLEMENTATION OF INDUSTRIAL ROBOTS AT MACHINE-BUILDING ENTERPRISES OF KAZAKHSTAN

Unfortunately, the dynamics of robotics used at enterprises in Kazakhstan has not yet been formed. But since industrial robots in our country have not yet been established, according to customs statistics, it is possible to assess the trend of their growth in the country's domestic market.

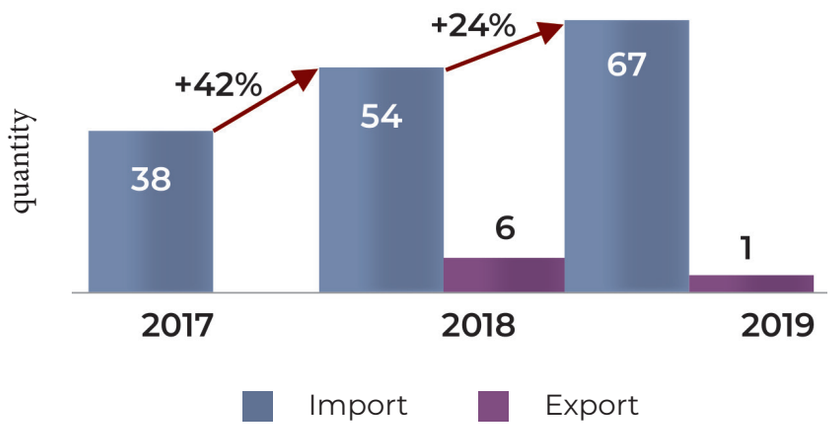
**The domestic market of industrial robots in Kazakhstan has expanded by 152 units over the past three years.**

If in 2017, Kazakhstan imported 38 industrial robots, in 2019 – already 67 units, 13 units, or 24%, higher than in 2018. Of course, Kazakhstan shows modest results in terms of the number of imported robots. However, the growth rate indicates that the need for industrial enterprises' robotization is increasing, and the process of introducing robotic technology in Kazakhstan has already been launched.

At the moment, the level of implementation of robots in our country remains quite low. It is estimated that only 1.7% of enterprises in the country's economy as a whole use robotic technology at their production sites.

Diagram 4.4

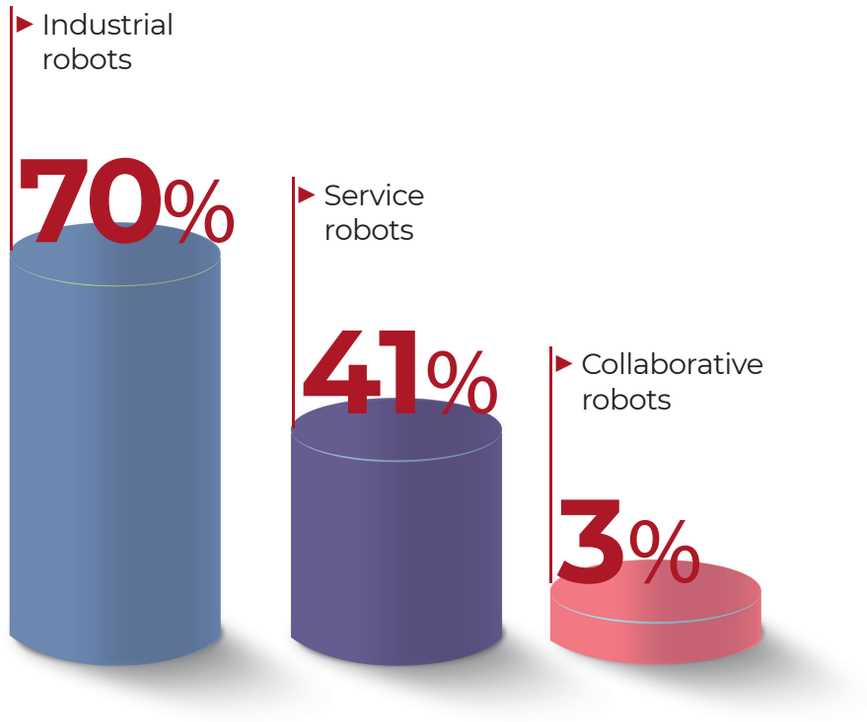
***Export and import of industrial robots to the Republic of Kazakhstan***




SOURCE: Committee on Statistics of the Ministry of National Economy of the Republic of Kazakhstan, State Revenue Committee of the Republic of Kazakhstan

[22] Committee of the Republic of Kazakhstan on Statistics, Committee of State Revenues of the Republic of Kazakhstan.

By the level of robotization, the manufacturing industry is one of the three leaders - 3.7% of enterprises in the industry are equipped with robots. 70% of them use industrial robots, 41% - service robots and 3% of enterprises - cobots.[23]




In mechanical engineering of Kazakhstan, robotics is used by 8% of enterprises. The highest level of robotization is observed in the production of machinery and equipment (40%).

Enterprises in other engineering industries have a significantly lower level of robotization.

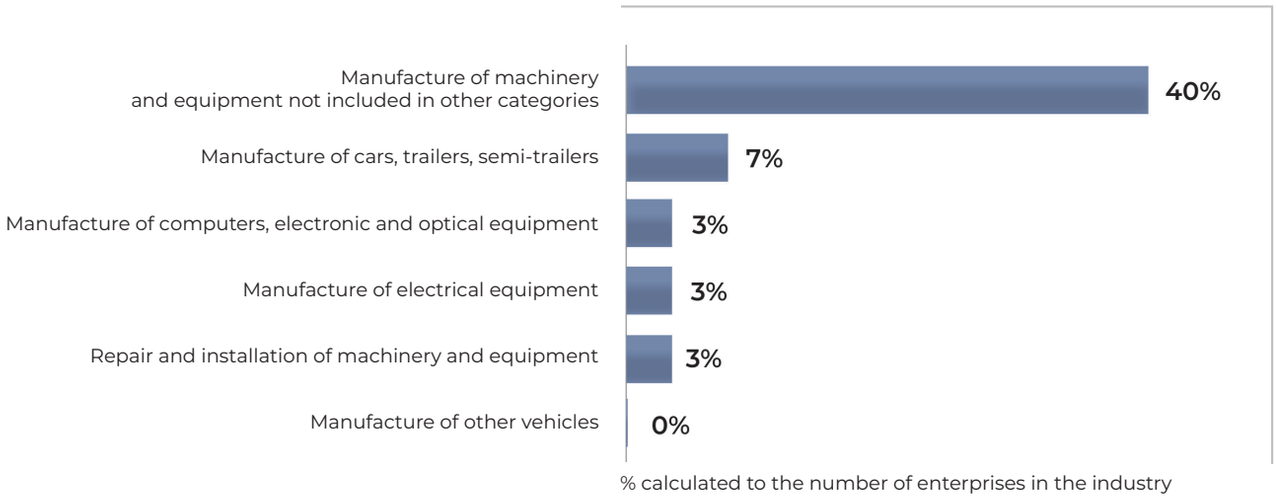
At domestic mechanical engineering enterprises, robotic manipulators are most often used for welding and painting, as well as robotic assistants that facilitate the work of personnel in moving goods.

In car factories, robots help in assembling seats, dashboards, wheels, etc.

[23] Selective study «The use of information and communication technologies in enterprises.» In 2019, 130 thousand enterprises took part in the survey, of which 1741 were mechanical engineering enterprises. Information and analytical system «Taldau» of the Committee on Statistics of the Ministry of National Economy of the Republic of Kazakhstan, https://taldau.stat.gov.kz/ru/Search/SearchByKeyWord

Diagram 4.5

## *The share of mechanical engineering enterprises of the Republic of Kazakhstan using robotics in 2019*




Source: Committee on Statistics of the Ministry of National Economy of the Republic of Kazakhstan.

## TREND EXAMPLE

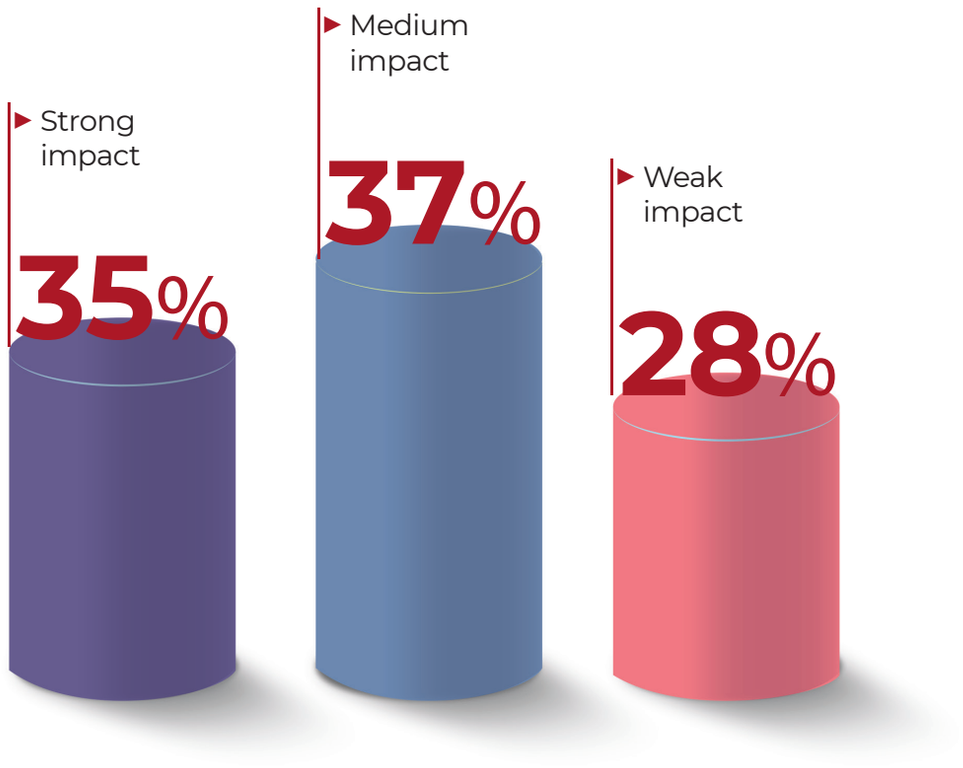
a. In 2019, the bridge construction plant in Almaty launched the production of railway sleepers with automated control of the heat and humidity treatment of products. The introduction of automation made it possible to double labor productivity, as well as to halve the production time.[24]

b. At the Karaganda plant «Maker», which is engaged in the production and repair of equipment for the mining industry, robotic equipment was introduced and the SIEMENS NX computer-aided design system was installed. After modernization of production sites, the plant has introduced manufacturing of products that had been previously imported from abroad, increasing labor productivity six times and 2 times the gross output. At the same time, the accuracy of processing parts has significantly increased.[25]

[24] Union of Mechanical Engineers of Kazakhstan. — URL: https://smkz.kz/bajbek-zapustil-innovacionnoe-proizvodstvo-v-almaty/.
[25] URL: https://kursiv.kz/news/otraslevye-temy/2019-08/karagandinskiy-zavod-maker-moderniziroval-mashinostroitelnoe.

# 4.2.
# DIGITAL MECHANICAL ENGINEERING

The expansion of the scope of digital and big data applications in the next 10-15 years, according to industry experts, will have a medium impact on the development of mechanical engineering.




Digitalization of production and processing of large amounts of data is one of the leading trends in the fourth industrial revolution.

The introduction of this trend in enterprises is associated with Big Data analytics and machine learning, artificial intelligence and the Internet of Things, additive


technologies and digital twins. The use of digital technologies allows collecting information from physical objects of the enterprise in real time, digitizing it, analyzing it using artificial intelligence and transferring it to the next stages to improve the efficiency of decisions made. Leveraging digital technology enables businesses

- to increase the volume of finished goods production;
- reduce downtime of industrial equipment;
- remotely control equipment;
- to reduce the number of rejects;
- reduce raw material costs.

Large-scale digital transformation of economic sectors is increasingly becoming a reality due to lower technology costs and increased availability of high-speed data transmission.

The process of digitalization of mechanical engineering in Kazakhstan is under the influence of four trends, three of which are related not only to domestic engineering, but also to the number of global trends.

- Growing demand for digitalization of mechanical engineering enterprises in Kazakhstan
- Increasing the volume in digitized industrial data
- An increase in the number of cyber attacks, an increase in the amount of damage they cause
- Reducing the time of launching new products into production

# 1 TREND
# GROWING DEMAND FOR DIGITALIZATION OF MECHANICAL ENGINEERING ENTERPRISES IN KAZAKHSTAN

The government of Kazakhstan pays great attention to the development of information and communication technologies (ICT) in the country and the introduction of digital innovations. The instrument regulating the spread of digitalization in the country is the State Program «Digital Kazakhstan». The goal of this program is to improve the socio-economic climate in the country through the use of digital technologies in the near future, as well as the formation of the digital economy of the future in the long term.

In the world ranking of the development of information and communication technologies in 2017 (ICT Development Index), Kazakhstan is in 52nd place out of 176 countries.[26]

| | |
|---|---|
| **52nd place** | ICT Development Index |
| **43nd place** | Sub-index: accessibility level and ICT |
| **55nd place** | Sub-index: ICT Practical Skills Level |

Despite some improvement in Kazakhstan's position in the ICT Development Index world ranking, at the moment the country's enterprises still have a low degree of penetration of digital technologies. According to statistics bodies, in 2019, only 2% of enterprises used digital technologies in the production.[27] First of all, this is due to the fact that until now digitalization by

[26] International telecommunication Union ICT Development Index 2017, https://www.itu.int/net4/ITU-D/idi/2017/index.html

[27] Sample survey «use of ICT in enterprises». In 2019, 130 thousand enterprises took part in the survey. Information-analytical system «Taldu» Committee on statistics of MNE of RK, https://taldau.stat.gov.kz/ru/Search/SearchByKeyWord

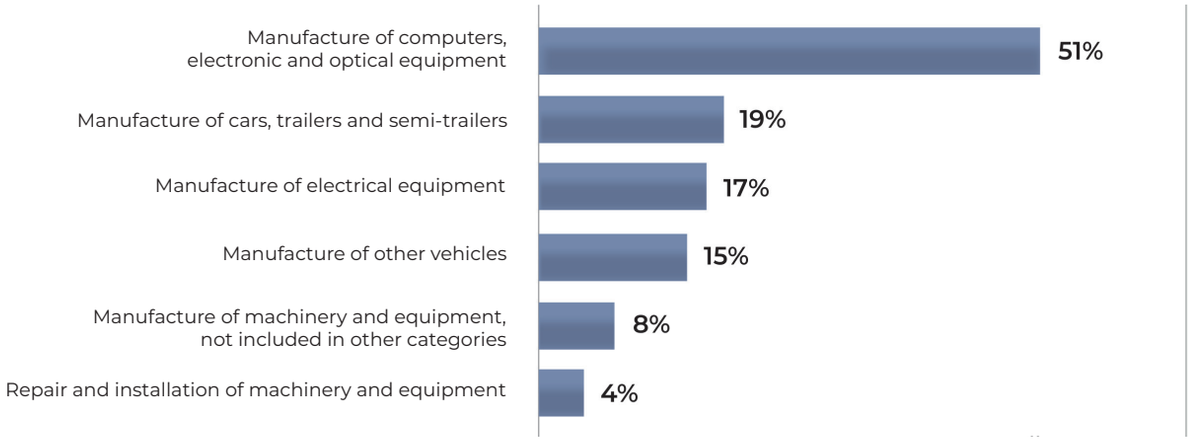
some manufacturers is mistakenly associated not with the expansion of opportunities, but with the high costs of its implementation and with the reduction of personnel due to the automation of production.

In mechanical engineering, digital technologies in the production of products are used by 8% of enterprises, which is 4 times higher than the national average.

The highest level of use of digital technologies in the production of products is noted at enterprises that produce computers, electronic and optical equipment (51%). The rest of the mechanical engineering industries lag significantly behind the leader of the rating.

Diagram 4.6

***The share of mechanical engineering enterprises of the Republic of Kazakhstan using digital technologies in the production of products in 2019.***




% calculated to the number of enterprises in the industry

Source: Committee on Statistics of the Ministry of National Economy of the Republic of Kazakhstan.

# 2 TREND
# INCREASING THE VOLUME OF DIGITIZED INDUSTRIAL DATA

According to experts from International Data Corporation, a leading provider of information on the information technology market, today more than 5 billion users interact with data every day. By 2025, their number will increase to 6 billion, or 75% of the world's population. And users of devices connected to the network will interact with the data every 18 seconds.

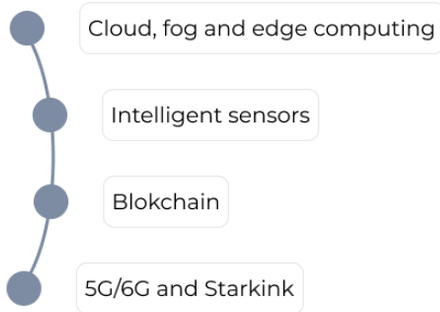
The global data volume in 2018 was 33 zettabytes. It is predicted that by 2025 it will increase more than 5 times and reach 175 zettabytes. Moreover, 30% of this data will need to be processed in real time. Therefore, Big Data Analytics is one of the most pressing challenges in the era of digital transformation. Frost & Sullivan experts point out that the largest amounts of data for such analysis will be generated by industrial enterprises, organizations of the financial sector, healthcare, retail and environmental protection.

**Energy ndustry is among the top 5 industries that generate the largest amounts of data requiring analysis.**[28]

Big Data is necessary for machine builders to improve the efficiency of business management. Using Big Data Analytics enables businesses to:

- reduce the number of equipment failures and unplanned downtime;
- reduce maintenance costs;
- to increase labor productivity and the efficiency of using industrial equipment;
- reduce operating costs.

**The main trend development technologies are:**




[28] The Digitization of the World. — URL: https://www.seagate.com/files/www-content/our-story/trends/files/idc-seagate-dataage-whitepaper.pdf.

# CLOUD COMPUTING

The first time they started talking about cloud technologies was back in 1960, but they began to be actively introduced only in 2006, when Amazon began to provide customers with access to remote computing resources.

Enterprises that have adopted cloud technologies gain a number of competitive advantages, the main ones of which are:

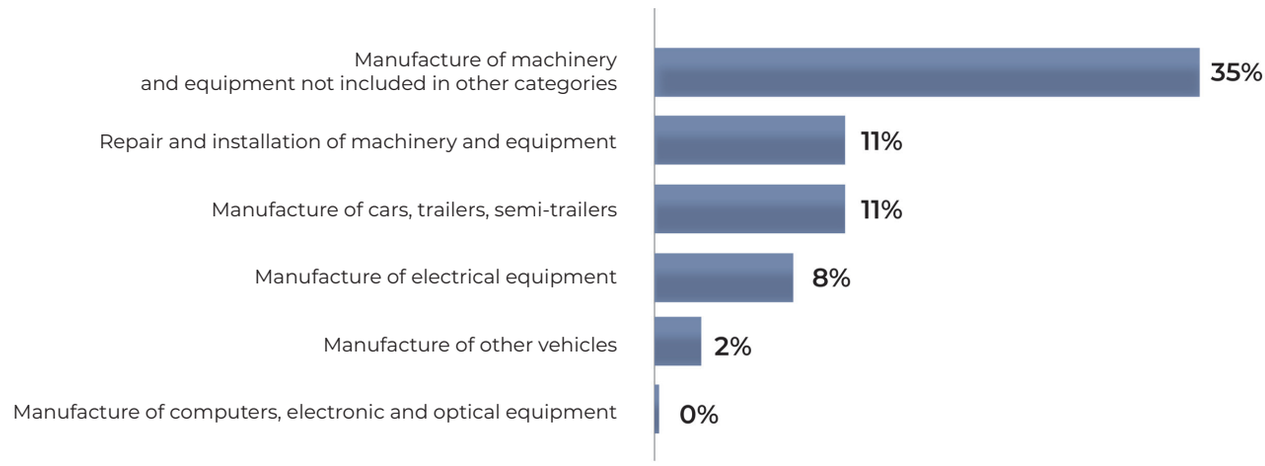
- savings in funds required for the purchase and maintenance of their own computer networks;
- constant and shared access to data from any device with Internet access;
- safety and reliable data protection by qualified personnel of the cloud provider.

According to the report "The Digitization of the World" by the International Data Corporation, by 2025, 49% of the world's data will be located on public cloud resources.[29]

Whereas at the end of 2019, in Kazakhstan, on average across the sectors of the economy, only 9% of enterprises used cloud IT services (Cloud services) via the Internet.[30]

Diagram 4.7

***The share of mechanical engineering enterprises of the Republic of Kazakhstan using cloud-based IT services via the Internet, at the end of 2019***




Source: Committee on Statistics of the Ministry of National Economy of the Republic of Kazakhstan.

[29] URL: https://www.seagate.com/files/www-content/our-story/trends/files/idc-seagate-dataage-whitepaper.pdf.
[30] Selective study «Use of ICT in enterprises», Information and analytical system «Taldau» of the Committee on Statistics of the Ministry of National Economy of the Republic of Kazakhstan, https://taldau.stat.gov.kz/ru/Search/ SearchByKeyWord

In mechanical engineering, cloud IT services over the Internet are used by 13.6% of enterprises, which is 2 times higher than the level of 2018.

Cloud IT services are more actively used by enterprises that produce machinery and equipment for enterprises in various sectors of the economy. The rest of the engineering industries have a significantly lower level of use of this technology.

## FOG COMPUTING

If cloud technologies allow you to store and process data remotely, in the provider's data centers, then fog calculations are performed in centers located as close to the equipment as possible.

This system allows you to analyze the collected information in the field, filter it and transfer only the most important to data centers.

Fog technologies have a number of advantages and disadvantages. The main advantages include:

- reducing the load on cloud storage;
- reduction of time for exchange of information of industrial equipment with each other, processing and transmission of data;
- provision of additional security by implementing a local level of protection.

The disadvantages of this technology are the complexity of implementation and a lower level of reliability compared to networks of large data centers.

## EDGE COMPUTING

Businesses don't need to connect all of their smart devices to the cloud to do their day-to-day calculations. For some equipment, you can use peripheral, so-called edge computing, which allows you to store data on the end device, increasing the efficiency of their processing in real time. The use of edge computing minimizes the time of data transfer, increases their security and allows you to process data even without an Internet connection.

This technology is widely used in mechanical engineering. For example, in the case of detecting malfunctions in the operation of the equipment, the device immediately sends a signal to the operator

## INTELLIGENT SENSORS

Intelligent sensors installed on industrial equipment allow manufacturers to quickly identify equipment malfunctions, as well as the causes of these failures, rationally approach the issues of planned technological maintenance, and prevent downtime leading to serious losses. The market for smart sensors has been developing in recent years under the influence of the following main trends:

- measurement methods are being improved, which require more powerful computational processing inside the sensor;
- consumer demand for wireless sensors for moving objects distributed in space is growing;
- the scale of development of miniature sensors that can be embedded in industrial

equipment, automation equipment and even materials is increasing;

- multifunctional sensors are widely implemented, combining several different sensors;
- increases the IQ level of sensors through the implementation of self-diagnostic functions, fault prediction and maintenance recommendations.

The demand for smart sensors equipped with sensor devices is growing rapidly.

According to research by by Marketsandmarkets company, the global smart sensor market in 2018 was $ 5.3 billion.

But by 2023, according to their estimates, the market will reach $ 22.5 billion, with an average annual growth rate of 33.6%.[31]

The main growth factors will be the following: active use of sensors as their size decreases and costs of their implementation decrease; an increase in the level of Internet penetration; high demand for connected and wearable devices; and the demand for real-time computing for Internet of Things (IoT) applications. According to analysts, by 2023, pressure sensors will have the largest share of the IoT sensor market, primarily due to the automotive industry. Most of the smart sensors will use wireless communication due to the large-scale implementation of IoT technologies in enterprises, the proliferation of mobile devices and the global BYOD concept (the use of personal devices of employees for work purposes).

## EXAMPLE OF USING THE TECHNOLOGY

In the production of elevators, ThyssenKrupp AG installs sensors on each of them in order to receive data on the current state and operation of elevators in real time via the Internet of Things. The use of sensors made it possible to prevent possible problems even before they appeared, sending a breakdown code to the operator in order to reduce the time for repairs. As a result of the introduction of the technology, on average, the uptime of elevators has increased by 50%, and the company has reduced the cost of their maintenance and repair, increasing the reliability and safety of the cabins.[32]

[31] Internet of Things news. — URL: https://iot.ru/gorodskaya-sreda/globalnyy-rynok-datchikov-iot-k-2023-godu-dostignet-22-48-mlrd-marketsandmarkets.
[32] Habr — community of IT professionals. — URL: https://habr.com/ru/company/newprolab/blog/314926/.

## 5 G/6G AND STARLINK

By 2030, next-generation, ultra-fast 5G wireless networks will be ubiquitous and 6G standards will already emerge. This will bring computing power closer to the edge of the network and reduce data processing time when using complex computing algorithms.

The proliferation of 5G will create a foundation for even greater deployment of monitoring devices in enterprises that generate intelligent data in real time. And Starlink's global reach, by providing access to high-quality Internet anywhere in the world, will unite billions of users in the global cyber community of the future. Which, in turn, will have an impact on the efficiency of production management.

## B LOCKCHAIN

The main feature of blockchain technology is the use of algorithms for mathematical calculations to make a decision with the maximum exclusion of the influence of the human factor.

Blockchain is characterized by

- data integrity;
- openness of codes for viewing the necessary information;
- the ability to track the history of transactions up to the first operation;
- a high level of protection and safety of the recorded data without the possibility of distorting them, let alone forging.

Thanks to the capabilities of blockchain technology to automatically control, record and store information about digital transactions, the scope of its application has expanded: from posting personal information to storing data at all stages of the production activities of companies. Blockchain is effectively used by machine builders at the stages of purchasing raw materials, shipping products, transferring assets - where a large number of contracts are signed and there is a possibility of making mistakes.

This technology is most widely used in the automotive and aviation industries. According to Reportlinker, by 2029, the cost of developing and using blockchain technology in these industries will reach $ 20 billion, with an annual

growth of 60.4%. This spread of technology is driven not only by its transparency, fast transactions and the elimination of fraud risks, but also by the increase in the number of cyberattacks in recent years. However, the large-scale implementation of blockchain in mechanical engineering is hampered by the lack of a sufficient number of qualified specialists in this area, and the low level of awareness of manufacturers about the opportunities provided by blockchain.

## 3 TREND
## GROWTH IN THE NUMBER OF CYBER ATTACKS AND THE INCREASING SIZE OF THEIR DAMAGE TO INDUSTRIAL ENTERPRISES

The process of exponential development of information technology, on the one hand, opens up unprecedented opportunities for enterprises - reducing the share of manual labor, increasing the safety of workplaces and the efficiency of enterprises in general.

On the other hand, the use of modern technologies and the digitalization of production processes increases the likelihood of unauthorized access to enterprise data for the purpose of stealing money and confidential information or for extortion.

Hacker attacks aimed at stealing money and extortion of «traditional» victims have recently faced increasing the level of protection of databases and supporting infrastructure of the latter from accidental or deliberate influences. Therefore, cybercriminals have to actively search for new, less protected subjects.

Cybersecurity experts note that half of all attacks in recent years have been carried out against small businesses, with 60% of companies shutting down their operations within six months after such an attack.

It is rather difficult to assess the possibility of a threat from attackers. It is even more difficult to give an objective assessment of the consequences of a potential cyberattack.

According to cybersecurity experts Cybersecurity Ventures, the number of ransomware increased 3.5 times in 2018. And if in 2016 cyberattacks in the world occurred every 40 seconds, then in 2019 - every 14 seconds, and by 2021 their frequency will increase to 11

seconds.

As the number of cyberattacks grows, so does the amount of damage they cause. According to experts, the damage from extortion in 2021 will be 57 times higher than in 2015. If in 2018 the losses of companies amounted to 1.5 trillion. dollars, then by 2022 the amount of global damage from cybercrime could reach 8 trillion. dollars.[34]

The Government of Kazakhstan pays great attention to the problems of information security, increasing the degree of protection of information and communication infrastructure from unauthorized threats - basic approaches to the development of the cyber security sphere have been developed, uniform requirements in the field of ICT and information security have been approved, and the concept of "Cyber shield of Kazakhstan" has been introduced.

According to the official report of the International Telecommunication Union, in 2018 Kazakhstan entered the top 40 countries of the international cyber readiness rating. Over the year, Kazakhstan has strengthened its position, moving from 83 to 40 place. Among the CIS countries, Kazakhstan is second only to Russia, which is ranked 26th.[35]

According to KZ-Cert, 20.8 thousand unauthorized access-to-database incidents were identified in Kazakhstan in 2019, which is 1.8% more than in 2018.
The greatest activity was recorded by botnets (17.3 thousand incidents), followed by blocking access to information resources (1075 cases) and phishing (883 cases).[36] Incidents such as malicious software, hacking of Internet resources, denial of service (DDoS attacks) are somewhat less widespread.[37]

According to Kaspersky Lab ICS CERT experts, the threat of possible cyberattacks is underestimated by industrial enterprises, because their automated control systems are not sufficiently protected from mass attacks and accidental infections. And the lack of a reliable security system and qualified specialists responsible for information security makes such enterprises an easy target for hackers hoping to receive a ransom for unlocking the systems they have compromised.[38]

According to experts from Cybersecurity Ventures, the

[34] 2019 Cybersecurity Almanac: 100 Facts, Figures, Predictions & Statistics. — URL: cybersecurityventures.com/cybersecurity-almanac-2019/.
[35] Global Cybersecurity Index (GCI). — URL: https://www.itu.int/dms_pub/itu-d/opb/str/D-STR-GCI.01-2018-PDF-E.pdf.
[36] Phishing is a type of Internet fraud, the purpose of which is to gain access to confidential user data (logins and passwords).
[37] KZ-CERT — Computer Incident Response Service. — URL: https://cert.gov.kz/press_club/infographics.
[38] Kaspersky Lab ICS CERT, Evgeny Goncharov «Problems of cyber protection of industrial enterprises». — URL: https://ics-cert.kaspersky.ru/reports/2018/12/05/challenges-of-industrial-cybersecurity/.

industry is among the top 5 industries most often subjected to cyber attacks in the last 5 years. Therefore, industrial enterprises must be prepared for the rapidly growing number and variety of threats, an increase in interest in industrial enterprises on the part of cybercriminals.

To prevent unauthorized access to information systems or minimize the amount of damage when it occurs, enterprises need not only to seriously approach the choice of means of protecting information bases, but also to constantly improve the qualifications of the relevant categories of specialists.

At the moment, enterprises in Kazakhstan continue to experience a shortage of specialists who ensure the security of databases, and the demand for information security specialists will only increase every year.

Business leaders who correctly assess the scale of the spread of cyber attacks, as well as their consequences, are interested in attracting qualified employees to regularly monitor the information bases of the business process.

## TREND EXAMPLES

a. On June 9, 2020, Japanese car giant Honda Motor announced a complete shutdown of its companies around the world for one day after the company was hit by a cyberattack. As a result of hacker intervention, the quality control systems of cars at three of the company's factories were completely disabled.[39]

b. In September 2019, the IT infrastructure of the Rheinmetall Automotive factories, owned by the large German concern Rheinmetall Group, a manufacturer of military equipment, was hit by malware attacks. According to the company's experts, the elimination of the consequences of the infection and the restoration of the normal functioning of the systems should have taken about 2-4 weeks, the expected losses ranged up to a million euros per week.

c. In June 2019, as a result of a cyberattack on Mitsubishi Electric, access to the internal systems and networks of 14 divisions of the company in Japan, China, Russia and other countries was hacked. As a result of the attack, 120 computers and servers were attacked, and part of the company's data, including confidential information, was stolen.[40]

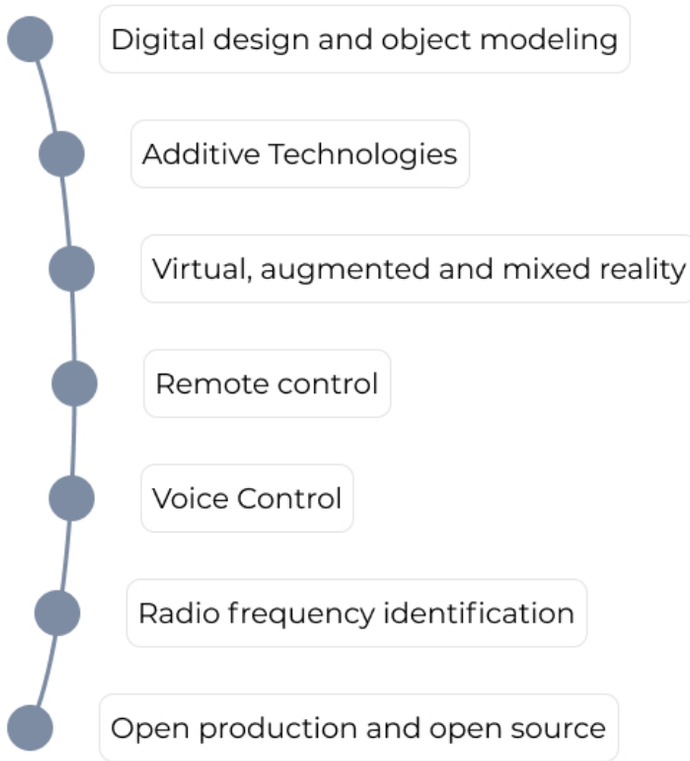
[39] Reuters News Agency. — URL: https://www.reuters.com/article/us-honda-cyber/honda-hit-by-cyber-attack-some-production-disrupted-idUSKBN23G1CI?feedType=RSS&feedName=technologyNews.
[40] Kaspersky Lab ICS CERT. — URL: https://ics-cert.kaspersky.ru/reports/2020/04/24/threat-landscape-for-industrial-automation-systems-ransomware-and-other-malware-key-events-of-h2-2019/.

# 4 TREND
# REDUCING THE TIME OF LAUNCHING THE PRODUCTION OF NEW PRODUCTS

Mechanical engineering refers to industries with a high level of science intensity and manufacturability.

In conditions of high competition for the entry of products to the consumer market, enterprises need to constantly increase the degree of structural complexity of their products and expand the range of products, including customized ones (on an individual order). In order to keep up with their competitors, enterprises have to reduce the time from the development of design documentation for new products to the release of its first batch.

Traditional production technologies can no longer cope with these tasks. Dynamically developing technologies of «digital» production come to the aid of machine builders:



# DIGITAL DESIGN AND OBJECT SIMULATION OF TECHNOLOGICAL PROCESSES, OBJECTS AND PRODUCTS

Digital design and modeling is an important direction in the development of the industry, which allows you to quickly develop and create competitive products that fully meet the requirements of the market. The basis of digital design is the development of digital twins of the product and production processes.

A digital twin is a virtual model of a designed or already existing product or even a production process. The development of a digital twin allows you to track the nature of its interaction with other objects throughout the entire life cycle.

The idea of creating digital twins appeared in 2002 and belongs to Michael Greaves, a professor at the University of Michigan. However, digital twins have joined the leading trends of the Fourth Industrial Revolution quite recently.

**The greatest development of digital design technology been observed in industry. According to the forecast of Gartner, a leading expert in the information technology market, by 2021 50% of large companies in the global industry will use this technology, which will lead to an increase in the productivity of these enterprises by at least 10%.**[41]

With the help of the digital twin, it will be possible in advance, even at the stage of developing a product model or production lines, to test and optimize design components, identify all errors and eliminate them before commissioning. All this will lead to a significant reduction in the terms of launching products into production and an increase in their quality.

## TREND EXAMPLE

Siemens, thanks to digital design technology, in 2 years was able to develop for the Russian company KamAZ 3D models of 20 universal machine tools, 28 CNC machines and several dozen pieces of equipment, including robots, tilters, manipulators, etc.[42]

[41] ICS-media. — URL: http://www.iksmedia.ru/articles/5585041-Czifrovye-dvojniki-v-promyshlennost.html#ixzz6N9pPzNrO.
[42] ICS-media. — URL: http://www.iksmedia.ru/articles/5585041-Czifrovye-dvojniki-v-promyshlennost.

# ADDITIVE TECHNOLOGIES (AT)

Additive manufacturing is a way to create real objects based on their digital model by adding materials layer by layer.

A variety of materials for AT, an increase in the list of their operational characteristics and properties, a decrease in the cost of 3D equipment and other advantages, contribute to an increase in the scale of introduction of additive technologies in industrial enterprises.

According to Sculpteo French 3D printing company said that in 2018 40% of industrial companies in the world used additive technologies to create their products.[43]

Additive technologies have a wide range of applications. In mechanical engineering, the following areas are most widespread:

1. conceptual prototyping for testing before launching new products into production for defects, design errors of the developed model;
2. 3D printing of finished products and parts for machinery and equipment, electronic components;
3. Creation of burned-out models for casting and production of tooling and molds.

The introduction of additive technologies will enable enterprises

- to reduce the time required for the introduction of new models of machines and equipment, as well as the time for the repair of existing parts;
- reduce the consumption of raw materials in comparison with traditional technologies;
- to improve the performance characteristics of finished products in comparison with analogs manufactured by the traditional method, due to the acquisition of a set of new properties;
- produce products of increased complexity that cannot be manufactured in any other way, for example, a part inside another part.
- to solve the problem of lack of necessary components for test models and equipment repair;
- to increase the mobility of production.

AT BASE IS AN ELECTRONIC MODEL OF A PRODUCT / PART DEVELOPED, WHICH CAN BE IMMEDIATELY TRANSFERRED TO A 3D DEVICE FOR PRODUCTION START-UP, EVEN FROM THE MOST REMOTE POINT OF THE WORLD.

[43] Institute of Mechanical Engineering, Materials and Transport, St. Petersburg Polytechnic University. — URL: https://immit.spbstu.ru/news/3d_pechat_na_osnove_keramiki_pomozghet_izgotavlivat_detali_dlya_samoletov_i_raket/.

## TREND EXAMPLE

The Ford Nascar racing team uses 3D printers to retrofit and test new engine, exhaust and fuel system components. Preparing for the race, the team uses additive technologies to quickly develop full-fledged prototypes of new parts, test and modify them to improve the performance of racing cars.[44]

## VIRTUAL, AUGMENTED AND MIXED REALITY TECHNOLOGIES

In mechanical engineering, virtual reality (VR) technologies can be used at all stages: from design to sales and after-sales service.

Thanks to technology, even at the design stage, it is possible to demonstrate to the customer in the smallest detail how the product will look in the end.

The use of augmented reality (AR) technologies contributes to the automation of a significant number of works, simplification of assembly and installation processes, increased labor productivity, the introduction of effective methods for training field personnel, and a reduction in the number of rejects.

AR is also used for remote consulting of technical personnel, which significantly reduces the cost of calling service engineers.

Mixed reality (MR), which combines virtual and augmented reality, allows a physically existing object to interact with digital models in real time.

The potential for using mixed reality in mechanical engineering is quite large, but it has not yet been fully used. Enterprises that implement MR will receive a number of competitive advantages:

- employees of enterprises will have complete information about a specific model of a product or process in real time;
- the time for service maintenance of products, assembly or disassembly will be reduced;
- the number of mistakes and rejects will decrease;
- labor productivity will increase.

[44] Globatek.3D, 3D-печать прототипов для функциональных тестов, https://3d.globatek.ru/3d-printers/functional_testing/

Most importantly, a geographically dispersed team of engineers, using 3D models of products and holographic images, can interact as if they are all nearby, which will increase work efficiency and prevent possible misunderstandings.

## TREND EXAMPLES

a. Ford (Germany) uses VR in the car design phase. This helps to most accurately design the location of individual parts and mechanisms of the car, to work out in more detail the elements of decoration and appearance of the car.[45]

b. The American company AGCO, a manufacturer of equipment for the agricultural industries, was among the first to use AR to scan the serial numbers on engine parts and receive instructions for assembly. Also workers on the AR device can leave voice recommendations for the pickers of the next shift. The technology made it possible to reduce the quality control time of products by 20% and increase the efficiency of personnel training.[46]

c. Mercedes-Benz, a German car manufacturer, was among the first to introduce MR technology into production. At the International Exhibition «Autosalon 2017», the company's specialists, using the MR headset, for the first time demonstrated the process of repairing a car brake, consulting a holographic image of auto parts instead of a staff of engineers.

[45] Ford Motor Company, Ford has designed a new model in virtual reality, — URL: http://www.km-ford.ru/ford/ford_news/VR/.
[46] URL: https://www.npr.org/sections/alltechconsidered/2017/03/18/514299682/google-glass-didnt-disappear-you-can-find-it-on-the-factory-floor.

# REMOTE CONTROL TECHNOLOGIES

The leading trend in modern production is the introduction of remote control technologies, which are actively introduced at various stages of the production process.

a) Remote control of industrial equipment.

The introduction of remote control systems for machine tools, automated lines is one of the ways to increase the production efficiency of enterprises in the engineering industry.

Remote production systems impose such requirements as ease of manipulation, consistency of hand movement with the direction of movement of the controlled part of the machine, accuracy of actions, speed of operations, and most importantly, remote control of equipment and the production process from anywhere, even outside the enterprise itself.

Within the framework of this direction, a whole complex of control and measuring devices is actively used, thanks to which, all information from objects in real time is automatically transmitted to the central control panel and is recorded in the RAM of the enterprise information system.

b) Remote consulting and training of personnel at the stages of commissioning and repair work / start-up of production.

The demand for this technology is dictated by the fact that enterprises, updating their equipment park, install machines and devices with various functional and technical characteristics. Moreover, technologies and devices are purchased mainly from foreign manufacturers.

The introduction of remote consulting allows

- eliminate transportation costs of the enterprise for calling service engineers from the manufacturer's company for setting up or repairing equipment;
- to reduce the time required for the equipment to be put into operation or downtime due to a breakdown;
- to improve the professional level of personnel;
- rational use of production facilities and labor resources.

This technology will allow machine builders, in turn, to increase added value by including remote after-sale services in their products.


# VOICE CONTROL TECHNOLOGIES FOR PRODUCTION EQUIPMENT

Along with remote control technologies, enterprises began to introduce voice control technologies, thanks to which automated systems are able to recognize human speech.

Voice control systems have been introduced and are successfully used in many sectors of the economy, however, their development for robotic machine tools is one of the most complex and demanded areas in the field of human-computer interaction.

The production process is often associated with situations in which it is impossible to ensure the efficiency of work or the safety of workers without voice control, for example, when an operator is servicing several objects at once or he has both hands busy, when instant access to the necessary information is required to make a quick decision.

The interaction of workers and machine tools takes place under conditions of an increased noise level generated by the operation of machine tools. Therefore, the ability to distinguish and separate human speech and extraneous noise is a basic requirement for voice control technologies.

The next step in the development of voice control systems is the development of an interface that will be the same for all machine tools of the enterprise, regardless of their brand or CNC rack. And the voice-activated interface will ensure the interaction of the entire workshop network, with the ability to connect to applications for monitoring and predicting maintenance, process control documentation, etc.

## TREND EXAMPLES

a. CSort, a Russian manufacturer of color sorters, developed the CsortCloud service at the beginning of 2020. Thanks to this, it became possible to remotely configure, control and repair the equipment produced by the enterprise. The development turned out to be timely due to the transfer of personnel to a remote mode due to the Covid-19 coronavirus infection pandemic. During this period, agricultural companies, on the one hand, needed to increase the volume of production of cereals, on the other hand, business trips of service engineers were limited.

b. ATHENA iTSpeex is one of the first voice operating systems specially designed for the interaction of workers with CNC machines (turning, milling and grinding). Using a headset, microphone and laptop, the worker has the ability to simultaneously instruct the machines to perform a specific operation and instantly access all the necessary instructions.[47]

## RADIO FREQUENCY IDENTIFICATION TECHNOLOGIES (RFID)

RFID technology integrated into production is designed to track the progress of all stages of the production process. Special marks are installed on finished products, components, equipment, with the help of which you can carry out:

- planning the utilization of production facilities;
- monitoring the movement of equipment and consumables;
- «smart» solution for accounting and control of production assets in warehouses;
- quality control of products and originality of the complete set;
- prompt after-sales service.

RFID technology allows not only to automate most of the work and eliminate personnel errors, but also to efficiently use their

[47] Modern Machine Shop. — URL: https://www.mmsonline.com/articles/how-voice-recognition-will-transform-machine-tool-technology-.

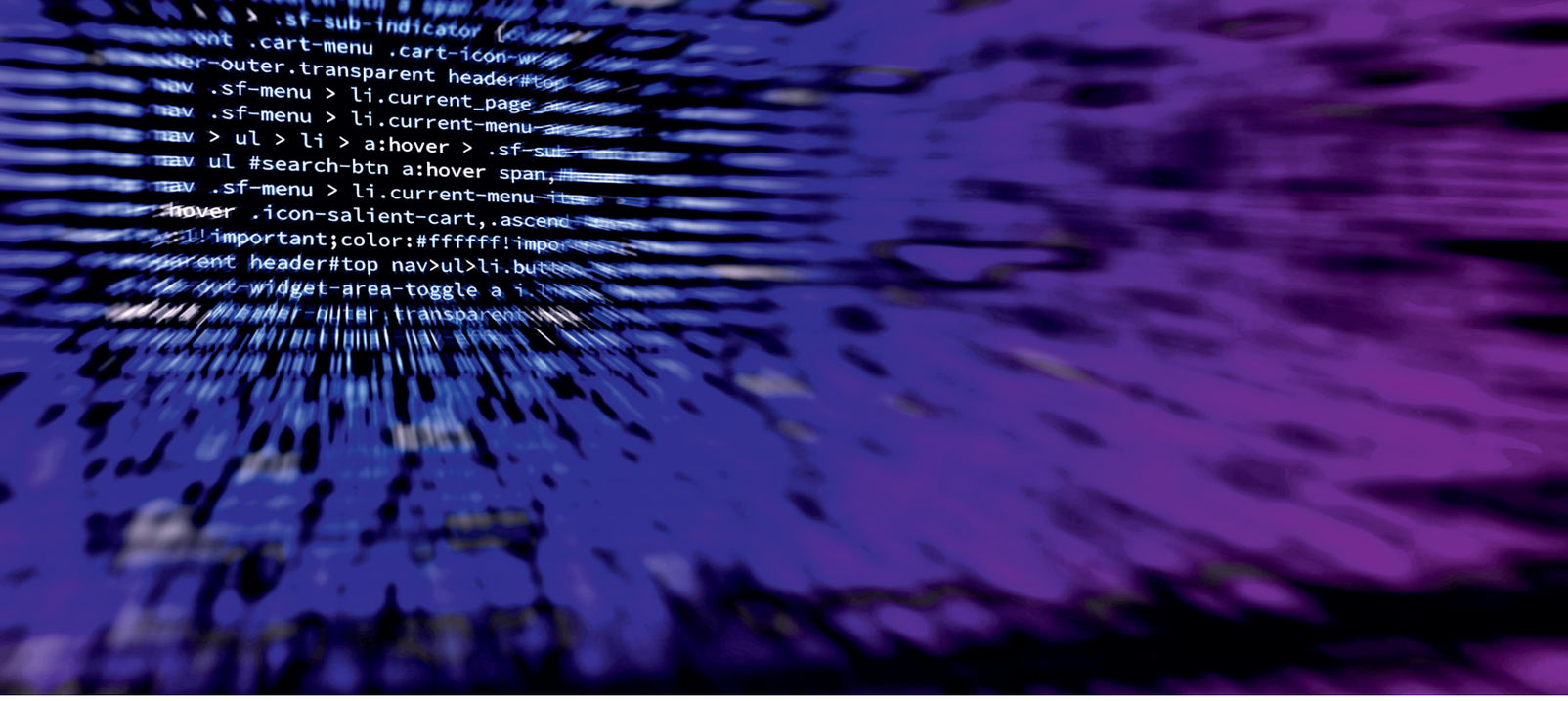
working hours. RFID can control the movement of employees in the workplace, and also act as an electronic pass to areas with limited employee access. RFID tags play an important role in improving the safety of personnel. The marks located on the clothes of the operators can be recognized by the robotic complex, which gives a signal if the worker enters the danger zone.

## TREND EXAMPLES

a. In 2019, the PROF-IT group announced the development of a passive UHF RFID Tag for mechanical engineering of an acid and alkali resistant, high temperature and humidity resistant UHF RFID Tag. The operating temperature range is from minus 50 to plus 85 degrees Celsius. At the same time, the tag is able to withstand overheating up to 240 degrees for two hours. The tag can be used in almost any production area (welding, painting, assembly, etc.), as well as for tracking finished products and solving quality control problems, collecting operating statistics and after-sales service.[48]

b. ISBC Tags Reflect42 is designed to identify and read large moving and stationary objects at a distance of 42 meters. It is used in supply chains within industrial enterprises, transport, construction, logistics. A distinctive feature of this tag is that the reading range of tags increases in cold weather.[49]

[48] URL: https://control.viz.world/media/@rusmicro/prof-it-rfid-tag-uhf-20190205/.
[49] URL: https://www.isbc-rfid.ru/_catalog/13821/.




## OPEN PRODUCTION AND OPEN SOURCE TECHNOLOGIES

The principles of open production and open source are based on the same philosophy. But in the first case, the focus is on the development of physical objects based on open design and source code, in the second - software that can be changed, adapting to your needs.

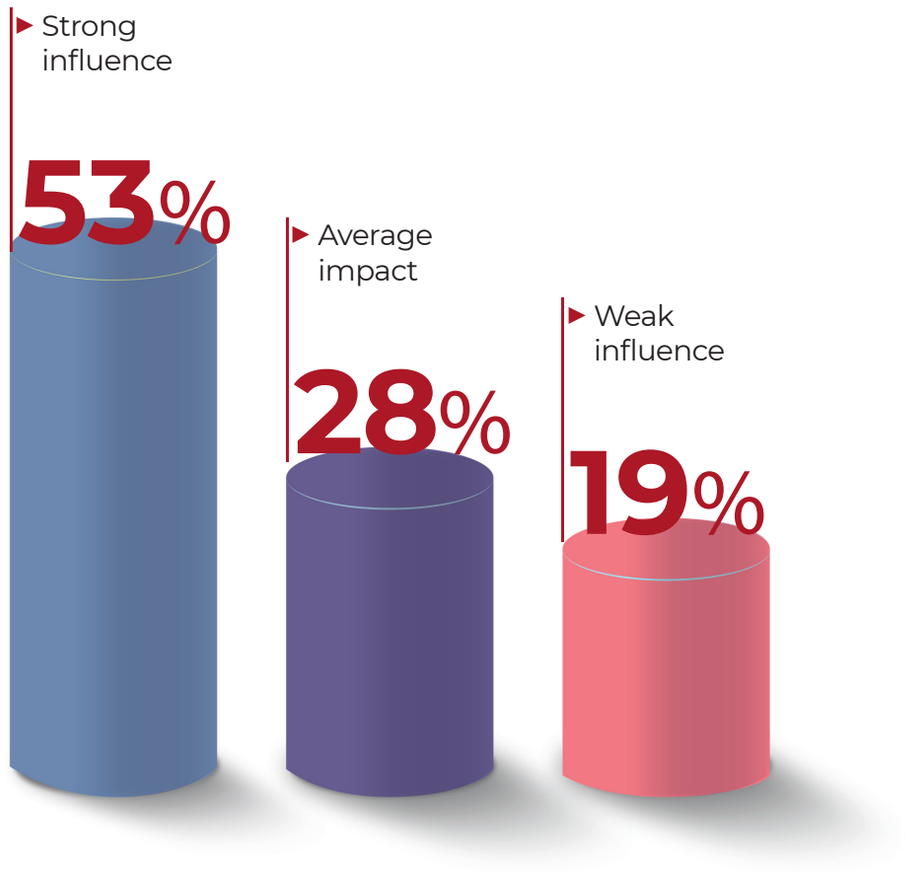
Jeremy Rifkin, in The Zero Marginal Cost Society, writes that the development of the IoT «will ultimately reduce the marginal cost of producing many goods to near zero, making them virtually free».[50]

Today, open source software is used to a large extent for solving management problems and for processing data. And open-source projects that were actively opening at the beginning of this century, for example, the RepRap project for the production of a 3D printer, are gradually being closed. Despite this, according to world experts, open-cast production belongs to the technologies of mechanical engineering of the future. The development of the concept of open production with open source in the future can lead to the fact that products will be as much as possible to meet the needs of a specific market, and dependence on imports will decrease, since the necessary mass-market products can be produced locally.

[50] Jeremy Rifkin is an American social philosopher, economist, writer, and public figure. Post-capitalist theorist, promoter of sustainable development and alternative energy, author of the concept of the third industrial revolution, The Zero Marginal Cost Society,

# 4.3.
# IMPROVING THE EFFICIENCY OF INDUSTRY RESOURCE MANAGEMENT

According to experts, improving the efficiency of resource management in the industry in the next 10 — 15 years will have a strong impact on the development of domestic engineering.




Supplies, production assets, raw materials, technological and other resources are the basis (or foundation) of technological and other resources they are the Foundation of any machine-building enterprise. However, resources cannot be unlimited and they need to be properly managed. According to industry experts, improving the rational and efficient management of resources

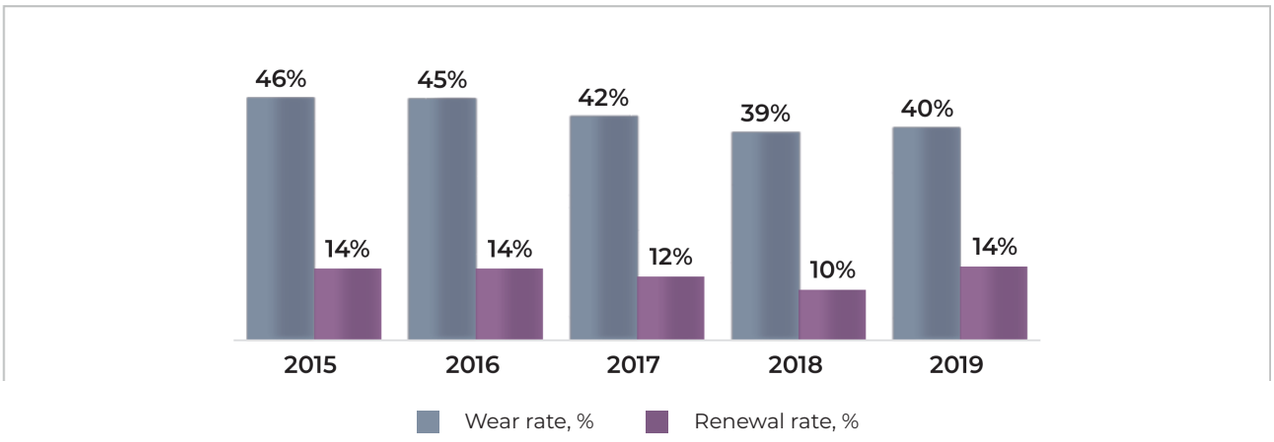
- High level of wear and tear of production facilities in mechanical engineering of Kazakhstan
- Growing demand for flexible production systems in mechanical engineering
- Expansion of applications of the latest technologies and construction materials
- Improving the efficiency of production management
- Growing demand for intra-industry cooperation of systemically important enterprises
- Growing need for an employee of the research institute and education with industry enterprises
- Increase in the outflow of qualified personnel to foreign countries and neighboring countries

# 1 TREND
# HIGH LEVEL OF WEARING OF PRODUCTION CAPACITIES IN THE MACHINE BUILDING OF KAZAKHSTAN

As we have already noted, equipment wear is one of the serious problems of enterprises, having an extremely negative impact on the economic results of their activities. In recent years, there has been a downward trend in the level of wear and tear of machinery and equipment at manufacturing enterprsises sector - from 46% in 2015 to 39% in 2019. At the same time, in 2019, enterprises in the sector renewed their equipment by an average of 14%.

Diagram 4.8

***Depreciation and renewal indicators of machinery and equipment in the manufacturing sector of the Republic of Kazakhstan.***




Source: Committee on Statistics of the Ministry of National Economy of the Republic of Kazakhstan.

If we look at the mechanical engineering industries, we can note a significant gap in the level of wear and tear and renewal of production equipment between them.

**The automotive industry, which is a relatively new machine building industry for Kazakhstan, has the lowest level of depreciation of production facilities and the highest level of their renewal.**

The industry's anti-leaders in the rating of depreciation and renewal of production facilities are

- enterprises for the repair and installation of equipment - the highest level of equipment wear;
- other vehicle manufacturing facilities - the lowest rate of capacity renewal.

For the efficient operation of enterprises, it is not enough to equip workshops with modern machine tools and robotic systems, to increase the level of professional training of personnel and the degree of their mastery of industrial equipment.

It is necessary to adjust the work process in such a way as to maximize the workload of industrial equipment and minimize its downtime, which leads to huge losses and an increase in the cost of production. However, machine builders are often faced with a situation where worn out or deformed parts of mechanisms cannot be found, for example, they have been discontinued.

In this case, manufacturers have to either retire the equipment, which causes serious material damage, or use reverse engineering technology to create a copy of the required part.

## REVERSE ENGINEERING TECHNOLOGY

Reverse engineering technology in mechanical engineering is used when it is required to obtain a 3D model of finished products, for example, to develop an upgraded sample based on existing ones, or when there is no design documentation for outdated equipment to restore its operability.

Reverse engineering makes it possible to quickly understand the design features of products or individual mechanisms and conduct digital modeling of the required operating modes, while maintaining the main parameters for further research. Reverse engineering using 3D scanning technology allows you to digitize

physical objects and the results of reworking parts. By combining reverse engineering and 3D printing, you can quickly set up the production of, for example, industrial equipment parts that require replacement due to wear or deformation.

The global 3D scanning market is projected to reach $ 4 billion by 2025, more than tripling from 2019.[51] At the same time, already now, according to IQB texnologies, 35% of tasks in which 3D scanners are used fall on reverse engineering tasks.[52]

High-quality creation of a complex product by the reverse method according to a sample is possible if there is complete initial data of the product, as well as if there is a specialist who has the skills of reverse engineering and is well versed in the technology of the sample.

## 2 TREND
## GROWING DEMAND FOR THE INTRODUCTION OF FLEXIBLE MANUFACTURING SYSTEMS IN MECHANICAL

Businesses that strive to meet market demands and remain competitive must adapt to the ever-changing needs and preferences of consumers. The most effective solution in this situation is the introduction of automated flexible systems.

The flexibility of production is understood as the ability of an enterprise to rebuild with a minimum expenditure of time and labor within the existing technological capabilities for the release of a new product or its improved model.

The introduction of flexible production systems helps to reduce the need for qualified personnel in enterprises, and also increases the efficiency of industrial equipment.

With the introduction of flexible systems, the mobility of production increases, production capacities are used more rationally, it becomes

[51] URL: http://xn--80aplem.xn--p1ai/analytics/Rynok-3D-skanirovania/.
[52] URL: https://3dfabprint.ru/uploads/all/e2/fe/a4/e2fea4f66a5453a5dd230a279a908524.pdf.

possible to expand the range of products, reduce the time of its manufacture, and reduce production costs through the introduction of equipment with a high level of automation.

The main components of flexible manufacturing systems are:

- Systems for managing production, resources and supplies of the enterprise, which ensure the optimization and control of all stages of the production process - from the purchase of raw materials to the delivery of finished products to the end consumer, and also allow them to quickly make adjustments to them when launching new products, minimizing losses and time spent on equipment changeover.
- Industrial equipment with automatic changeover, which allows not only to quickly rebuild to a new type of product, but also to reduce the volume of work in progress, minimizing the production cycle of manufacturing products.
- Flexible technologies that allow you to quickly respond to changes in the product range. This primarily applies to digital design and modeling technologies, virtual, augmented reality and 3D printing.

## 3 TREND
## EXPANSION OF APPLICATION SCOPE OF THE LATEST TECHNOLOGIES AND CONSTRUCTION MATERIALS

Many materials used in mechanical engineering are obtained from irreplaceable resources. This primarily applies to polymers, the primary feedstock for which is oil, and to individual metals.

Along with this, the technological and operational properties of metallic and non-metallic materials, which were traditionally used in mechanical engineering, have reached their limit and no longer meet modern requirements.

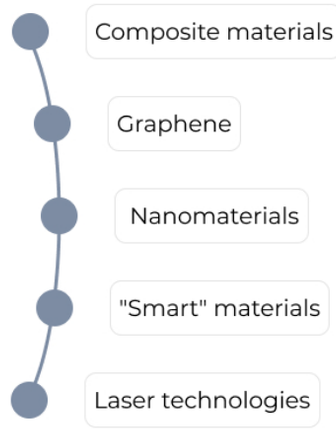
Therefore, the creation of the latest materials with improved characteristics is one of the urgent tasks of modern materials science. Moreover, the process of their creation is happening today much faster than ever, which is associated

with the rapid development of scientific and technological progress in general.

However, in order for a new material to be introduced into production, a clear understanding of how this material will be correlated with the technologies and equipment used at the enterprise, and the requirements of design documentation is necessary.

That is, it is required at the stage of creating a material to determine the relationship between material - technology - design - equipment. And the use of the latest materials by enterprises operating in a highly competitive environment for the development of fundamentally new and modernization of already manufactured products will be due to the expansion of the structural properties of these materials, as well as the high potential of their industrial applicability.

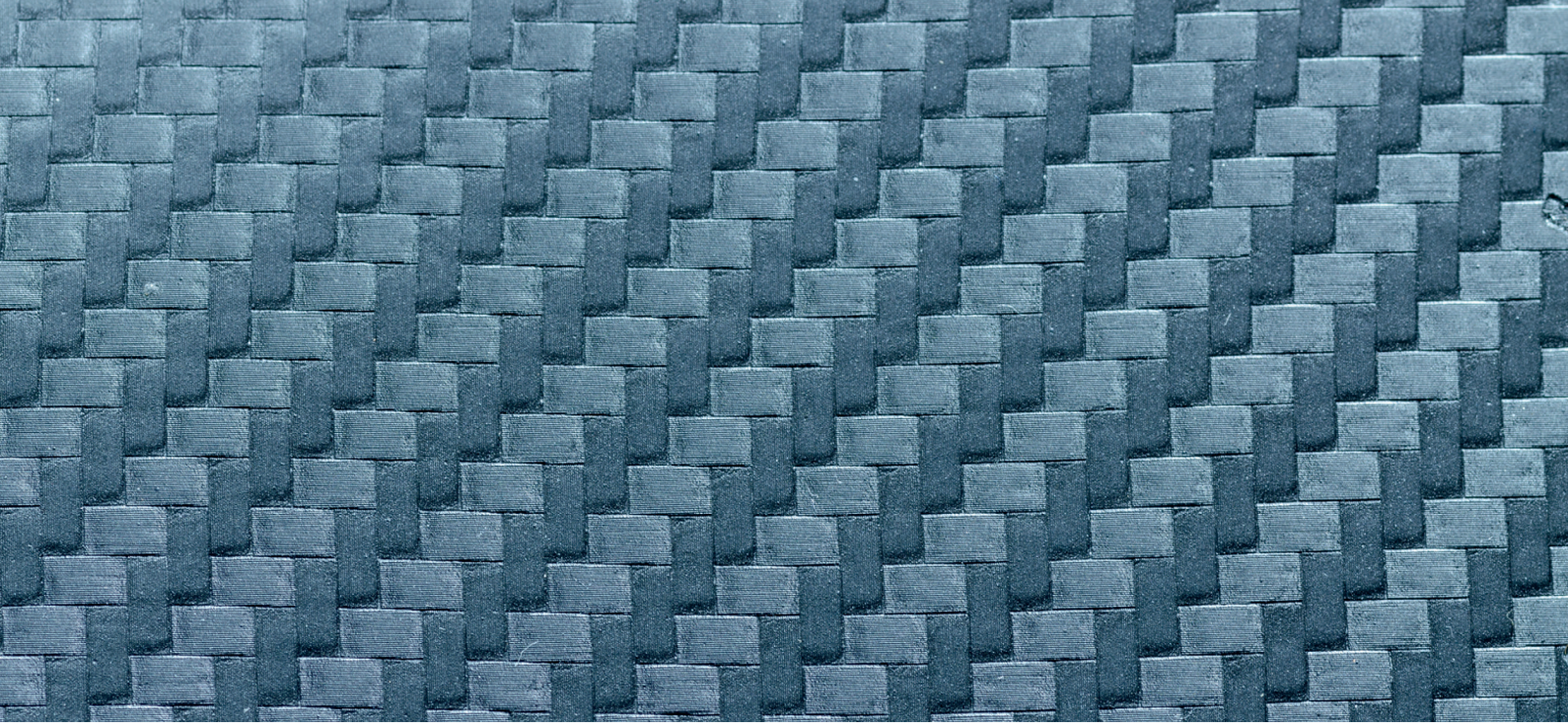
Within the framework of this trend, the industry experts were named the following, the most significant for mechanical engineering, the latest technologies and materials:




## COMPOSITE MATERIALS (COMPOSITES)

The first mention of composites dates back to about 5000 BC, when people in Mesopotamia impregnated their boats with resin. Adobe brick - a material made of clay and straw, also belongs to ancient composites, and some buildings made of it even survived to this day, this material turned out to be so strong.

Modern composites differ significantly from their ancestors, combining a heterogeneous



spectrum of properties (high strength and stiffness, heat resistance, wear resistance, plasticity, etc.) that cannot be obtained using traditional materials.

**The global composites market, according to experts from Markets and Markets Research, will grow from $ 90.6 billion in 2019 to $ 131.6 billion by 2024 with an average annual growth rate of 7.7%.**[53]

Replacement of cast iron products with composite materials made it possible to significantly increase the accuracy of manufactured products.

Thanks to composites, a new qualitative leap has become possible in increasing engine power, reducing the weight of machines and structures, and creating safe, comfortable and environmentally friendly vehicle models. The use of metal composite materials in aerospace engineering is aimed at ensuring flight safety, reducing operating costs and reducing harmful emissions into the environment during aircraft operation.
In the production of railway and water transport, composite materials solve the problem of increasing the efficiency and environmental safety of vehicles while reducing their weight and increasing their power-to-weight ratio.

In the field of information technology, composites significantly increase the storage capacity of disks and significantly reduce the size of magnetic storage devices.

Composite products last much longer than their metal counterparts, do not rust under the influence of water and oxygen, and also have high resistance to chemical and physical effects.

[53] URL: http://basalt.world/ru/obyom-globalnogo-rynka-kompozitov-dostignet-1316-mlrd-k-2024-godu/.

## TREND EXAMPLES

a. For the manufacture of wings and other elements of the SU-26M aircraft, the Sukhoi design bureau used a composite material based on high-strength carbon fibers. Thanks to this, the manufacturing technology was simplified, the weight of the airframe was reduced by 120 kg, the fuel consumption was reduced, and the flight characteristics of the aircraft increased.

b. The Japanese firm Toyota has manufactured aluminum-based metal composites for automotive parts, the use of which in the production of piston linings, has allowed to raise the temperature in the combustion chamber of the engine and its power. By increasing the wear resistance of the pistons, the vehicle's mileage increased to 300 thousand km.[54]

## GRAPHENE

Graphene, which was discovered in 2004 by scientists from the University of Manchester A. Geim and K. Novoselov, is one of the most breakthrough and promising technologies of our time, as it has a number of unique properties:

- about 200 times stronger than steel;
- has better electrical and thermal conductivity than copper;
- weighs less than 1 milligram per square meter.

**The projected growth rate of the graphene market is very high. Experts from Grand View Research believe that the graphene market, from $ 80 billion in 2019, will increase 13.5 times by 2027 and reach $ 1,078 billion.**[55]

The growth in demand for graphene is due to

- widespread use of renewable energy sources and electric transport, which require high-capacity batteries;
- high demand for durable and lightweight materials.

The unique properties of graphene make it promising in the production of microcircuits, measuring devices, biosensors,

[54] New structural materials: Educational-methodical complex / Saint Petersburg Mining University. — URL: https://old.spmi.ru/system/files/lib/uch/metodichki/2016-147.pdf.
[55] Global graphene market. — URL: http://мниап.рф/analytics/Mirovoj-rynok-grafena/.

ultracapacitors, flexible displays and other innovative devices that surpass modern devices in their characteristics.

Next-generation graphene-based materials offer great promise for the automotive industry, in particular for electric vehicles, helping to reduce vehicle weight and increase body rigidity, allowing them to accelerate faster and consume significantly less energy.

### TREND EXAMPLES

a. Spanish engineers have developed a new generation battery. It is 77% cheaper than analogs and allows you to charge an electric car in just 8 minutes and drive 1000 km before the next recharge. Graphene batteries have already been tested by two of the 4 German car companies.

b. Ford suggests adding graphene to traditional foams. Tests have shown that this combination provides a 17% noise reduction, a 20% improvement in mechanical properties and a 30% improvement in thermal conductivity compared to non-graphene foam.[56]

## NANOMATERIALS AND NANOTECHNOLOGIES

Scientific research of nanoobjects began in the 19th century, and the term «nanotechnology» was first used in 1974 by the Japanese scientist N. Taniguchi in relation to the processing of brittle materials with high precision. Recently, nanotechnology has become one of the fastest growing and demanded areas of science and technology. This was facilitated by the fact that it is an interdisciplinary area that unites specialists from different fields - physics, chemistry, materials science, IT technologies, etc. And its methods allow to obtain fundamentally new products and materials with improved characteristics.

The main areas of nanotechnology application are consumer electronics, semiconductor

[56] URL: https://3dnews.ru/977241.

industry, and automotive industry - they account for 58% of the world market.[57]

Modern nanotechnology makes it possible to create small storage devices with a huge amount of memory, nanoprocessors with low power consumption and significantly higher performance. Nanomaterials are indispensable in the aerospace and automotive industries. Due to the unique properties of the material, the manufactured products become safer, more comfortable and intelligent. And nanosensors and nanosensors provide monitoring of the operability of industrial equipment of enterprises in the industry.

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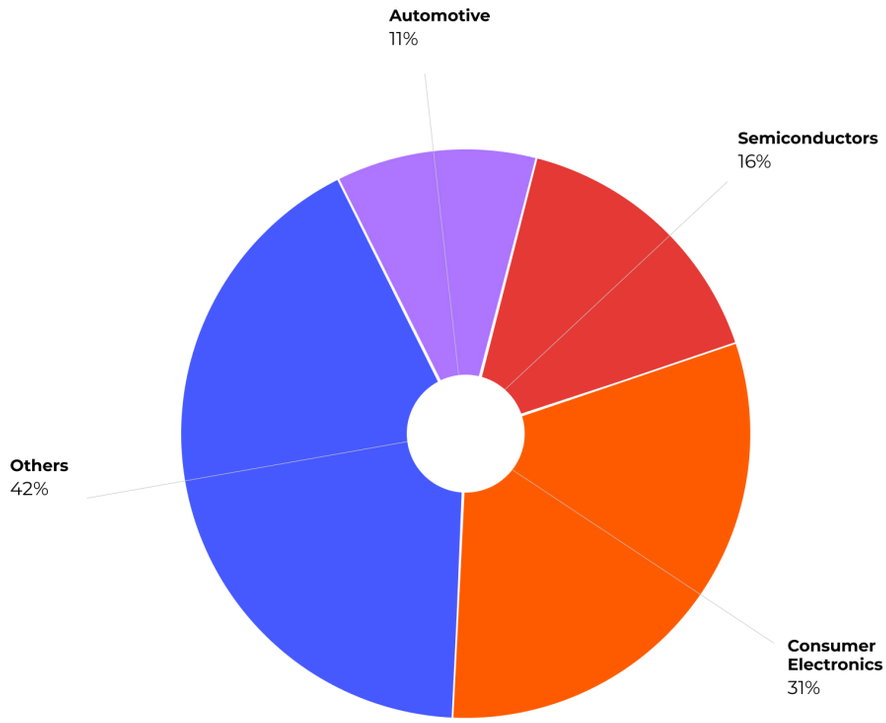
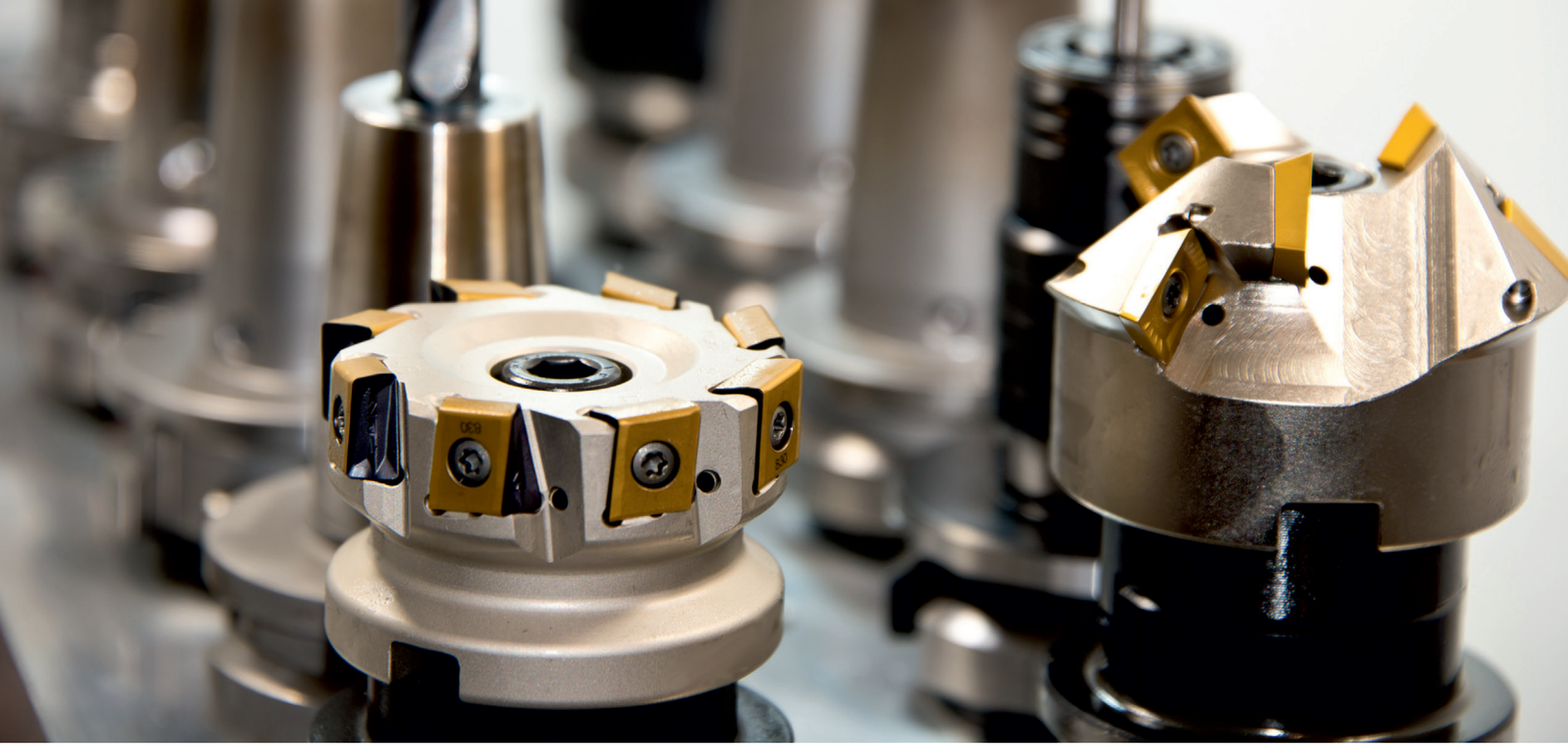
Diagram 4.9

## *The world market for nanotechnology by fields of application*




Source: Review of the global and Russian nanotechnology market for 2018.

[57] URL: https://fiop.site/o-fonde/godovye-otchety/2018/?/ru/30-overview-of-the-global-and-russian-nanotechnology-market.



## «SMART» MATERIALS

One of the main directions in the development of new materials is the creation of «smart» materials intended, for example, for smart structures. Such materials may have

- shape memory (restoring the original configuration of the part after removing the load);
- opportunities for self-healing;
- the ability to reversibly change the internal structure of the material depending on the operating conditions;
- the ability to change its shape and even configuration.

Thanks to smart materials, cracks can be healed on the surfaces of electronic devices, and minor scratches on cars will not lead to metal corrosion.

## PHOTONICS, RADIOPHOTONICS, NANOPHOTONICS AND METAMATERIALS

At present, photonics, which studies the properties of light, and combines laser physics, optoelectronics, electro-optics, optical communication, holography, etc., is one of the most important areas of science and technology development.

The European Union singled out photonics among the six leading technologies, including it in the research and innovation program "Horizon 2020: Photonics as an engine of economic growth in Europe". According to the experts of the OIDA Commission, devices based on photonics account for more than 35% of the volume of global consumer technical products.[58]

Today, a breakthrough direction in this area has been the development of radio-photonics - the transition of radio-frequency devices to the optical range. This technology enables products with characteristics that are unattainable for conventional electronic devices, such as broadband radars with «radar vision» or radio-photon antennas that are immune to electromagnetic pulses.

Nanophotonics is another completely new direction in the development of photonics, which is associated with the study of physical phenomena that occur as a result of the interaction of photons with nanoobjects. As a result, new ultra-thin metamaterials have been discovered that demonstrate a negative refractive index.

This property can find wide application, for example, in the production of quantum computers, optical lenses and mirrors, which are thinner than the wavelength of visible light, etc. Thanks to this discovery, all optics can go into the field of ultra-thin optics.

## TREND EXAMPLES

a. A traditional ground-based radar station is as large as a multi-storey building. When using radio photonics technologies, it will reduce its size so much that the station can be placed on a conventional KAMAZ. At the same time, the indicators of efficiency and signal range will remain unchanged.[59]

b. If the information volume of a conventional optical disk is about 1 GB, then the use of nanophotonics can increase its volume up to 10-100 GB.[60]

[58] URL: https://www.skoltech.ru/industriya/prioritetnye-tehnologicheskie-oblasti-industrialnyh-proektov/tehnologii-fotoniki/.
[59] Kazan National Research Technical University. A. N. Tupolev. — URL: http://mwpt.kai.ru/%D0%B0%D0%B1%D0%B8%D1%82%D1%83%D1%80%D0%B8%D0%B5%D0%BD%D1%82%D0%B0%D0%B.
[60] The Russian Academy of Sciences. — URL: http://www.ras.ru/digest/showdnews.aspx?id=9770a6f8-f983-45cd-9668-83d6482a1385&print=1.


VFO/MR
A/B
BAND
MENU
EXIT
1 STEP
2 TXP
3 SAVE
SCAN
4 VOX
5 WN
6 ABR
0 SQL
7 TDR
8 BEEP
9 TOT

# 4 TREND
# IMPROVING THE EFFICIENCY OF PRODUCTION MANAGEMENT

There are many ways to increase the competitiveness of an enterprise. It is possible to introduce new technologies, purchase expensive equipment, change the range of finished products, and send workers for internships abroad. But all these methods significantly increase the production cost.

And it is even possible, even on the basis of existing production facilities, using advanced production management technologies, to increase the efficiency of each stage of the business process and the interaction of all its participants. The main technological solutions in the field of production management, according to experts, are:

- High level of depreciation of production facilities in mechanical engineering of Kazakhstan
- The growing need for the introduction of flexible production systems in mechanical engineering
- Expansion of the scope of application of the latest technologies and construction materials
- Improving the efficiency of production management
- Growing demand for intra-industry cooperation of strategic enterprises
- The growing needs of cooperation between reseach institutes and education with industry enterprises
- Increase in the outflow qualified personnel to the countries of near and far abroad

## LEAN PRODUCTION

The most popular among the world's leading companies is the Lean Manufacturing technology, which is based on the concept of eliminating all types of losses and unleashing the creative potential of the company's employees.

This technology includes many tools such as Continuous Improvement System (Kaizen), Manufacturing and Marketing Phase Planning (Canban), Ideal Workplace Management (5S), Rapid Equipment Changeover (Smed) and Equipment Maintenance (TMP), production (Pull productio), and a number of others that can be used independently of each other.

However, Lean technology gives the greatest result with the integrated implementation of these tools, the sequence of actions and the maximum involvement of company personnel in this process.

**Lean manufacturing is the hidden potential of any enterprise.**

Using Lean methods, according to the world's leading experts, can give tangible results:

- growth of labor productivity by 35-70%;
- reduction of the production cycle time by 25-90%;
- reduction of rejects by 58-99%;
- growth of product quality by 40%;
- increase in the time of equipment up to 98%;
- release of production space by 25-50%.

Though this technology became widespread in the world at the end of the twentieth century, in our country it began to be introduced relatively recently - the first 15 enterprises introduced Lean tools in 2009.

At the same time, enterprises almost immediately felt the economic effect, which became an incentive for other companies.

## TREND EXAMPLES

a. LLP «Kainar AKB» from the implementation of the Kaizen system for 2 months received more than 208 million tenge of net profit, JSC «Munaymash» achieved an economic effect of 47 million tenge due to the introduction of management technologies.[61]

b. At the Kovrov Mechanical Plant (Russia), the production of a centrifuge took over a thousand hours. After the introduction of lean management methods, the time was reduced by 55%, and the costs decreased by almost 2 times.[62]

## ENTERPRISE RESOURCE MANAGEMENT SYSTEM

For successful automation in industry, an integrated enterprise business process management (ERP) system is required, since enterprise management affects all areas of its activities, from recruiting to the production and sale of final products.

The successful solution of the issue of planning the activities of the enterprise is aimed at improving the quality of products, increasing the efficiency of business processes.

In 2018, the global enterprise resource planning (ERP) software market volume reached $ 35 billion, an increase of 10% compared to 2017.[63]

There are a large number of software modules that allow you to control the execution of the stages of the technological chain of production of products, the main of which are automated systems:

- manufacturing execution systems (MES);
- customer relationship management (CRM);
- supply chain management (SCM);
- product lifecycle management (PLM);
- quality performance management (QPM);
- human resource management (HRM).

[61] URL: https://www.zakon.kz/4513200-lin-tekhnologii-vnedrjajutsja-na-36.html.
[62] URL: https://genuspeha.ru/berezhlivoe-proizvodstvo-eto/.
[63] URL: https://www.tadviser.ru/index.php/Article: ERP systems_(world market).

According to Panorama Consulting Solutions, 43% of ERP projects in the world are implemented in production, in half of the cases ERP projects pay off in up to three years, and the effect of implementation is noticeable within the first year.[64]

## CROWDSOURCING

The concept of crowdsourcing in industrial enterprises most often comes down to involving consumers in the process of developing a product or service. Both parties benefit from this. At the end, the customer receives a product that meets his requirements as much as possible. The manufacturer can test the product and correct the mistakes made before launching it into mass production, as well as form the future demand for the product in demand on the market.

Success stories of companies show that crowdsourcing technologies are an effective way to overcome the crisis, reduce costs, and improve the sales system.

### TREND EXAMPLES

LocalMotor Company (USA) has united a 30,000-strong community of designers, engineers, constructors to develop, design and then sell vehicles. Their goal was to create a new automotive design, organize high-tech production and implement the latest technologies to expand the range of products through crowdsourcing.

[64] URL: https://www.panorama-consulting.com/.

# 5 TREND
# GROWING DEMAND FOR INTRA-INDUSTRY COOPERATION OF STRATEGIC ENTERPRISES

Currently, there is no stable collaboration between machine-building enterprises and manufacturers of finished high-quality metallurgy products in Kazakhstan.

One of the solutions to the issue of meeting the needs for materials and components for finished products can be the creation of centers of basic production in regions with a large concentration of machine-building plants.

Since the production of high-quality steel grades is insufficiently established in the country, machine-building enterprises are completely dependent on imports. The main problem with the purchase of imported metallurgical products is that the metal is purchased through intermediaries, while the price of metal increases from 30% to 40%.

There is also no opportunity to buy metal directly, since metal producers sell them by car, and one car is loaded with metal of the same type.

The creation of centers of basic production would make it possible to reduce the cost of purchasing metal, upon receipt of an order for metal from several machine-building enterprises, as well as the most optimal way to cut the metal, focusing on the needs of a particular manufacturer.

All this would definitely entail a decrease in the price of finished products and increase the efficiency of the machine-building enterprises.

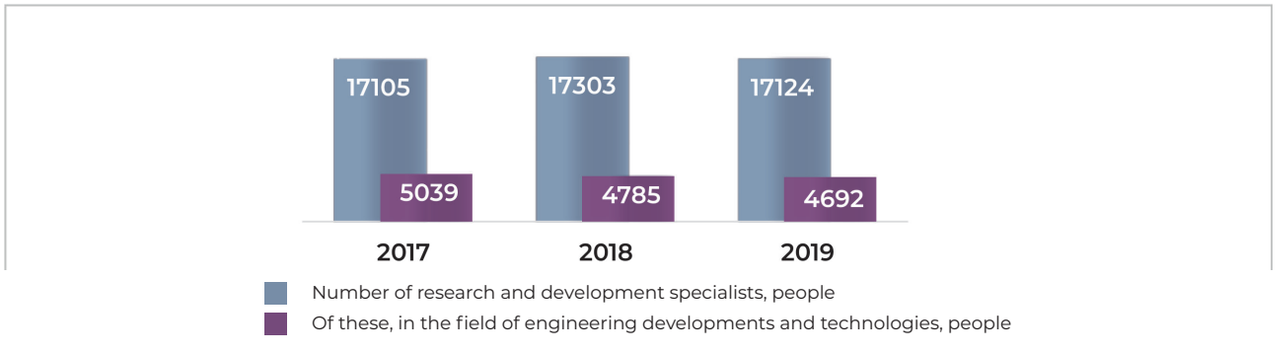
# 6 TREND
# GROWING DEMAND FOR AN EMPLOYEE OF RESEARCH INSTITUTES AND EDUCATION WITH INDUSTRY ENTERPRISES

Currently, in Kazakhstan, 17 thousand researchers are engaged in research and development (R&D), 27% of whom are engaged in research in the field of engineering developments and technologies.

And if the number of R&D researchers in all directions in 2019 increased by 19 people compared to 2017, then the number of researchers in the field of engineering developments and technologies decreased by 347 people, or by 6.9%.

Diagram 4.10

***The number of research specialists carrying out R&D in the Republic of Kazakhstan***




Source: Committee on Statistics of the Ministry of National Economy of the Republic of Kazakhstan.

At the same time, in the conditions of the modern development of mechanical engineering, characterized by the rapid introduction of the latest technologies and the obsolescence of knowledge, effective interaction between research institutes (SRI) and industrial enterprises is becoming increasingly important.

Enterprises that implement cooperation with research institutes in production processes gain a competitive advantage due to the rapid transfer of created innovative products, and research institutes receive support in the form of regular orders for new developments.

Cooperation between educational institutions and enterprises also has a positive impact on the development of domestic mechanical engineering, being one of the main factors in the development of human resources

in the industry.

Every year, 55 universities and 132 colleges of the country graduate about 25 thousand young specialists in the field of mechanical engineering (6 thousand - universities, 19 thousand - colleges), the level of training of which, according to industry experts, does not fully meet the requirements of employers.

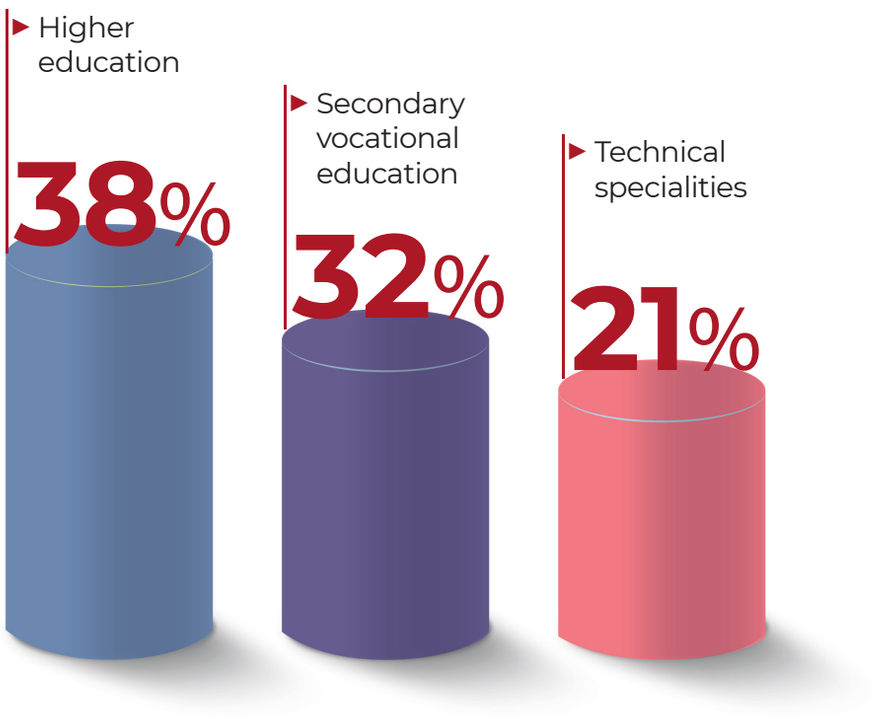
In connection with the isolation of educational programs from the real needs of the industry, there is a growing need for interaction between universities and enterprises, as well as the choice of an effective model of this cooperation that best meets the interests of both parties. For example, cooperation between educational institutions and enterprises can take such formats as

- targeted training of specialists;
- creation of business incubators at educational institutions;
- undergoing practical training at enterprises;
- attraction of engineering personnel of enterprises to teaching at universities and colleges;
- involvement of employers in assessing the professional knowledge and skills of student youth;
- participation of representatives of industry enterprises in the defense of diploma projects, international conferences, as a result of which a base of potential employees of enterprises is created, and other methods..

The interaction of higher educational institutions and enterprises through the teaching of individual disciplines by employees of factories, identified by industry experts as the most effective format, contributes to increasing the competitiveness of universities and colleges, updating educational programs and obtaining students of practical professional competencies.

# 7 TREND
# INCREASE IN THE OUTFLOW OF QUALIFIED PERSONNEL TO THE COUNTRIES OF NEAR AND FAR ABROAD

In the last year alone, 33.6 thousand people over the age of 15 have left Kazakhstan for the countries of near and far abroad, of which 94% are of working age, 38% - with higher education, 32% - with technical and vocational education and 21% have technical specialties.



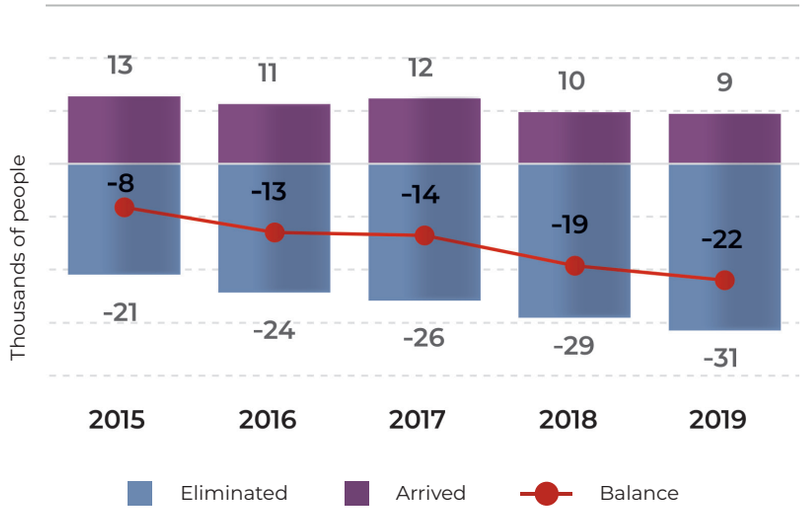
Since 2012, Kazakhstan has seen an increase in the outflow of the population to the countries of near and far abroad, including the population of working age. The negative balance of migration of the working-age population is growing, in 2019 it reached 22 thousand people.

The indicators of migration of the population in terms of education indicate the prevalence of qualified specialists among those leaving the country. Whereas among those arriving in the country, the largest share is the population with basic school education.

Developed and developing countries are interested in attracting labor resources with a high level of qualifications, therefore they actively offer such specialists favorable conditions when moving and the prospective application of their knowledge and work experience. All this can lead to a significant decrease in the «quality» of labor resources in Kazakhstan. Whereas already now, experts of the domestic engineering industry note a shortage of qualified personnel at enterprises, which are so necessary for the implementation of innovations of the Fourth Industrial Revolution.

Diagram 4.11

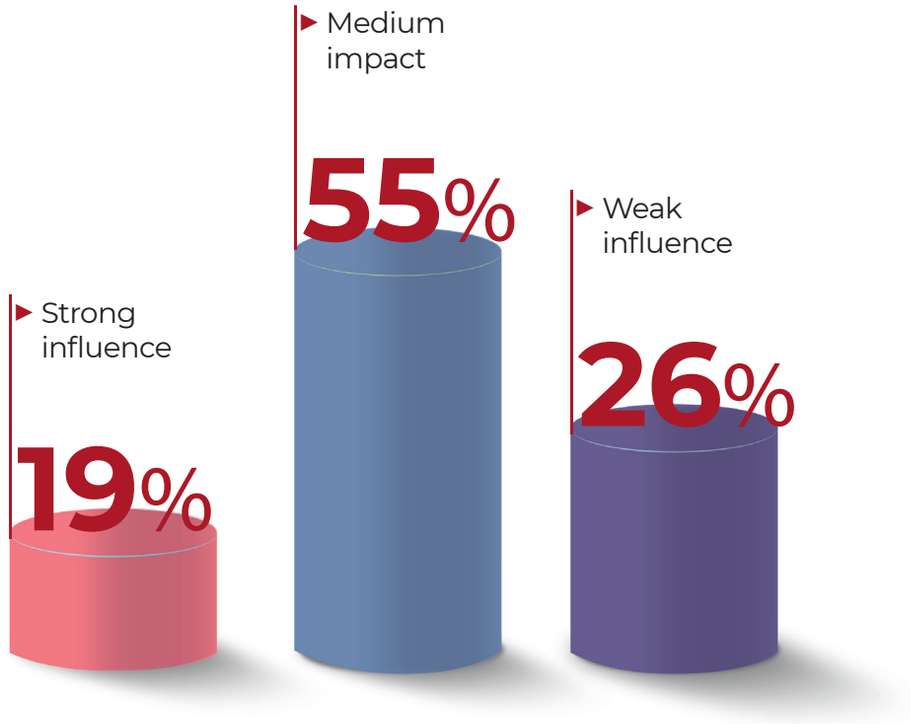
***External migration of the able-bodied population in the Republic of Kazakhstan***




Source: Committee on Statistics of the Ministry of National Economy of the Republic of Kazakhstan


# 4.4.
# INCREASING REQUIREMENTS TO ENVIRONMENTAL FRIENDLINESS OF PRODUCTION

Increasing requirements for environmental friendliness of production and products in the next 10-15 years, according to industry experts, will have an average impact on the development of mechanical engineering in Kazakhstan.




In recent years, the concept of transition to sustainable development - the integration of environmental safety with balanced economic development, has become a strategic priority for most countries.

The acceleration of this process is facilitated by the use of the potential of the latest technologies, which not only reduce the negative impact on the environment, but also increase the efficiency of the use of natural resources.
The implementation of the concept of transition of the country's machine-building complex to sustainable development occurs under the influence of the following trends:

- Increase in harmful emissions by enterprises of the manufacturing sector of Kazakhstan
- Increasing requirements for environmental friendliness of production processes
- Increase of requirements in the field of industrial waste management

# 1 TREND
# INCREASE IN HARMFUL EMISSIONS BY ENTERPRISES OF THE MANUFACTURING SECTOR OF KAZAKHSTAN

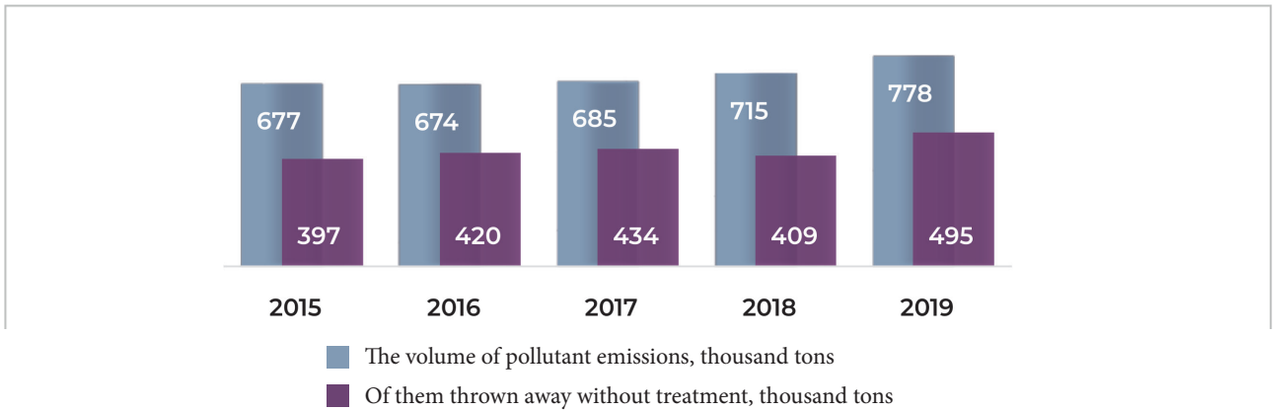
Any production activity is accompanied by harmful emissions. On average, each resident of Kazakhstan annually accounts for 138 kg of pollutants emitted by all enterprises in the country in the form of soot, hydrogen sulfide, ammonia and other harmful substances.

About a third of these emissions are generated by the manufacturing industry. In 2019 alone, emissions from all stationary sources of enterprises in the industry amounted to 14.2 million tons, and their level compared to the previous year increased by 10%.[65]

Though 94.5% of the total volume of emissions was captured and neutralized by the treatment facilities of the industry enterprises, 778 tons were nevertheless emitted into the atmosphere, of which 63.6% did not go through the treatment facilities at all.

The manufacturing sector has so far failed to reduce emissions of pollutants into the atmosphere. Their volumes annually increase by an average of 2.7%, and emissions without treatment - by 3.7%. But the situation could change dramatically. This requires that enterprises are interested in the

Diagram 4.12
***Volumes of pollutants emitted by manufacturing***




Source: Committee on Statistics of the

[65] Information and analytical system «Taldau» of the Committee on Statistics of the Ministry of National Economy of the Republic of Kazakhstan.

transition to «green» production and begin to introduce environmentally friendly technologies and innovations.

One of the levers of such a transition is the increased environmental requirements for the activities of enterprises.

## 2 TREND
## INCREASING REQUIREMENTS FOR ENVIRONMENTAL FRIENDLINESS OF PRODUCTION PROCESSES

Increasing environmental requirements for enterprises, introducing an automatic system for monitoring emissions of harmful substances, tightening the administrative responsibility of violating enterprises, forces manufacturers to install treatment facilities and introduce innovative technologies in order to reduce the harmful impact on the environment.

In 2018 alone, fines levied in compensation for damage caused by violation of environmental legislation by domestic enterprises of the manufacturing sector amounted to 944 million tenge, which is 2.5 times higher than the fines levied in 2016. Compared to 2000, the amount of fines increased 35 times.

From which it follows that in the manufacturing industry today there are still enterprises that are insufficiently equipped with treatment facilities, or do not fully use their production capacity.

**In 2019, out of 47 thousand stationary sources of emissions of pollutants from the manufacturing industry, 92.7% were sources with established emission limits, 14.9% were equipped with treatment facilities.**

**At the same time, only 0.4% of enterprises in the industry have introduced environmental innovations.**

At the moment, the issues of environmental friendliness of production are among the top priorities, requiring additional capital investments from enterprises.

At the same time, the use of environmental innovations turns around for enterprises and tax incentives, which for several years can justify the costs of introducing innovative solutions.

The transition to a «green» economy can be accelerated by the maximum coverage of enterprises with technologies with a lower index of negative impact on the environment, the introduction of environmental innovations and environmental expertise of production and finished products.

# 3 TREND
# INCREASE OF REQUIREMENTS IN THE FIELD OF INDUSTRIAL WASTE MANAGEMENT

The process of any production is accompanied by the generation of waste. In 2018, the country's enterprises generated 0.8 billion tons of industrial waste, of which only 32.2% was sent for recycling.[66]

**It should be noted that the number of waste management methods is increasing annually in Kazakhstan. If in 2016 only 16 methods of waste processing were used, then in 2018 there were already 38 of them.**

In mechanical engineering, waste is generated not only as a result of mechanical processing of parts, but also in connection with the irrational use of raw materials, the release of defective products, and the decommissioning of obsolete equipment.

**The main concept of modern production is environmentally friendly closed-cycle production with the introduction of waste-free and low-waste technologies.**

Remelting metal shavings, processing it into powder for recycling in powder metallurgy are among the main methods of processing industrial waste. But the solution to the problems of reducing the volume of waste is within the power of modern technologies, such as 3D printing, smart sensors, robots, etc.

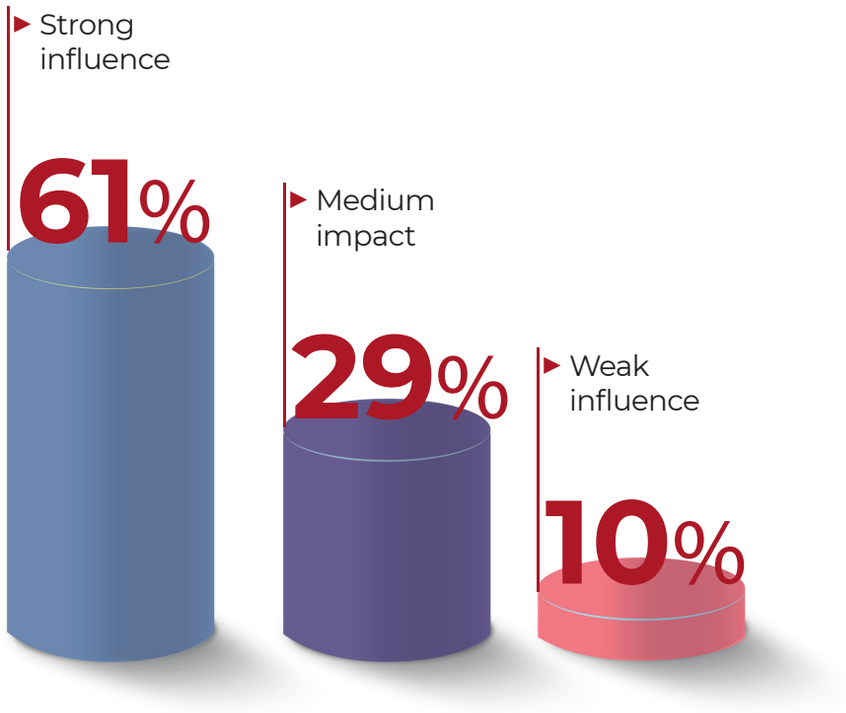
With traditional technologies, the loss of raw materials can reach 80-85%. And for the manufacture of parts using a 3D printer, exactly the amount of material that is required for this is used.[67]

The use of «smart» sensors and robotic systems contributes to a significant reduction in the number of rejects.

[66] Information and analytical system «Taldau» of the Committee on Statistics of the Ministry of National Economy of the Republic of Kazakhstan.
[67] Globatek. 3D. Additive technologies and additive manufacturing. — URL: https://3d.globatek.ru/world3d/additive_tech/.

# 4.5.
# CHANGE IN REQUESTS OF GENERATION Y AND Z

Changing the demands of the new generation of specialists Y and Z in the next 10-15 years will have a strong impact on the development of mechanical engineering in Kazakhstan.



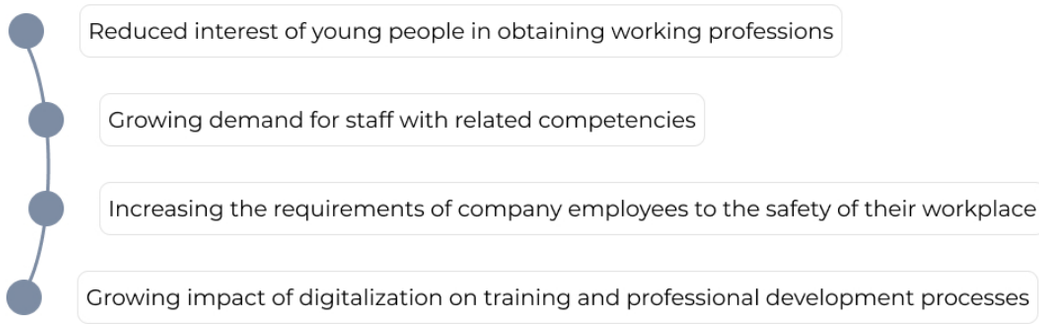

The labor market has never faced a situation where representatives of five generations can work side by side in one company.

Young people who were born in the era of computers, the Internet and social networks, having completely different values and behaviors compared to previous generations, are now beginning to take an increasingly active position in the labor market.

At the same time, employers increasingly began to experience difficulties in hiring young specialists. One of the reasons for this process is the current demographic situation in Kazakhstan, which in the near future will only aggravate the problem of replenishing personnel. If the number of young people aged 25-29 over the past five years has decreased by 159 thousand people, then the age group from 20 to 24 years old is decreasing even more rapidly - its number has decreased by 227 thousand people.

A significant influence on the formation of the labor market is also exerted by the increasing demands and requirements of the new generation of specialists for working conditions and remuneration, equipping the workplace, the possibility of moving up the career ladder, etc.

According to industry experts, the change in the requests of the generation of specialists Y and Z is taking place under the influence of 4 trends that have the greatest impact on the development of mechanical engineering in the next 10-15 years.




# 1 TREND
# REDUCED INTEREST OF YOUNG PEOPLE IN OBTAINING WORKING PROFESSIONS

The decline in the prestige of blue-collar occupations and the lack of young people at enterprises are becoming the main constraining factors for the development of production. Young people of today, especially in large cities, do not want to join factories. The days when standing at the bench was considered a prestigious occupation have long been forgotten. Today, parents and schools are more oriented towards school graduates to enter universities.

Every year the Kazakhstani labor market is replenished by 280 thousand young specialists. At the same time, not all of them, after graduation, enter employment according to their university or college specialty.

**Only every fifth employee of mechanical engineering enterprises is among the youth under the age of 28, and 80% of the personnel are representatives of the older age groups.**

**Therefore, the tendency of aging of the staff is becoming more and more noticeable.**

In mechanical engineering, there is also a fairly high employee turnover rate, the highest is in the automotive industry, where during the year almost every third employee leaves at their own request. Whereas, in general, for industries, the turnover rate does not exceed 20%.

# 2 TREND
# GROWING DEMAND FOR STAFF WITH RELATED COMPETENCIES

It is rather difficult to assess the economic consequences of the outflow of the able-bodied population to the countries of near and far abroad and the decrease in the interest of young people in the development of working specialties.

However, today it becomes obvious that in the near future mechanical engineering may face a shortage of highly qualified specialists.

In such a situation, employers will be forced to hire or independently train specialists with the maximum number of professional competencies.

In order to be in demand in the labor market, employees of enterprises and young specialists are also interested in expanding their competencies in order, if necessary, to perform duties that go beyond the main job responsibilities.

All this, in turn, increases the demand for educational products of educational institutions and advanced training courses.

The development of related specialties helps enterprises to distribute the workload on staff in such a way as to maximize the workload of each employee and to quickly resolve the issues of replacing some employees with others.

**Employees who have mastered related professions (specialties) are of great value not only for the company in which they work, but also in the labor market as a whole.**

The concept of a related profession is often confused with continuing education. In fact, these are two different things. When taking advanced training courses, an employee acquires additional knowledge in his own specialty and, as a result, can perform more complex work.

Mastering a related profession consists in taking certain courses, usually short-term, which make it possible to expand their professional competencies and perform the work of a specialist in another profession.

The combination of professions is most effective when it concerns professions interconnected by a chain of one technological process.


# 3 TREND
# INCREASING THE REQUIREMENTS OF COMPANY EMPLOYEES TO THE SAFETY OF THEIR WORKPLACE

Most of the stages of production at machine-building enterprises are associated with a high level of danger, work in difficult and hazardous working conditions. Robotic systems implemented at enterprises also belong to production systems with an increased level of danger.

Employees of enterprises, taking over a shift, must be sure that nothing will happen to them at the workplace. Therefore, the issues of ensuring the safety of production and labor protection of workers are among the priority tasks.

You can ensure the safety of the production process by introducing special monitoring sensors (emergency, alarm, gas analyzers, vibration meters, etc.), protective light curtains, laser scanners and other solutions.

For the safe movement of non-stationary robots, special markings are used along its entire route.

Equipment monitoring for possible threats, defects or malfunctions leading to emergency situations should be carried out continuously in order to timely stop their further development.

Therefore, enterprises should have specialized personnel who, with the help of modern devices, can monitor the operation of all industrial equipment of enterprises, quickly respond to the slightest disruptions in its operation and make decisions in order to reduce industrial injuries.

### TREND EXAMPLE

The German company SICK, a leader in the segments of industrial automation and sensor technology, creates conditions for reliable and efficient process control, as well as contributes to the reduction of industrial injuries. For example, the final assembly of an electric motor uses a safety concept that includes a safety laser scanner, a light curtain and a safety controller.[68]

## 4 TREND
## GROWING IMPACT OF DIGITALIZATION ON TRAINING AND PROFESSIONAL DEVELOPMENT PROCESSES

Under the influence of progress, everything around is rapidly changing - technology, the labor market and its requirements. Specialists who want to remain in demand in the labor market and be as efficient as possible in the profession must constantly improve their knowledge and skills. Today, continuing professional education plays a significant role, which does not always mean advanced training directly in the field in which the education was originally received.

[68] SICK Sensor Intelligense, https://www.sick.com/ru/ru/industries/automotive-and-parts-suppliers/parts-suppliers/powertrain-suppliers/safe-human-robot-collaboration-in-the-final-assembly-of-electric-motors/c/p571844

The education system also did not remain aloof from the global transformation of society. Today, it is moving away from traditional training to orienting itself toward an entire industry, offering modern forms of education and involving digital technologies in the educational process.

The most promising areas of digitalization for implementation in the education system are

- BigData;
- deep immersion in the professional environment (Deep Learning);
- cloud and blockchain technologies;
- online training;
- gamification;
- visualization.

The ability to work with **BigData** allows you to use the potential of artificial intelligence to support educational, scientific and creative activities of students - consulting assistance in matters where it is required to operate with large amounts of information.

**Deep Learning** is of particular interest in connection with the development of virtual and augmented reality technologies that allow simulating production processes in a virtual space, using online tips, instructions and recommendations.

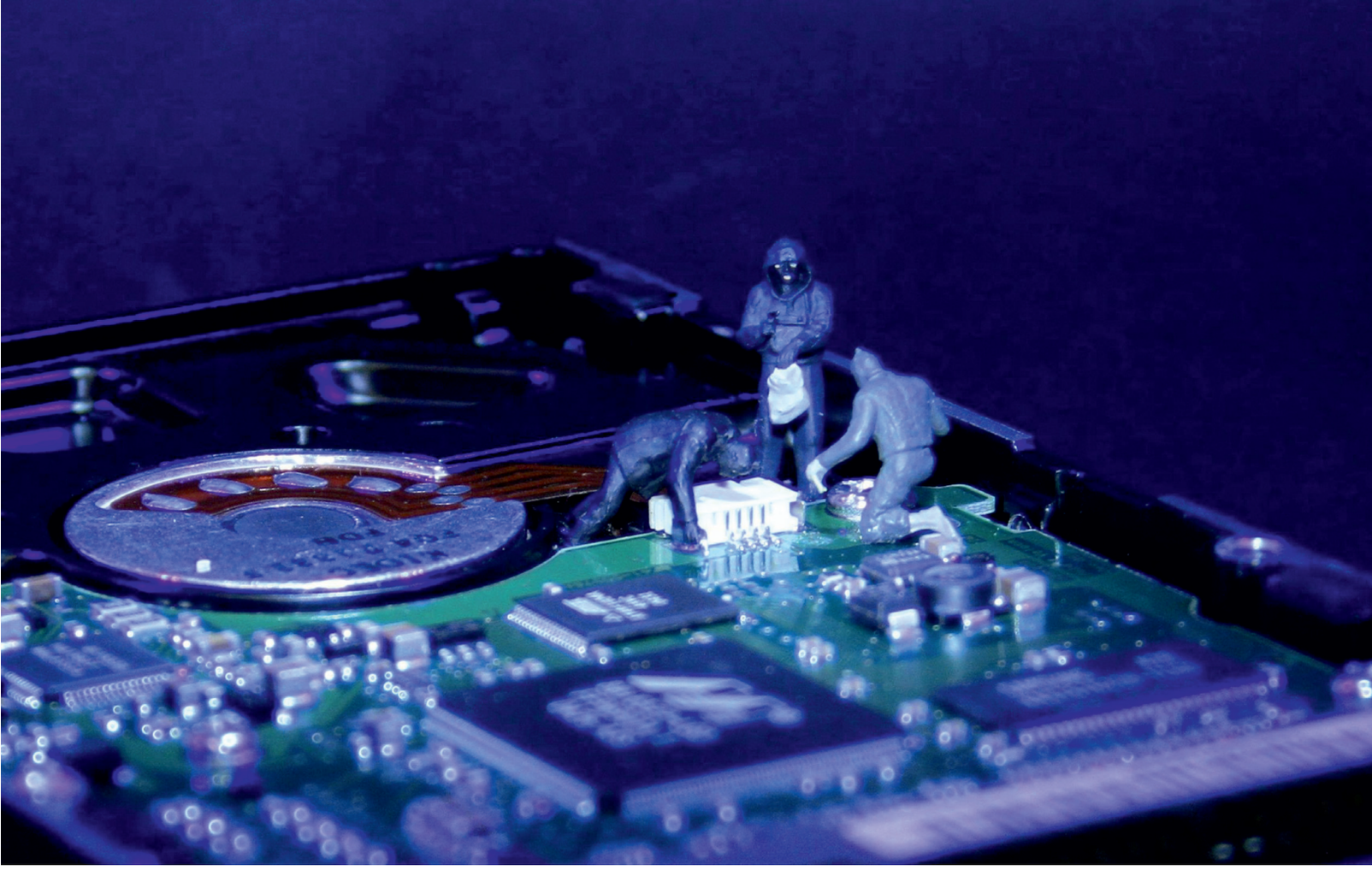
**Cloud technologies and blockchain** are actively used in some universities abroad in the preparation of diploma theses. This allows teachers and employers in an open information space to track the progress of the stages of preparation of diploma projects, to assess the promising opportunities for students to attract to work in the company.

**Online training**, as one of the forms of distance learning, is most actively used to improve the qualifications of employees of enterprises on the job.

The introduction of gamification into the education process is widespread today.

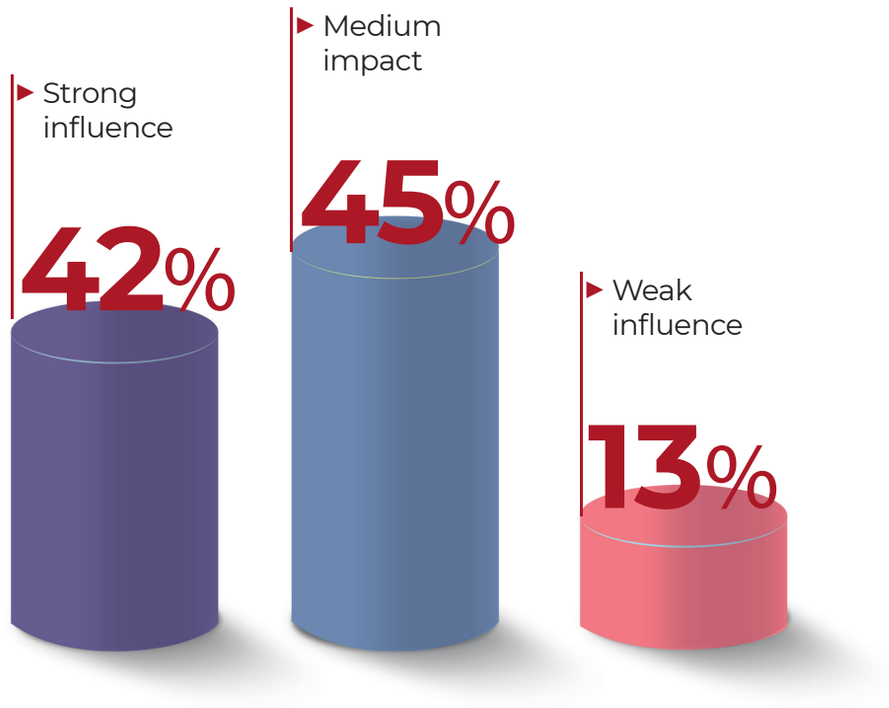
The game format increases the interest of students and specialists in mastering new knowledge. And the use of **visualization** technologies allows you to speed up the process of memorizing information by building associative links.

The use of digital technologies is very important for the development of the system of higher and vocational education, however, along with this, it is necessary to form a scientifically based approach to their implementation.



# 4.6.
# CHANGES IN CONSUMER PRICES PREFERENCES

Changes in consumer preferences in the next 10-15 years will have a medium-strong impact on the development of mechanical engineering in Kazakhstan.




The growing influence of digitalization in business and society is widely discussed today. But more and more often it became emphasized that production should be oriented towards consumers, who, even in their daily activities, are becoming more and more dependent on innovative developments. Changing consumer preferences are forcing businesses to seek new opportunities and expand their product range.

While yesterday the consumer dreamed of a washing vacuum cleaner, today he may opt for a robot vacuum cleaner. The same applies to the automotive market, where electric vehicles are beginning to be popular.

Therefore, manufacturers have to quickly respond to changes in demand and make adjustments to the range of products.

The change in consumer preferences, according to industry experts, occurs under the influence of 4 trends that have the greatest impact on the development of mechanical engineering in the next 10-15 years.

- Growing demand for upgrading the production capacities of the sectors of the economy of Republic of Kazakhstan
- Growing demand for the production of customized mechanical engineering products
- Growing demand for innovative mechanical engineering products

# 1 TREND
# GROWING DEMAND FOR UPGRADING THE PRODUCTION CAPACITIES OF THE SECTORS OF THE ECONOMY OF KAZAKHSTAN

It is not only at the enterprises of the machine-building complex that there is a high level of wear and tear of production facilities. The high level of wear and tear of machinery and equipment in the most important sectors of the country's economy, such as the mining industry (72%), construction (52%) and agriculture, forestry and fisheries (43%), against the background of a low rate of renewal of production capacities, is a potential opportunity for domestic machine builders in the field of expanding the range and volumes of products.

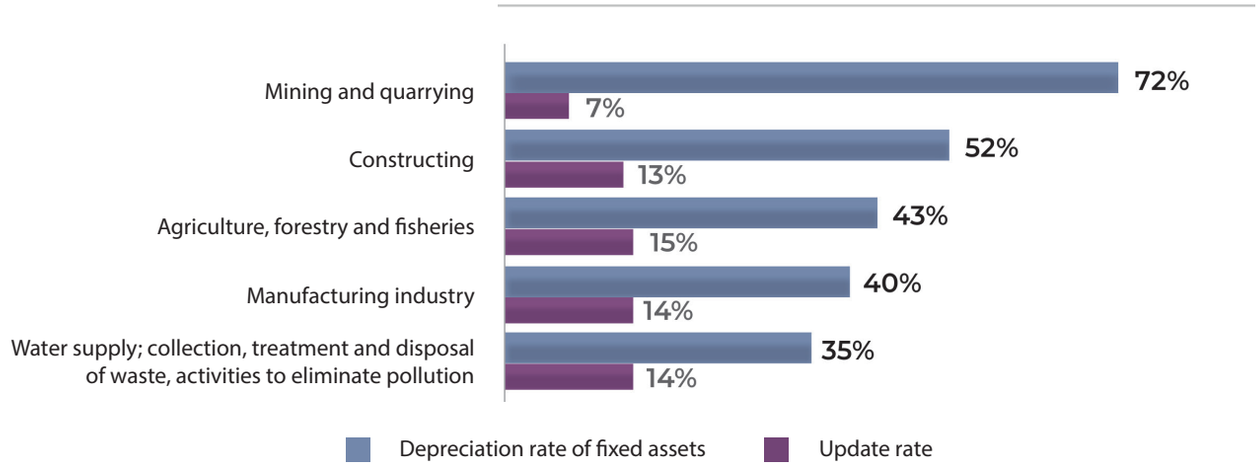
In Kazakhstan, out of 148 thousand tractors and 40 thousand combines, only 16% and 46%, respectively, have a service life of less than fifteen years. The rolling stock of railway transport has a similar problem: wear of locomotives is 64%, passenger cars - 58%, freight cars - 46%.[69]

However, despite the high wear and tear of rolling stock in agriculture and railway transport, the level of domestic production of mechanical engineering in this direction is still at a very low level and does not cover the needs of the industry. All this opens up great prospects for domestic machine builders producing machines and equipment for economic sectors in the development of this market.

[69] Comprehensive plan for the development of mechanical engineering of the Republic of Kazakhstan for 2019 — 2030. — URL: https://smkz.kz/img/kompl-plan-proekt2018.pdf.

Diagram 4.13

***Top 5 industries of the Republic of Kazakhstan with the highest degree of wear and tear of machinery and equipment at the end of 2019.***




Source: Committee on Statistics of the Ministry of National Economy of the Republic of Kazakhstan.

# 2 TREND
# GROWING DEMAND FOR THE PRODUCTION OF CUSTOMIZED MECHANICAL ENGINEERING PRODUCTS

Before the appearance of factories and plants, all goods were customized - clothes and shoes were sewn according to individual measurements, furniture and household utensils and even food were also made.

With an increase in demand and the development of industrial production, companies began to focus on optimization and cost reduction, producing consumer goods. Recently, there has been a tendency again to move from serial production of products to small-scale and customized production for individual orders in a single copy. This is due to the presence on the market of a large number of almost identical products.

Customized production is developing in two directions:

- individual production, which includes the creation of a unique product, most often an elite segment, according to the individual needs of a particular client;
- modular manufacturing, which is used where a product can be broken down

into its constituent parts or components.

In this case, the consumer can choose his own version of the complete set of system elements. A classic example is buying a car in one configuration or another.

The equipment and technologies used at the operating enterprises are set up for the production of serial products.

A new approach to the organization of production involves the release of customized products based on computer engineering technologies, the use of new materials, additive technologies and the industrial Internet of things.

## 3 TREND
## GROWING DEMAND FOR INNOVATIVE MECHANICAL ENGINEERING PRODUCTS

The need for innovative mechanical engineering products is growing every year.

This is dictated not only by the rapid development of scientific and technological progress, but also by changes in consumer preferences for assortment, quality, environmental friendliness and functionality of the products.

In recent years, both in the world and in Kazakhstan, there has been an increase in demand for industrial and household robots, electric vehicles, unmanned ground and aircraft, ultra-powerful computers and smart sensors, for installations of alternative energy sources, etc.

But what about the production of innovative mechanical engineering products in our country?

**In 2019, the share of mechanical engineering enterprises accounted for 34% of the total republican volume of manufactured innovative products. It should be noted that in 2018 this figure was only 19%.**

Over the past years, there has been a steady growth trend in the volume of innovative mechanical engineering products - in 2019, amounting to 333.3 billion tenge, it increased by 2.1 times compared to 2017.

The above data paints an optimistic picture. However, this indicator does not fully reflect the level of innovative activity in mechanical engineering. In international practice, two indicators are used for such an assessment:

- the share of enterprises that have carried out innovations over the past three years

among all enterprises in the industry;

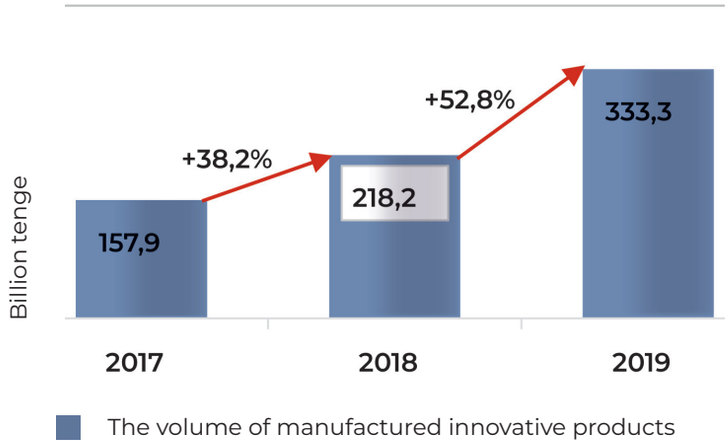
- the share of innovative products in the total output of the industry.

The leader of the rating in the mechanical engineering of the Republic of Kazakhstan according to the first indicator is the industry, the enterprises of which produce computers, electronic and optical equipment (49%), according to the second - the production of cars, trailers and semi-trailers (73%).

The results of other industries are much more modest. From the analysis presented above, it becomes obvious that the current level of innovative activity of individual engineering industries does not allow meeting the growing demand of business entities and the country's population for innovative products.

Diagram 4.14

***The volume of innovative products produced by mechanical engineering enterprises of the Republic of Kazakhstan.***




Source: Committee on Statistics of the Ministry of National Economy of the Republic of Kazakhstan.

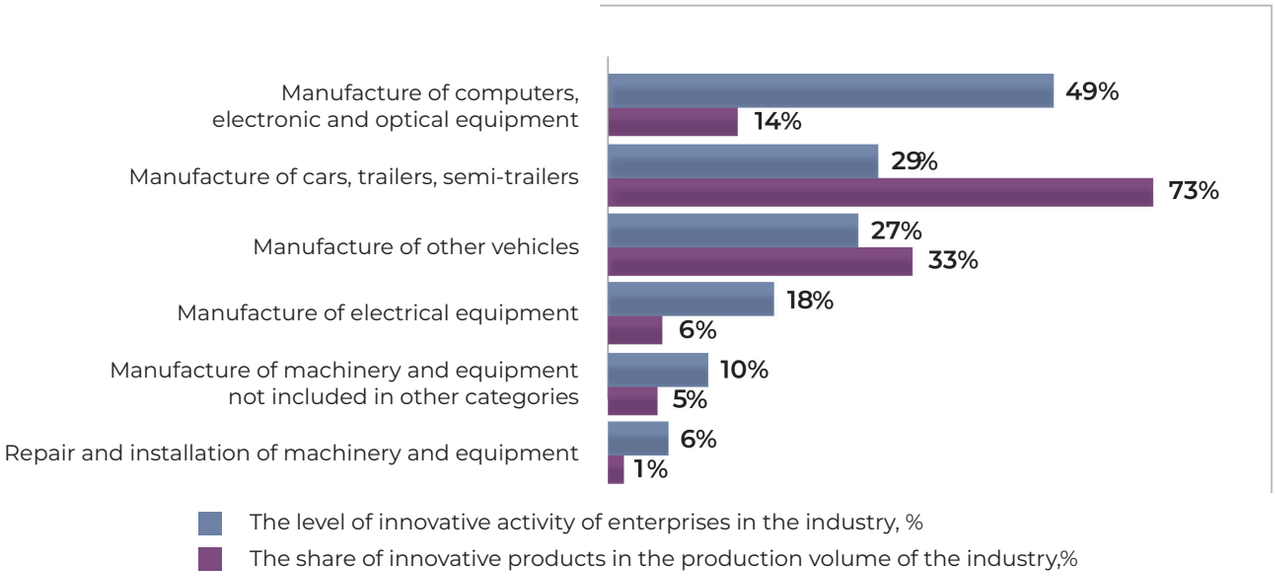
In this regard, the enterprises of these industries must decide on the direction in which they will develop production in the coming years: to organize the production of innovative products, entering into competition for entering the market, primarily with Russian manufacturers, for example, robotics, or find your unique niche.

In discussing this issue, industry experts have not come to a consensus.

Perhaps, in the future, we will face two scenarios for the development of the mix policy of mechanical engineering - an innovative one and focused on a unique product.

Diagram 4.15

***Innovative activity of mechanical engineering enterprises of the Republic of Kazakhstan, at the end of 2019***




Source: Committee on Statistics of the Ministry of National Economy of the Republic of Kazakhstan.

# THE FUTURE IS JUST AROUND THE CORNER. WHAT WILL IT BE LIKE FOR MECHANICAL ENGINEERING?

5.


# THE FUTURE IS JUST AROUND THE CORNER. WHAT WILL IT BE LIKE FOR MECHANICAL ENGINEERING?

What will mechanical engineering be like in a few decades? What trends will have the greatest impact on the industry? What innovations of the Fourth Industrial Revolution will come to the mechanical engineering of Kazakhstan and strengthen their positions on it, and which will fail to conquer it?

There are many opinions on this matter, including futurologists, expert communities, and ordinary people too. We dream, reflect, hope ...

In a world that is changing at an incredible speed, what seemed impossible quite recently can easily enter our daily life in a few years.

The experts from the engineering industry who took part in the foresight session also tried to look 10-15 years ahead.

Look, brushing aside such thoughts as: «this is unrealistic», «we definitely will not have this» or «we are still very far from this.» At the same time, when assessing a possible scenario scenario of development, do not get off the ground and do not go into futuristic reasoning.

According to the expert community of machine builders, in the next 10-15 years, a qualitative transformation of the industry will take place thanks to:

- introduction of innovative technologies;
- using new materials.

The result of the experts' discussion was a collective vision of the future of the machine-building industry, based on trends and technologies that will have the greatest impact on the development of the industry, on the risks and opportunities that these trends bring.

The efficiency and competitiveness of the machine-building complex is characterized by the availability of flexible use of digital management methods and innovative developments. Let's consider what key changes will be achieved in 10-15 years in the domestic mechanical engineering, as well as what technologies will contribute to these changes.

## 1 BY 2035, THE PRODUCTION CAPACITY UPDATE RATES WILL EXCEED THEIR WEAR LEVEL.

At the end of 2019, the degree of wear and tear of machinery and equipment in the manufacturing sector was almost 3 times higher than the level of its renewal. By 2035, a tipping point will come and plant equipment will be renewed faster than it will wear out. Of course, in 15 years, production facilities will not be completely replaced with modern machine tools, let alone robotic complexes. But the large-scale introduction of monitoring sensors will protect the equipment from serious breakdowns. Prompt response of sensors to the slightest malfunctions and malfunctions in the operation of equipment, scheduled preventive maintenance, high level of maintenance, all this will extend the service life of industrial equipment.

The introduction of monitoring sensors will allow enterprises, on the one hand, to significantly reduce the number of equipment failures, reduce unplanned downtime and maintenance costs.

On the other hand, it will increase labor productivity and the efficiency of using industrial equipment. In this case, we are not talking about obsolescence of machines, however, the monitoring sensors will fully cope with technical problems of equipment failure.

## 2 RAPID PREPARATION FOR THE LAUNCH OF A NEW RANGE OF RELEASED PRODUCTS WILL BE POSSIBLE BY INCREASING THE MODULARITY OF THE INDUSTRIAL EQUIPMENT

Manufacturing facilities at the machine-building factories of the future will be modular and flexible and can be moved from one area of work to another, thus creating a new kind of assembly line. All this will allow, in a short time and with minimal losses, to reconfigure the equipment for the release of a new type of product.

## 3 ENGINEERING ENTERPRISES WILL PRODUCE A COMPETITIVE PRODUCT USING DIGITAL DESIGN AND OBJECT MODELING TECHNOLOGIES

There will be significant changes in the mechanical engineering of the future - the emphasis will shift to the product design phase. The design will no longer use approaches that were based on making changes to the designed sample of the structure by conducting real tests.

Enterprises will move from creating new products by modifying existing prototypes, which hindered the release of radically new products, to manufacturing products that take into account individual customer requirements. This approach will be possible due to the large-scale implementation of digital design and object modeling. The creation of digital twins will allow enterprises to reach a completely different level of project activity and create a competitive product that fully meets the requirements of the market.

With the help of the digital twin, even at the stage of model development, all errors will be identified that can be eliminated before the product is put into operation. The terms of launching products into production will be significantly reduced, and the quality of products will increase.

## 4 WITH ADDITIVE TECHNOLOGY, ENGINEERING COMPANY DETAILS CAN PRODUCE MOST COMPLEX STRUCTURES, WHICH WILL RESULT IN A FUNDAMENTALLY NEW MACHINES WITH A COMPLEX INTERNAL STRUCTURE AND INCREASE THE STRENGTH PROPERTIES, QUALITY AND RELIABILITY, WHICH INITIALLY WILL MEET ALL SPECIFIED CHARACTERISTICS

Additive technologies will be among the most demanded technologies in the domestic mechanical engineering market. The use of 3D scanning and 3D printing will allow enterprises to reduce the time it takes to introduce new products and improve their performance; reduce the consumption of raw materials; expand the range of products and increase the mobility of production.

## 5 ISSUES OF LACK OF NECESSARY PARTS WILL BE QUICKLY SOLVED BY APPLYING REVERSE ENGINEERING TECHNOLOGY

Machine-building factories of the future will forget about the problem when the necessary part for repairing a machine tool cannot be found anywhere, for example, when the manufacturer stopped producing it long ago. A specialist in reverse engineering will quickly create a digital model of the required part, exactly repeating the original. According to this sample, it will be possible to make not only one part, but a whole batch.

Thus, the downtime of the equipment will be significantly reduced.

## 6 THE ENTERPRISE STAFF USING VR / AR TECHNOLOGIES WILL HAVE FULL INFORMATION ABOUT A SPECIFIC PRODUCT MODEL IN REAL TIME THAT WILL SIGNIFICANTLY SIMPLIFY THE STAGES OF PRODUCT ASSEMBLY AND REPAIR

At the moment, the potential of these technologies is not fully exploited. But by 2035, according to industry experts, VR / AR technologies will be used at all stages of product production, from design to sales and after-sales service. With the help of these technologies, enterprises will be able to increase labor productivity and the effectiveness of on-site staff training; reduce the time for service maintenance of products, assembly or disassembly; reduce the number of errors and defects.

## 7 OCCUPATIONAL INJURIES WILL BE REDUCED TO A MINIMUM BECAUSE PERSONNEL SAFETY WILL BE ASSIGNED BY RADIO FREQUENCY IDENTIFICATION TECHNOLOGIES

The marks placed on the clothing of the personnel will be recognized by the production equipment, which will give a signal if the employee enters the danger zone. This will be especially relevant at enterprises that will begin to implement robotic installations at their production sites. But not only security issues will be addressed by RFID technologies. They will be used to monitor the movement of equipment and consumables; quality control of products and originality of the complete set; prompt after-sales service.

RFID technology will control the movement of employees in the workplace, as well as act as an electronic pass to areas with limited employee access.

## 8 THE NEW GENERATION INNOVATIVE PRODUCTION IN INSTRUMENTATION WILL BE POSSIBLE DUE TO THE USE OF NANOTECHNOLOGIES, RADIOPHOTONICS AND NANOPHOTONICS

Today, in-depth research in these areas has not yet been carried out in the domestic engineering industry. However, by 2035, the need to master these technologies will increase significantly.

Enterprises, together with research institutes, will begin to deal with the development and creation of modern storage devices with a large memory capacity; nanosensors and nanosensors that monitor the performance of industrial equipment; broadband radars with «radar vision».

Will robots be produced in Kazakhstan by 2035?

The experts did not come to a consensus. It is quite difficult to compete in the robotics market with such giants as FANUC (Japan), KUKA (Germany) or ABB (Sweden, Switzerland), and, in their opinion, there is no great need for this.

However, progress does not stand still, moreover, in Kazakhstan, the younger generation is taking an active position in this direction, taking part in international competitions in robotics.

At the end of 2019, the national

team of Kazakhstan in the International Robotics Olympiad (WRO), which was held in Hungary, took 3rd place in the senior creative category.[70]

Therefore, the production of industrial robotics in our country was attributed by industry experts to the distant future, and the production of household robots to the medium term.

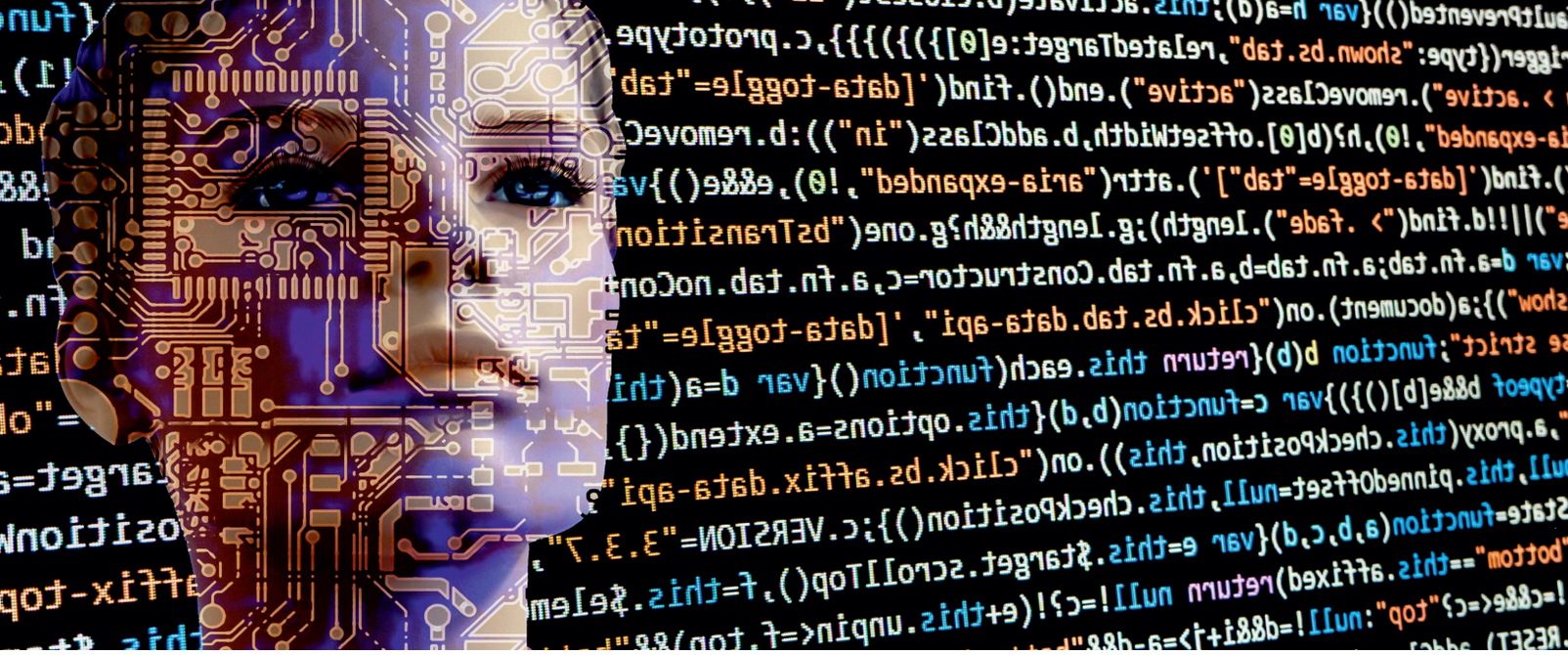
It should be noted that large-scale robotization of domestic mechanical engineering, from the point of view of the industry expert community, is also aimed at the long term. However, the global trend towards a decrease in the average cost of robotic equipment and a reduction in the payback period on the one hand, and increased competition for the right to enter the world market of mechanical engineering products, on the other, will require industry players to radically reconsider their position and start taking confident steps towards the robotization of their production sites. Of those technologies that have already been introduced or are just beginning to be introduced in the global mechanical engineering market, most of them are likely to gain a foothold in Kazakhstan, including in the medium term.

At the same time, it makes no sense to count on a comprehensive large-scale technological leap, since the domestic machine-building industry needs to solve a large number of internal problems.

Nevertheless, innovations are necessary, in many respects they contribute to overcoming these same difficulties, but at the same time dictate a completely new concept for the development of the machine-building industry market.

Therefore, the process of technical renewal must be approached carefully weighing risks and assessing opportunities. Analyze in detail the profitability of advanced technologies and, based on in-depth analysis, carry out their consistent integration in accordance with the objective needs of the industry.

[70] URL: https://blog.beyondcurriculum.kz/kazakhstan-at-wro-2019/.

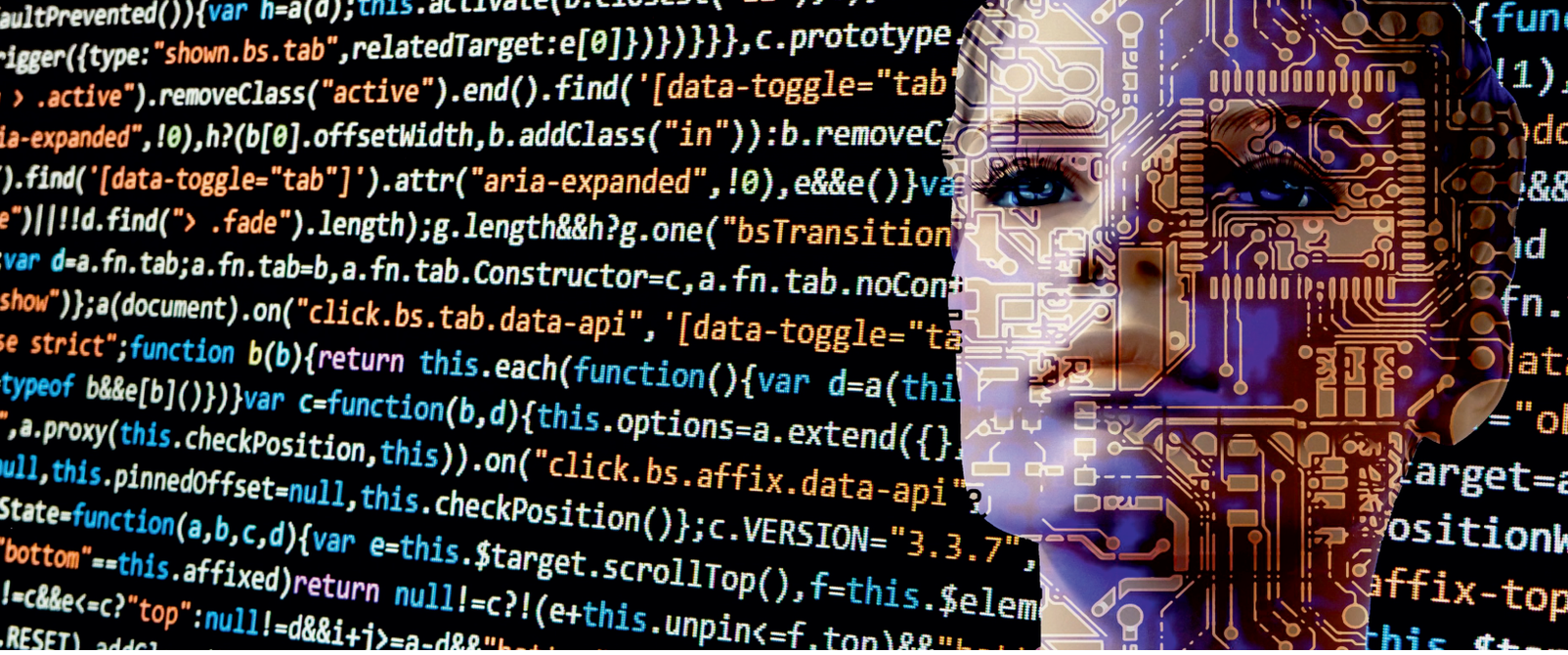


## USING NEW MATERIALS

An important place in the mechanical engineering of the future will be given to innovative materials, primarily composite and nanomaterials, which will be actively used to manufacture products with improved operational and structural characteristics.

THE USE OF COMPOSITE MATERIALS will allow the domestic automotive industry to increase engine power, reduce the weight of vehicles and their structures, create safe, comfortable and environmentally friendly vehicle models.

Composites will help manufacturers of railway and water transport to increase the efficiency and environmental safety of vehicles while reducing their weight and increasing the power-to-weight ratio. In the field of information technology, composites will significantly

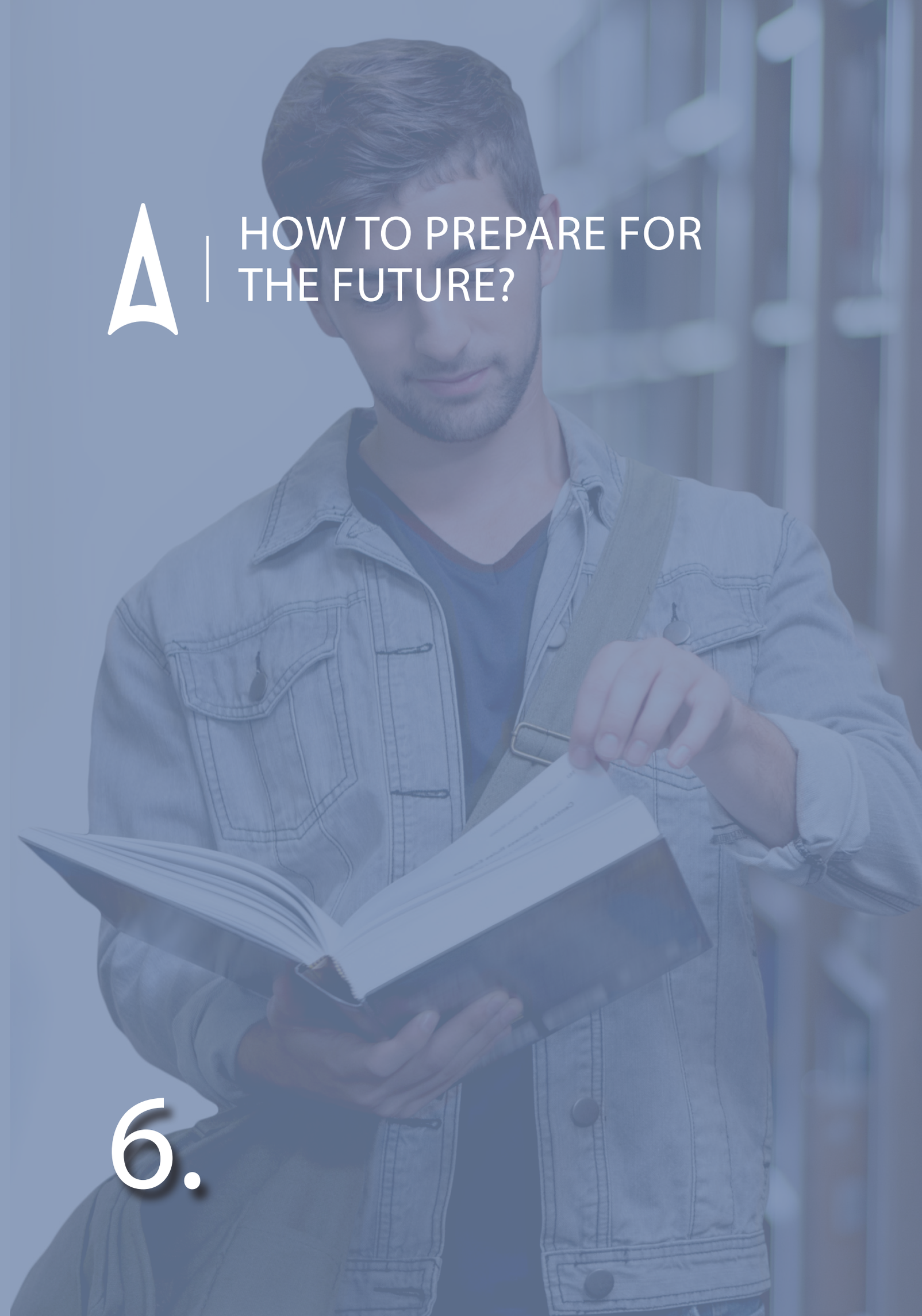


increase disk capacity while reducing the size of magnetic storage devices.

Supernova developments in the field of materials science will also begin to be used, for example, metamaterials, which have a negative refractive index, and are just beginning their ascent in the field of world instrumentation. By 2035, metamaterials will receive an impetus for development in the domestic instrument making industry. Metamaterials will be used to create quantum computers, ultra-thin optical lenses and mirrors.

Summing up, we can briefly say that the base of mechanical engineering in 2035 will be:

- Digital production, which will provide maximum automation of all stages of the enterprise; reduce the time for designing products and launching them into production by creating a digital twin; will simplify the accounting system of the enterprise's inventory and accounting. Data flows from all connected smart devices, processed by predictive analytics, will increase the level of uptime of production equipment.
- «Smart» production, which is characterized by maximum automation and robotization, reducing the influence of the human factor on decision-making. Includes production equipment equipped with software control or artificial intelligence, the latest materials and production management methods.
- Virtual production, which, using the results of digital and "smart" manufacturing, ensures the release of competitive products of the next generation; unites into a single network all participants in the production process (material suppliers, transport company, consumers of finished products, etc.), in order to ensure the transparency of all contractual obligations.



# HOW TO PREPARE FOR THE FUTURE?

6.

# HOW TO PREPARE FOR THE FUTURE?

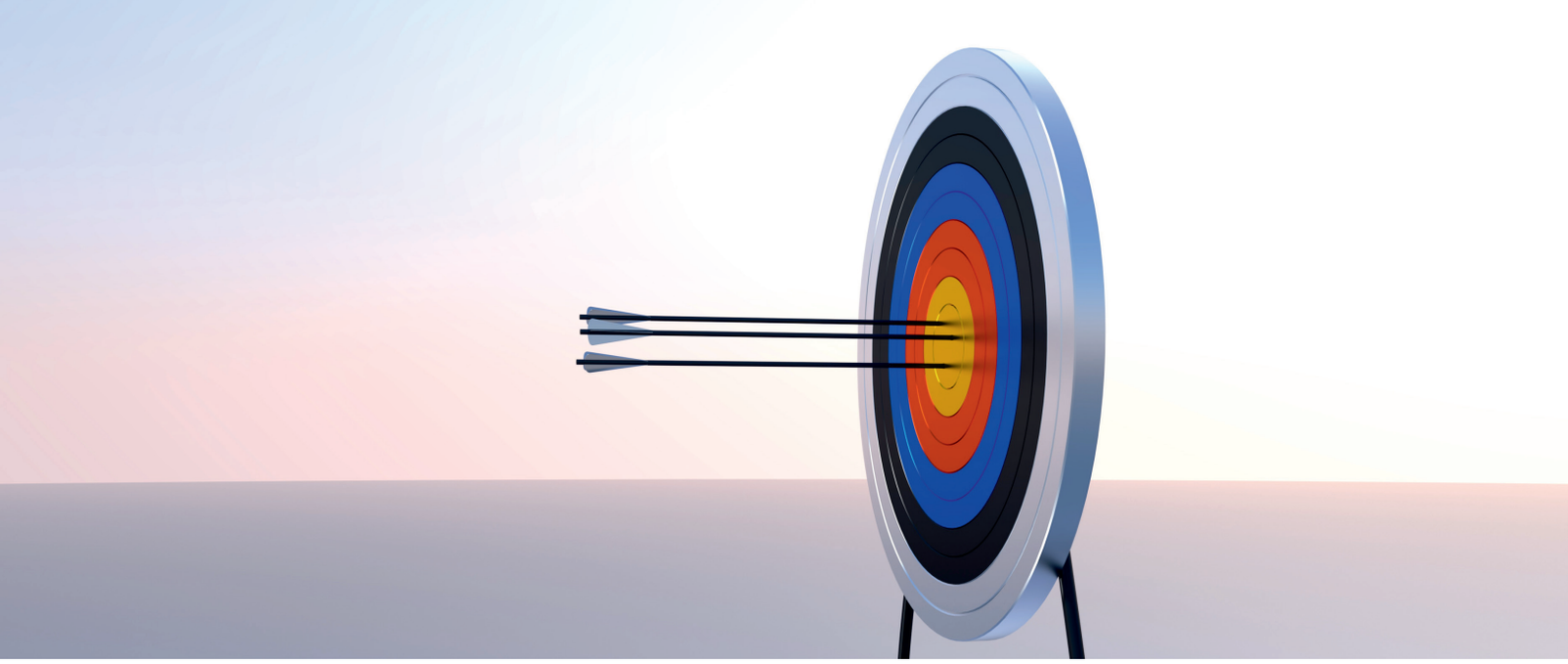
Increasingly, the terms "competence" and "skill" are being used by employers and recruitment agencies. We will also use these terms to describe new and transforming professions. But first, let's try to distinguish between these concepts.

Translated from Latin, competo means «I achieve, I meet, I come up.»

If we open the Big Encyclopedic Dictionary, we will see there: «Competence —

1. the terms of reference given by law, statute or other act to a specific body or official;
2. knowledge, experience in a particular area».

According to the «Comprehensive Dictionary of N. Ushakov», «a skill is a skill created by habit», i.e. this is an action that, due to repeated repetition, is performed unconsciously, or brought to automatism. Based on these definitions, when using the concept of «key competencies» we will refer to the professional activities of employees, and «over-professional competencies» - to what is outside the scope of professional knowledge and skills.



# 6.1.
# ASSESSING THE QUALIFICATION LEVEL OF INDUSTRY SPECIALISTS OF THE INDUSTRY

Key competencies, as mentioned above, mean such competencies (hard skills) that we acquire in the learning process and develop by applying in work, which can be clearly demonstrated and even evaluated or measured.

This approach fully coincides with the position of representatives of the British school of labor psychology, who by professional competence understand the ability to act in accordance with the standards of work performance.

With this approach, the focus is not on the personal characteristics of employees, but on the quality performance of their job duties, consisting of specific operations. For example, the key competencies include: the ability to compose programs for controlling a CNC machine

tool, knowledge of digital design and Big Data processing methods, the ability to conduct remote consulting using virtual technologies, etc.

Each profession has its own list of competencies, which is presented to a specific employee, depending on their skill level.

Therefore, in this section, we will not dwell in detailed examples of key competencies of employees of machine-building enterprises.

Key competencies specifically for each of the new professions will be presented in the «List of new professions» section.

However, it is worth paying attention to how things are today with the level of qualifications of specialists in mechanical engineering. We asked industry experts to answer this question.

As it turned out, experts are seriously concerned with the situation with the level of staff/ personnel qualifications in mechanical engineering.

65% OF EXPERTS NOTICE A DECLINE IN THE RECENT YEARS OF QUALIFICATION OF THE INDUSTRY PERSONNEL. AND ONLY 9% OF INDUSTRY EXPERTS RECOGNIZE THE TENDENCY OF IMPROVING THE PROFESSIONAL QUALIFICATIONS OF THE INDUSTRY SPECIALISTS.

According to 34% of experts, the level of qualifications has deteriorated in all professions, and 31% of experts believe that the level of qualifications in some professions has improved, but at the same time has deteriorated in others.

## *They lowered their qualifications*

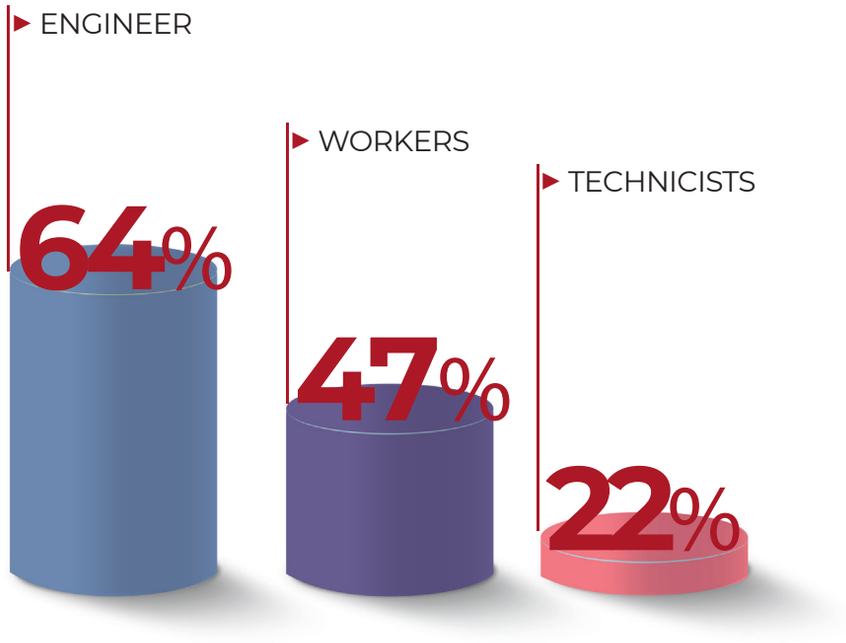
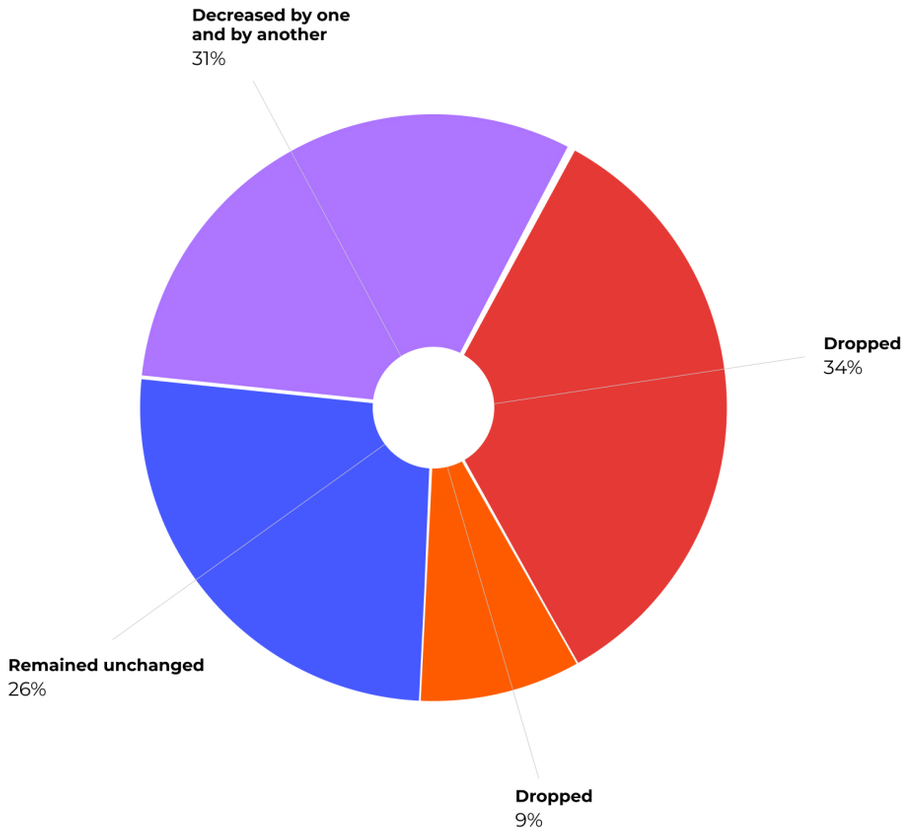



Diagram 6.1

## *Assessment of changes in the level of qualifications of industry specialists in recent years, in% of the number of industry experts*



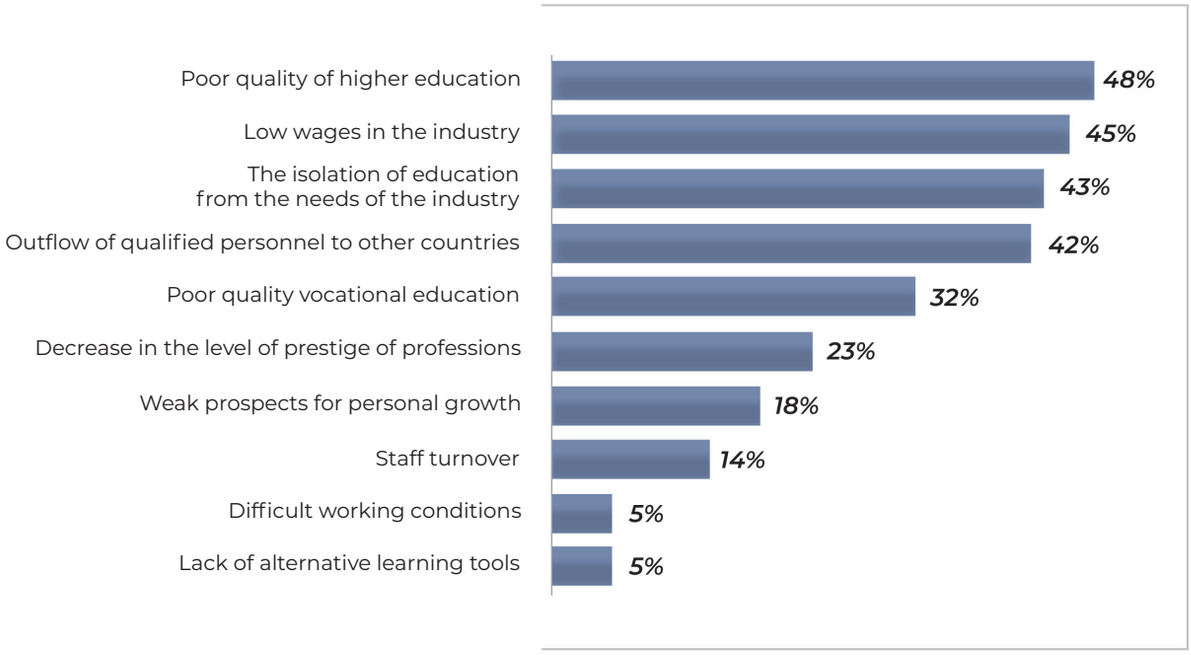
64% of industry experts believe that engineering professions have shown declining skills in recent years. Most often, in this context, experts indicated such professions as design engineer and process engineer. Moreover, in their opinion, these are the most important and demanded professions in mechanical engineering both today and in the future.

The second position of the anti-rating with a share of 47% is occupied by the professions of working specialties, and the leaders among those who have worsened their qualifications are locksmiths and turners.

LOW QUALITY OF HIGHER EDUCATION, LOW WAGE, EDUCATION MISMATCH WITH THE REAL NEEDS OF THE INDUSTRY, AS WELL AS THE OUTFLOW OF QUALIFIED PERSONNEL TO OTHER COUNTRIES.

Diagram 6.2

***Rating of reasons for the decline in the qualification level of industry specialists***



# 6.2.
# OVER-PROFESSIONAL COMPETENCES OF THE FUTURE

In order to master a new profession and build a successful career, it is necessary to understand what super-professional competencies you need to possess. Kazakhstan's leading mechanical engineering experts have rated the most in-demand career development skills in the industry.

In their opinion, in order to remain in demand as a specialist in the future, it is not enough to just raise your professional level. Indeed, already now, large companies in the industry are more willing to hire and promote those specialists who have leadership qualities and know the methods of effective management.

And although today this trend has not yet received widespread use, in 5-7 years the presence of over-professional skills will become a prerequisite for the career growth

of young specialists. At the same time, the list of demanded supra-professional competencies will be constantly expanding.

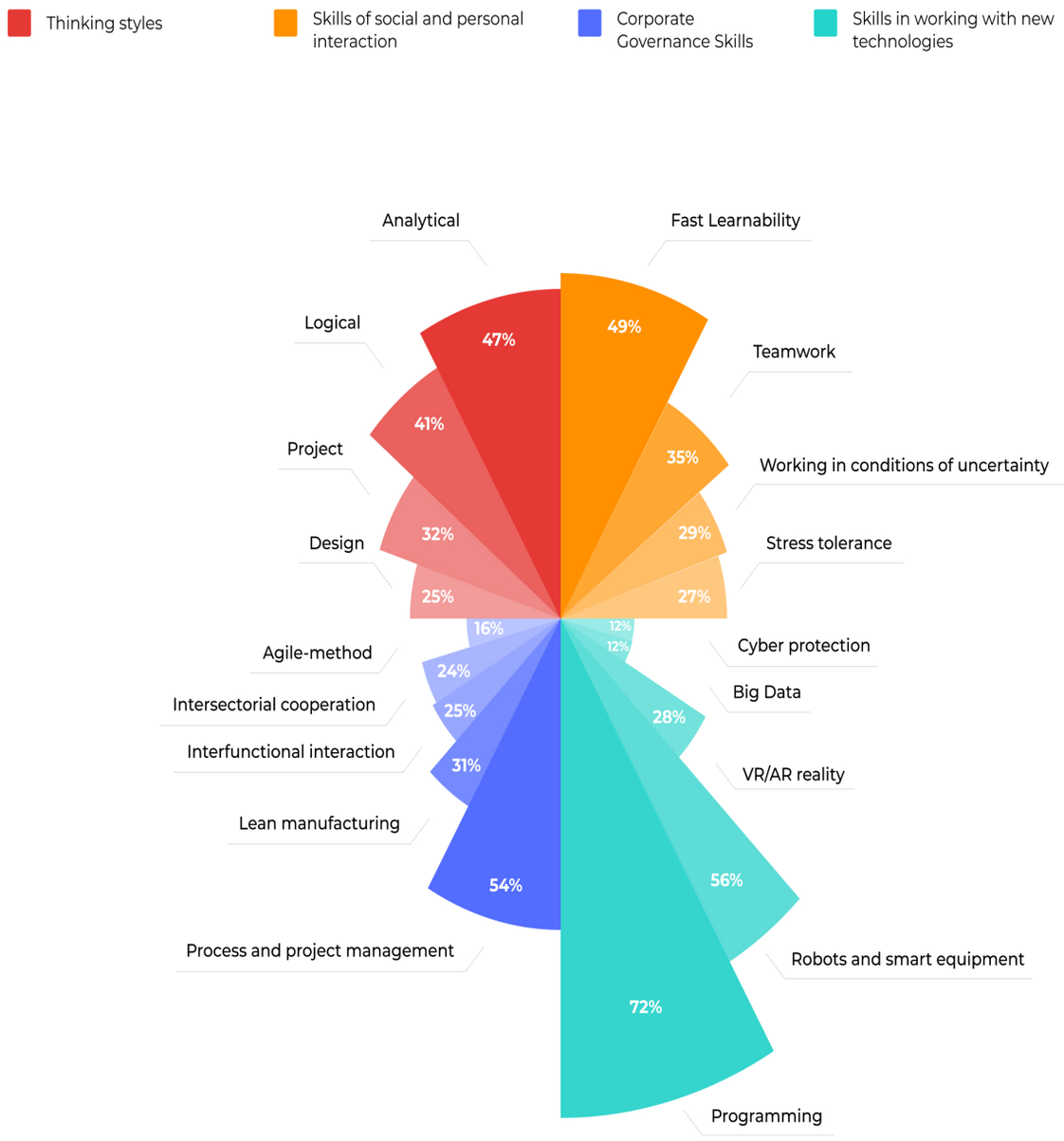
All this will lead to a change in the educational model. If the so-called industrial model of education, which has been used for decades, was built according to the algorithm “school-college-university-higher school”, now the emphasis will shift towards lifelong education throughout life.

| Distinctive features of the old model: | The distinctive features of the new model will be: |
|---|---|
| 1. Getting an education in adolescence;<br>2. One education for life;<br>3. Long-term training in the received specialty from three to five years, depending on the level of education;<br>4. Fundamental theoretical training;<br>5. After receiving education, advanced training is optional, it is not necessary, the exceptions are established by law;<br>6. The training system is localized in the educational institution.<br>7. The new model of education has not yet taken shape, and different authors describe it in different ways. | 1. Continuing education of mixed age groups: It will become the norm to acquire a new profession in adulthood. New teaching methods will be created, taking into account the age characteristics of students: weakening of memory, a higher level of responsibility and perseverance.<br>2. The emergence of educational programs of various duration, from ultra-short (10-15 hours) to ultra-long.<br>3. Globalization of the educational space. (On the one hand, residents of the regions will have more opportunities for access to quality education. Moving to the capital or highly developed countries will no longer be the only opportunity to get a specific education, for example, in biology, astrophysics, etc. There will be more equal opportunities).<br>4. The emergence of educational ecosystems and unified thematic educational platforms in the country (unified medical, engineering and other platforms uniting classical universities). |

Within the framework of the Atlas of New Professions and Competencies of Kazakhstan project, the skills under study were grouped into four blocks:

1. Styles of thinking.
2. Skills of social and personal interaction.
3. Skills in the field of corporate governance.
4. Skills in working with new technologies.

## *Most in-demand skills, according to industry experts*



Among these skills, the following were chosen as the supra-professional competencies of the future:

1. Lean manufacturing.
2. Customer-oriented approach
3. Multilingualism and multiculturalism.
4. Cross-industry communication.
5. Artistic creativity.
6. Programming / Robotics / Artificial Intelligence.
7. Systems thinking.
8. Project and process management.
9. Environmental thinking.

## 1 LEAN MANUFACTURING

Lean Manufacturing is an enterprise management concept based on the constant search for, reduction or elimination of waste. Losses are understood as those actions, processes or operations that consume resources (human, time, material, etc.), but do not add value to the final or intermediate consumer. Lean manufacturing changes the approach to enterprise performance management from extensive (work harder and faster) to intensive (work more efficiently, i.e. do only what is necessary and not do what can be done without).

The relevance of lean management practices is increasing, because traditional management methods have already reached their peak, the further development of the business will increasingly focus on intensive development and methods of lean improvement.

## 2 CUSTOMER-ORIENTED APPROACH

Customer focus is understood as the ability to work with the needs of the consumer, the ability of the company and its employees to timely identify the desires of customers in order to satisfy them with their products or services with maximum benefit.

Competition for the consumer is growing all the time, and all employers want to see customer-oriented employees. This requirement has become critical to the success of companies.

In the second half of the 20th century, the concept of an internal client appeared, i.e. an intermediate consumer located further along the production chain within one company.

Possession of this skill allows you to accurately understand the client's request and offer the most suitable solution for him, as well as build the production and service process more rationally, excluding the stages that are not important for the client.

## 3 MULTILINGUALISM AND MULTICULTURALISM

Multiculturalism is the preservation and development in a particular community (state or enterprise) of the cultural characteristics of people united in this group. Multiculturalism and multilingualism at an enterprise involves not only taking into account national or religious cultures, but also cultures of thinking, psychotypes, communications and individual characteristics.

Already, it is not uncommon for companies to employ specialists who were born or live in different parts of the earth. The policy of multiculturalism and multilingualism sets the vector of interaction between people who are unlike each other: not to conflict, but to recognize each other. The changes taking place today pose new tasks for the teams that have never been set or solved before.

It is believed that the most effective solutions are born at the intersection of different areas of knowledge, approaches, cultures. The most effective teams include people with different characteristics of thinking, psychology, distribution of roles in the team. Multicultural teams will be able to find effective, unusual solutions and even solve problems that have not yet been resolved

## 4 CROSS-INDUSTRY COMMUNICATION

Cross-sectoral communication is characterized by an understanding of technologies, processes and the market situation in various related and non-related industries, cross-functional and cross-disciplinary interactions. More and more advanced products are being created at the intersection of different industries, so specialists need to be able to understand several areas of knowledge at the same time.

Experts with this competence can create unexpected, unique, breakthrough solutions.

## 5 ARTISTIC CREATIVITY

Artistic creativity - the ability to express feelings and emotions in figurative forms, the ability to create your own artistic images, the presence of a developed aesthetic taste. In the future, robots and machines will replace humans in many areas. Creativity is the only area that is still inaccessible to artificial intelligence.

Professionals with creative skills will gain an edge in virtually all areas of business.

The emerging trend of personification and individualization of goods and services will continue to develop. And the day is not far off when all goods and services will become as personalized as possible.

## 6 PROGRAMMING / ROBOTICS / ARTIFICIAL INTELLIGENCE

This area includes a variety of skills related to the design and configuration of artificial intelligence systems, the adjustment and tuning of robots, the development of programs for the control of manufacturing processes and individual machines.

Automation and robotization are rapidly penetrating all areas, and primarily in production.

It is expected that in 15-20 years, machines will replace humans in most routine tasks that do not require creative skills.

Therefore, the need for specialists with these skills will grow in all industries. It is these specialists who will have to ensure the massive arrival of machines in all sectors of the economy.

Specialists will be in demand in the field of maintenance and tuning of machines, robots and systems that make algorithmic decisions.

## 7 SELF-DEVELOPMENT AND ADAPTABILITY

Self development can be described as a process of conscious purposeful self development as a person or specialist.

Self-development consists in self-improvement of their knowledge, personal qualities, and professional competencies. The presence of motivation and the ability to self-development indicates that the specialist himself is able to make efforts to more fully realize his opportunities in professional activity, to achieve maximum success.

Unfortunately, not everyone has the qualities that are necessary for purposeful work on themselves.

Therefore, specialists with self-development skills stand out from other employees. therefore, they will always be in demand at any stage of the production chain.

And effective disclosure of the existing potential of each employee can form a decisive competitive advantage for the enterprises of the future.


# 8 SYSTEM THINKING

System thinking includes the ability of a specialist to combine (generalize) particular facts into a general picture, build hierarchical levels for understanding various situations (economic, political, business) and making long-term decisions.

An important quality is understanding how a change in one element, subsequently, will be reflected in other elements.

Currently, under the influence of ongoing transformations, the focus of the systems approach has shifted. Previously, interest was directed inside the system itself; the analysis of its constituent components was more in demand.

Now the first place is given to what is outside the system, part of which, more global system, it is, how it interacts with other systems.

Specialists with the competencies of systems thinking can:

- perform a comprehensive analysis of large amounts of information;
- identify patterns and cause-and-effect relationships;
- to form a holistic picture of what is happening;
- assess the risks and opportunities associated with making certain decisions

The increase in the scale of the introduction of digitalization and the latest technologies, the expansion of the range of subjects interacting with each other within the same process, leads to an increase in the demand for specialists with systems thinking.

And this tendency will not only maintain its pace, but also increase it.

## 9 PROJECT AND PROCESS MANAGEMENT

Project and process management includes the ability to focus on the goals of the project, the ability to competently plan and organize the team's actions to effectively complete the assigned tasks, the ability to assess the existing risks and opportunities for all parties to the interaction.

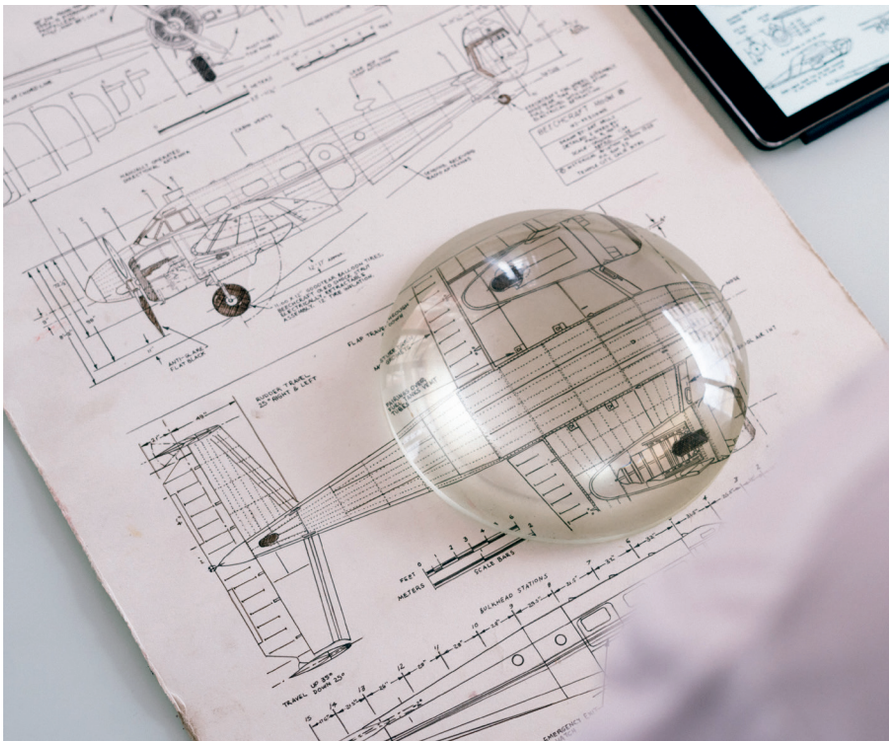
A specialist who owns this competence knows how to properly organize the work on a project within a given funding framework, knows how to correctly distribute work in order to meet the deadlines indicated by the project. Such a specialist is constantly learning something new, is not afraid to make mistakes, knows how to generate new effective ways to solve problems and tasks.

The demand for specialists with knowledge and tools in the field of project management will increase, since project activities are viewed by companies as the most important factor in their effective development.

## 10 ENVIRONMENTAL THINKING

Environmental thinking is focused on achieving harmony between business and the environment.

An ecological mindset puts health and sustainable development a top priority. The importance of ecological thinking is increasing due to the fact that the development of industry has reached a limit and all further models of sustainable growth of society, economy and business should be built on the basis of mutual interests with nature, ecosystem, in order to maintain and develop it. Experts with the skills of ecological thinking will be able to solve such problems as conserving resources, achieving zero emission of harmful substances into the environment, recycling waste and using secondary resources.



# 6.3.
## ASSESSMENT OF THE DEMAND FOR PROFESSIONAL SKILLS IN THE NEXT 10—15 YEARS

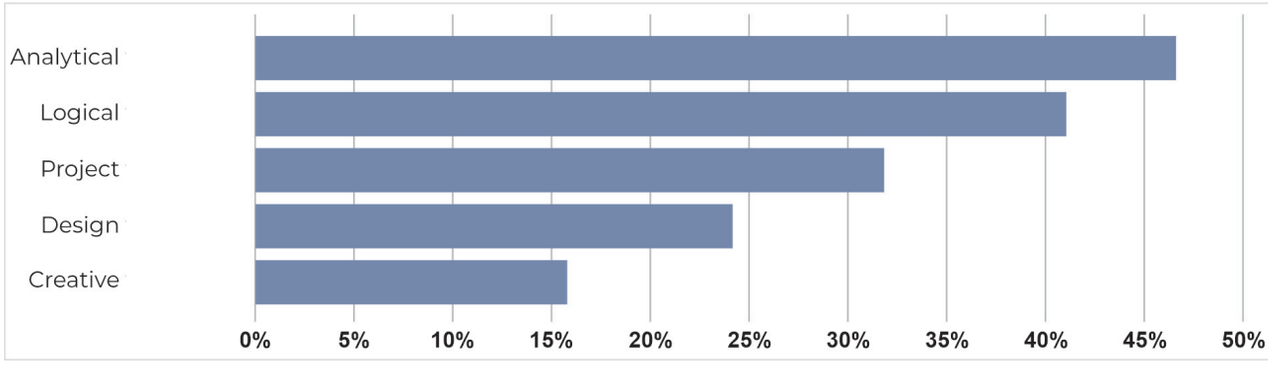
The ranking of the most popular skills of mechanical engineering specialists in the coming coming 10-15 years was formed based on the assessments of industry experts, as part of a survey conducted using the questionnaire method.

## STYLE OF THINKING

### THE MOST DEMANDED FUTURE THINKING STYLES, IN THE OPINION OF THE INDUSTRY EXPERTS, WILL BE ANALYTICAL, LOGICAL AND DESIGN THINKING

Diagram 6.3

***Top 5 Thinking Styles Most Demanded by Industry Professionals in the Next 10-15 Years***




## ANALYTICAL AND LOGICAL THINKING

The leaders of most companies, not without reason, attach great importance to the presence or absence of analytical and logical thinking in employees. After all, such an employee more effectively performs his duties, perceives incoming information critically, based on objective factors, and also, operating on cases that have already happened, is able to predict the development of events in the short or long term.

Mechanical engineering is a science-intensive and high-tech industry that generates large amounts of data that need not only be collected, but how to professionally process and analyze in real time. Therefore, in order to increase the efficiency of production and the competitiveness of enterprises in the market, managers are interested in attracting employees who are able to do it efficiently.

The fact of increased demand for analytical skills and logical thinking among mechanical engineering specialists in the next 10-15 years is confirmed by the results of a survey of industry experts, almost half of whom put these skills in the first position in the ranking.

## PROJECT THINKING

The activity of machine-building enterprises is the implementation of a large complex of interrelated processes, dispersed in time and space. Algorithms of interaction between employees, departments and divisions, technologies for managing production and business processes can work fully only within the framework of debugged design solutions. Therefore, businesses need a staff with this skill.

Specialists of this level assess what is happening through the prism of existing opportunities and risks; determine the trajectory of the best way to achieve the set goals, clearly understand not only what and how to do, but also what impact these actions will have on the subject of project activities.

Today, the design activities of machine-building enterprises are implemented under the influence of global trends of the Fourth Industrial Revolution. These trends contribute to the emergence of an even larger number of interconnected internal and external objects of the production chain, the interaction algorithms of which are constantly becoming more complex. Therefore, the demand of enterprises for employees with project thinking will have a stable growth trend in the near future.

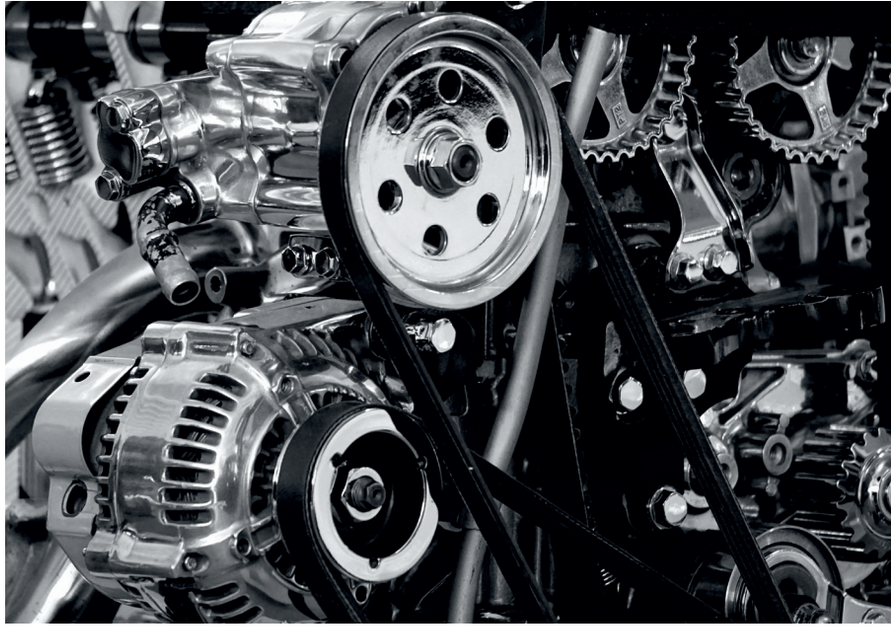
## DESIGN THINKING

Design thinking allows you to understand how a specific process, mechanism or device works, to make changes to improve their quality, operational and functional characteristics, or to design something completely new, which has no analogue yet. Modification or creation of a new product is a complex process that includes several stages:

- understanding the needs of consumers;
- collection, systematization of information and focusing on the main goal;
- generation of various ideas and selection of viable ones;
- creation of a prototype of a product;
- industrial testing.

Industry experts note that in mechanical engineering, as a science-intensive industry, there

is an especially acute shortage of specialists with the skills of researchers who are able to think outside the box, generate non-standard ideas focused on the interests of the company and the end user. And in the next 10-15 years, the need for specialists with design thinking will only increase.



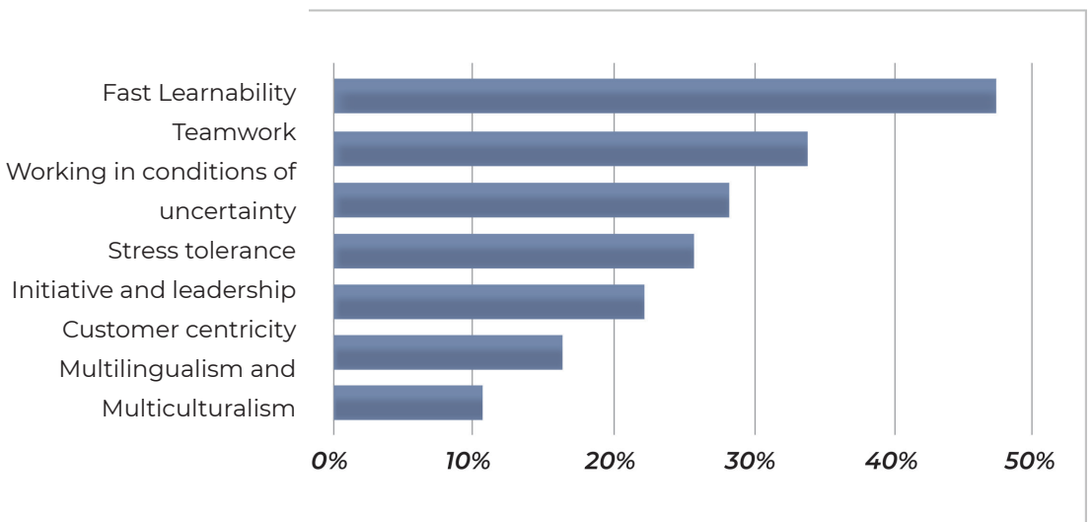
As the over-process competencies of the future, we singled out creative thinking from the thinking styles, as well as analytical, logical, design and design types of thinking, which combined the concept of systems thinking.

## SOCIAL-PERSONAL INTERACTION SKILLS

AMONG SOCIAL AND PERSONAL INTERACTION SKILLS WILL BE MOST NEEDED: FAST LEARNING, TEAM WORK AND UNCERTAINTY

Diagram 6.4

***Rating of social and personal interaction skills most in demand among industry specialists in the next 10-15 years***



## FAST TRAINABILITY

It is impossible not to notice how fast the world is changing around us. Some technologies are replaced by others, new data processing algorithms appear, and the latest materials are created. And unless an employee decides to raise their his educational level, then at some point, the volume of skills, experience and knowledge acquired earlier, begins to play a secondary role.

In the context of global changes, such qualities as the reluctance to act by stereotyped methods, the desire to constantly improve, to acquire new knowledge and the ability to quickly assimilate them, come out on top.

Corporate leaders also note the speed of the changes. Therefore, when hiring, they would surely will give preference to employees with a high level of learning, since they are observant and know how to look at things from different points of view, have flexible thinking and easily generate new ideas, are ready to take risks and make mistakes. They are constantly learning something and therefore are more likely to succeed than their peers, who are less interested in continuous learning.

## ABILITY TO WORK IN A TEAM

Though the concepts of team-spirit (team spirit) and team-building (team building) began to be introduced back in the 50s of the last century in America and Western Europe, the skill of teamwork remains relevant today, since it is one of the leading components of increasing the competitiveness of any enterprise.

The effectiveness of teamwork increases when each of the team members competently interacts with all team members and does not allow conflict situations to arise, clearly performs the assigned work area and is always ready to help colleagues at work, knows how to admit his mistakes and accept someone else's point of view, and the interests of the company prioritizes personal ambition.

Mechanical engineering enterprises are among the industries with a rather complex organizational structure and a large number of employees who closely interact with each other. Therefore, management is interested in employees with teamwork skills. And this tendency will only grow stronger.


## ABILITY TO WORK IN CONDITIONS OF UNCERTAINTY

Under the influence of the changes we are now seeing, plant personnel often have to work in conditions of much greater uncertainty than before, or even in completely new environments. The speed of technology change leads to problems of rapid obsolescence of information. Sometimes, before they have had time to reorganize to new working conditions, the personnel of the companies must be trained in even more advanced technologies.

If you do not consider uncertainty as a negative factor, then it leads the personnel of enterprises to big breakthroughs, professional growth and an increase in the level of self-confidence, makes them learn to make decisions quickly, overcome problems and difficulties, rationally manage their time and achieve their goals.

According to industry experts, the demand for employees with the skills to work in conditions of uncertainty will have a stable growth trend in the next 10-15 years.

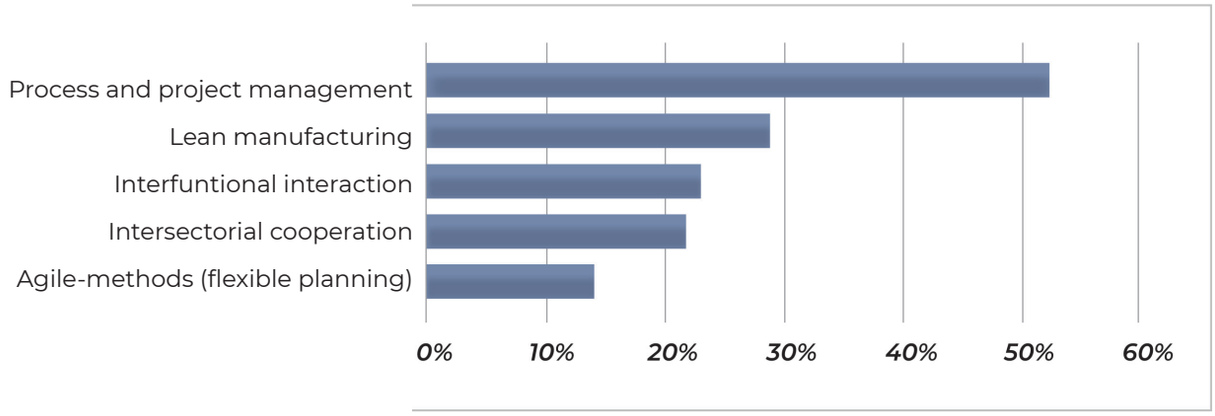
Though customer focus, multilingualism and multiculturalism, according to industry experts, did not make it into the top 3 most demanded skills, we believe that these two skills will be the supra-professional competencies of the future for the next 10-15 years in the context of social and personal skills.

## CORPORATE GOVERNANCE SKILLS

THE LEADING FUTURE SKILLS IN CORPORATE GOVERNANCE WILL BE SKILLS IN PRODUCTION MANAGEMENT, INTERSECTORAL INTERACTIONS AND LEAN PRODUCTION

Diagram 6.5

***Top 5 corporate governance skills most in demand among industry professionals in the next 10-15 years***




## CROSS-FUNCTIONAL INTERACTION SKILLS

The composition of a machine-building enterprise includes a large number of services that perform various functions:

- production and auxiliary workshops,
- administrative divisions,
- warehouse and transport facilities.

The operational outcomes of the entire enterprise depend on the competent interaction of the subdivisions among themselves in the process of performing production tasks. The classical model of production management, which is characterized by strict subordination, narrow specialization of individual employees, where each is responsible for the performance of only their own duties, ceases to work. There is a need to search for new solutions to improve the quality and efficiency of interaction between personnel of various production subdivisions, to develop the skills of interfunctional interaction among employees.

Cross-functional interaction is a competently built on the principles of a team approach, cross-

[71] Cross-functional communication is a collaboration that allows for fast and complex interaction of employees to achieve common goals.


functional interaction of enterprise personnel and managers.71 Personnel possessing the skills of cross-functional interaction are able to build communication channels between departments, effectively resolve conflict situations, approach their duties with greater responsibility. Therefore, in the next 10-15 years, the availability of cross-functional interaction skills will be an important criterion when hiring employees and promoting them up the career ladder.

## FLEXIBLE PLANNING SKILLS (AGILE)

The most important aspect about flexible planning is focusing on the needs of the customers.

This method allows you to plan the work process more efficiently, breaking it down into short time cycles, to create a test model faster and, using feedback, to quickly make changes. All this is accompanied by transparency at all stages of the production chain.

Projects that are executed using Agile methods are many times more successful than those that adhere to the standard approach. And the availability of flexible planning skills among personnel allows them to take into account the constantly changing conditions of the external and internal environment and effectively use feedback from all subjects of interaction.

This approach encourages plant personnel to experiment and look for new solutions, without limiting themselves to rigid frameworks and standards.

Agile professionals are already in demand in the labor market.

The large-scale transformation of mechanical engineering will further contribute to the growth of the need for such employees.

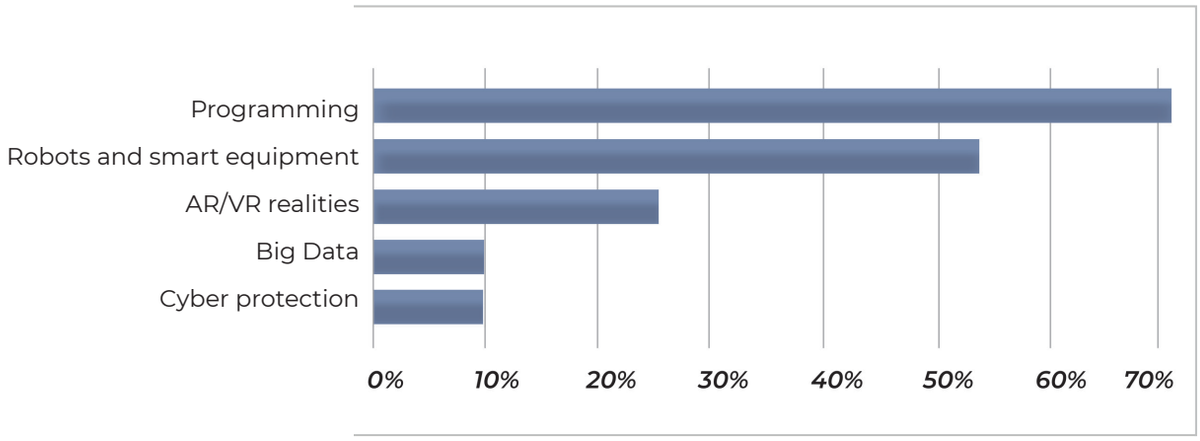
We have identified cross-industry interaction, lean manufacturing, and project and process management as the supra-professional competencies of the future in the field of corporate governance.

## SKILLS IN WORKING WITH NEW TECHNOLOGIES

### FUTURE SKILLS IN WORKING WITH NEW TECHNOLOGIES - KNOWLEDGE OF THE BASICS OF PROGRAMMING, ABILITY TO INTERACT WITH SMART EQUIPMENT AND ROBOTIC SETS

Diagram 6.6

***Top 5 skills in the field of working with new technologies most in demand among industry professionals in the next 10-15 years***



## PROGRAMMING SKILLS

To some, programming is the main functional responsibility. But in this case, programming is considered from the point of view of additional knowledge to the main professional competencies.

Back in 1981, at the 3rd World Conference in Lausanne, Andrei Ershov (Soviet computer scientist) made a presentation «Programming - the second literacy». According to him, «while the development and spread of printing has led to universal literacy, the development and spread of computers will lead to universal programming skills.».[72]

Employers have long begun to realize how valuable the employees with basic programming skills are. And today, when most of the processes are automated, the volume of data that requires processing and analysis is growing rapidly, the value of such specialists increases significantly. This is confirmed by the numbers - 70% of the interviewed industry experts ranked programming skills as one of the most demanded skills for the next 10-15 years.

## SKILLS IN WORKING WITH SMART EQUIPMENT AND ROBOTS

Today, at every step - in everyday life and at work, we are surrounded by intelligent devices.

Intelligent equipment that reads information from running machines and machines, exchanges it with various

[72] Programming is the second literacy. — URL: http://ershov.iis.nsk.su/ru/second_literacy/article.

production systems, is the foundation of the intelligent factory of the future.

Robotic sets, cyber-physical systems interacting with each other via the Internet of Things, smart sensors, controllers, etc. are designed to facilitate the hard manual labor of the personnel of machine-building enterprises.

Though such equipment works with a high degree of autonomy, it cannot, at least not yet, work completely autonomously, without human intervention.

At machine building enterprises, already at all stages of production, there is a shortage of qualified personnel to work on smart equipment. And with the increase in the scale of the introduction of new technologies, this trend will only grow.

## SKILLS IN WORKING WITH VIRTUAL AND AUGMENTED REALITY TECHNOLOGIES

Technologies of virtual and augmented reality have not yet received significant distribution in mechanical engineering.

But at the same time, the areas of their potential application are already clearly visible:

- At the design stages - VR and AR technologies allow a team of designers, even at a distance from each other, to make the necessary adjustments to the prototype of the future product they are developing;
- In marketing, virtual reality technology can create a powerful wow effect.[73]
- Present a product and service that cannot be demonstrated in real life.
- At the stages of personnel training and professional development.

The scope of application of virtual and augmented reality technologies will only expand, and the demand for specialists with these skills will increase every year.

**As the supra-professional competencies of the future in the field of working with new technologies, we singled out programming, interaction with smart equipment and robots as basic ones.**

[73] Wow effect is the effect that makes you buy a product right here and now

# WHO SHOULD I STUDY FOR?

7.

# WHO SHOULD I STUDY FOR?

The new technological revolution is leading to the world of work going through a global transformation.

Many experts, analyzing the problems and risks associated with the introduction of innovative technologies, believe that in the future, a serious threat will be the growth of unemployment due to the robotization of jobs, large-scale automation of management processes, the expansion of the scope of application of additive technologies and new materials.

However, not all world experts share this point of view, believing that digitalization and robotization will lead not to a surge in technological unemployment, but to the emergence of new jobs that require workers to have a higher level of qualifications and / or the availability of competencies in related professions.

Many professions, not only related to manual and unskilled labor, but also individual professions of intellectual labor, will gradually be replaced by robots and artificial intelligence.

Employees involved in these professions need to understand that the only way out for them may be to acquire additional skills in related professions or acquire knowledge for mastering a new profession.

At the same time, according to the International Labor Organization, about 70% of professions in the future, even retaining their names, will significantly change the set of necessary professional competencies.[74]

Industry experts expressed their opinion about what professions will appear in the next 10-15 years on the labor market in mechanical engineering in Kazakhstan, what professions are being transformed and which will disappear, at a foresight session held on August 26-28, 2020 as part of the preparation of the Atlas of New Professions. in the machine-building industry ", as well as in a questionnaire survey of experts.

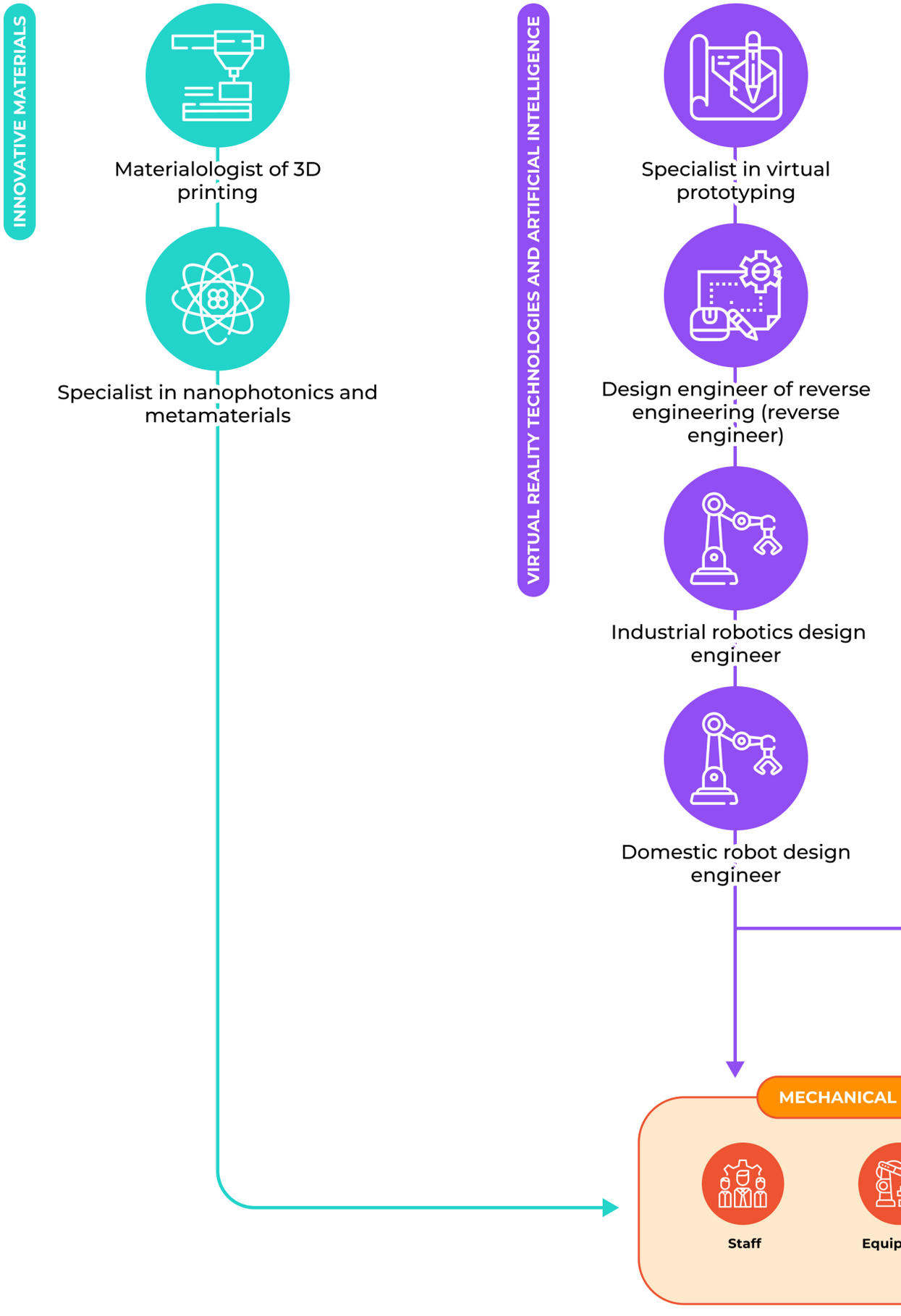
A generalized analysis of the results of these activities is provided in the following sections.

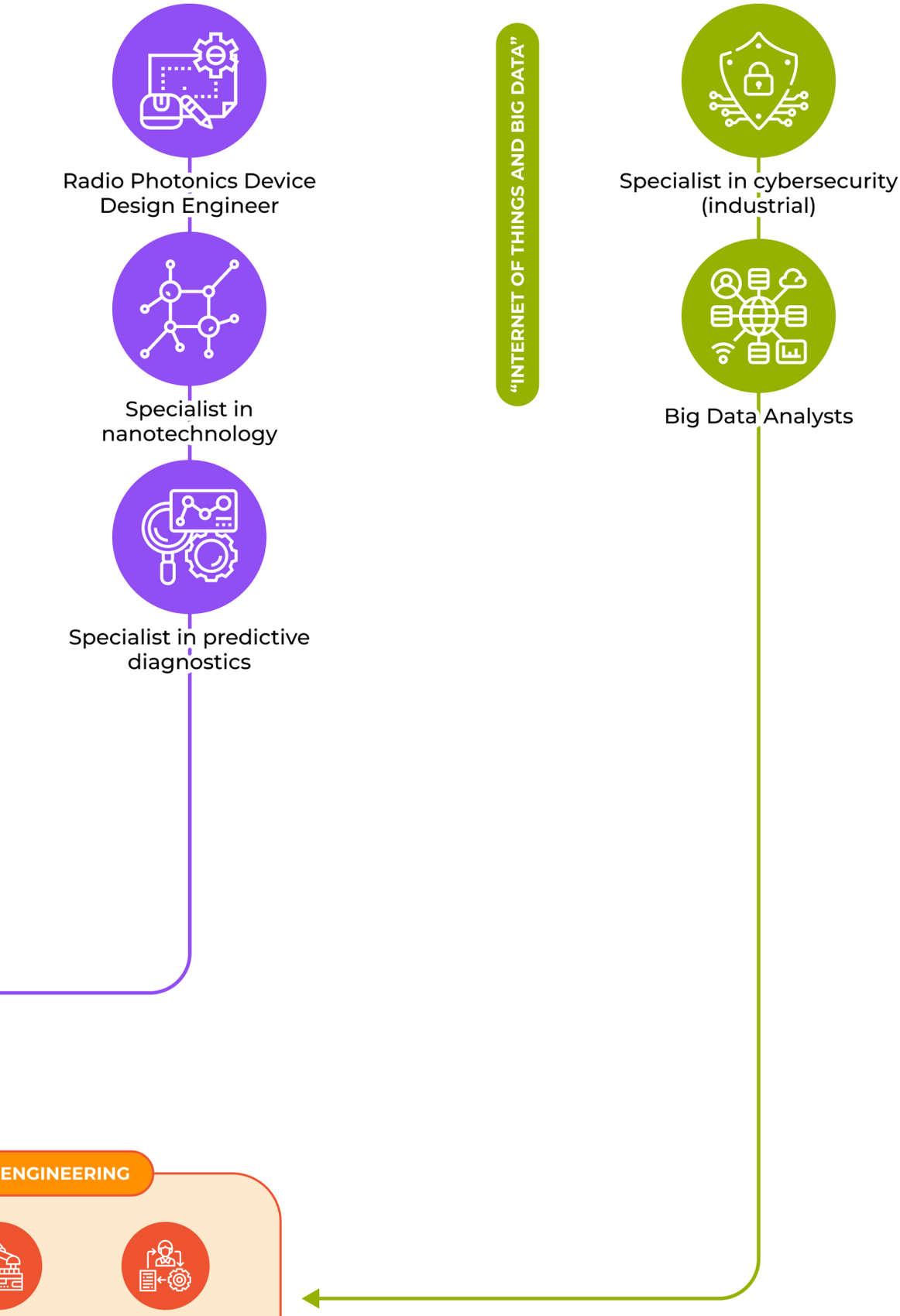
[74] The world of the new economy, 2017. No. 4, Podvoisky G.L. «The world of work: the contours of the future», http://www.fa.ru/org/div/edition/mne/journals/2017%20%E2%84%964.pdf

# NEW PROFESSIONS IN MECHANICAL ENGINEERING


# 7.1.


УНИВЕРСИТЕТІ


INNOVATIVE MATERIALS
Materialologist of 3D printing
Specialist in nanophotonics and metamaterials
VIRTUAL REALITY TECHNOLOGIES AND ARTIFICIAL INTELLIGENCE
Specialist in virtual prototyping
Design engineer of reverse engineering (reverse engineer)
Industrial robotics design engineer
Domestic robot design engineer
MECHANICAL
Staff
Equip


Radio Photonics Device Design Engineer
Specialist in nanotechnology
Specialist in predictive diagnostics
"INTERNET OF THINGS AND BIG DATA"
Specialist in cybersecurity (industrial)
Big Data Analysts
ENGINEERING
Processes

# 1. VIRTUAL REALITY TECHNOLOGIES AND ARTIFICIAL INTELLIGENCE

▶ 1.1

# SPECIALIST IN VIRTUAL PROTOTYPING

THE HORIZON of appearance

▶ 2030

NOVELTY of the profession

- It is now possible to create a virtual prototype of a product using virtual and augmented reality technologies, thereby reducing the time for launching new products

KEY competence

- Programming, computer modeling, graphic design
- Basics of building an object in virtual and augmented reality.

- A specialist develops a virtual prototype of products and technological processes (for example, remote consulting of personnel, visual demonstration of the product to the customer at the design stage).

Their responsibilities include:

- computer simulation of creating a virtual image of the product;
- modeling of technological processes using high-performance computing systems;
- analysis of simulation results in virtual environments.

TRENDS

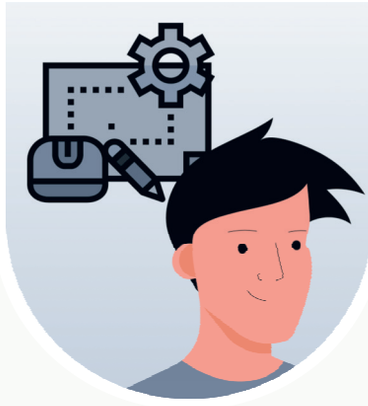
- Expanding the scope of the latest technologies in mechanical engineering.
- Shorter start-up times for new products.

PROFESSIONAL skills and abilities

- Client orientation.
- Cross-industry communication skills.
- Artistic skills.
- Programming/ robotics/ artificial intelligence.
- Systems thinking.
- Ability to manage projects and processes.

▶ 1.2

# DESIGN ENGINEER OF REVERSE ENGINEERING (REVERSE ENGINEER)



## THE HORIZON of appearance

▶ 2025

## NOVELTY of the profession

- The emergence of technology 3D scanning allowed us to create a digital prototype of finished products and their design documentation, i.e. to carry out the reverse engineering process.

## KEY competence

- Object modeling, descriptive geometry, fundamentals of industrial design.
- Additive technologies.
- Materials science.

- Use scanning to develop a digital model of existing machine and equipment parts that need to be replaced in wear and deformation or improve models.

Their responsibilities include:

- creating a digital image of the product/part using 3D scanning and design documentation based on it;
- determining the parameters of the designed part (material, its properties, the nature of the load on the part, weight restrictions, heat treatment parameters, etc.);
- testing of the received samples, drawing up technical documentation of the part processing process.

## TRENDS

- Expanding the scope of application of the latest technologies in mechanical engineering.
- Shorter start-up times for new products.
- High level of wear and tear of production facilities in mechanical engineering.

## PROFESSIONAL skills and abilities

- Lean production.
- Client orientation.
- Cross-industry communication skills.
- Artistic skills.
- Programming/ robotics/ artificial intelligence.
- Systems thinking.
- Ability to manage projects and processes.

▶ 1.3

# INDUSTRIAL ROBOTICS
## DESIGN ENGINEER

THE HORIZON of appearance ▶ 2035

NOVELTY of the profession

- The work's novelty is a complex system consisting of a manipulator and a reprogrammable control device. For Kazakhstan, the production of industrial robots is a new direction for mechanical engineering

KEY competence

- Materials science (physical and mechanical properties of materials, strength properties, etc.).
- Descriptive geometry and theoretical mechanics.
- Fundamentals of industrial design.
- Fundamentals of robotics, Cybernetics, radio engineering, and electronics.
- Mechatronics.

- A specialist who is engaged in the design of industrial robotic equipment and their components.

Their responsibilities include:

- development of 3D models/drawings/ diagrams of industrial robots;
- technical calculations for projects, selection of components and materials;
- production support, interaction with the Assembly production during Assembly/ installation preparation of design and operational documentation;
- participation in building, testing, and commissioning
- the operation, as well as in work on the modernization of the designed products.

TRENDS

- Growing demand for the introduction of industrial robots in machine-building enterprises
- High level of wear and tear of production facilities in mechanical engineering
- There is a growing need to introduce flexible production systems in mechanical engineering.
- The growing need to upgrade the production capacity of the country's economic sectors.

PROFESSIONAL skills and abilities

- Client orientation.
- Programming/ robotics/ artificial intelligence.
- Systems thinking.
- Ability to manage projects and processes.

► 1.4

# DOMESTIC ROBOT
## (HOUSEHOLD ROBOT) DESIGN ENGINEER

THE HORIZON of appearance ► 2030

NOVELTY of the profession

- Household robots' novelty is a complex system that differs from even the most modern devices, consisting of a manipulator and a programmable control device. Since Kazakhstan, household robots' production has not yet been established, and such specialists' training is required.

KEY competence

- Descriptive geometry and theoretical mechanics.
- Fundamentals of industrial design.
- Fundamentals of robotics, Cybernetics, radio engineering and electronics, mechatronics.

- A specialist who designs household robots and their components.

Their responsibilities include:

- development of 3D models/drawings/ diagrams of household robots;
- technical calculations for projects, selection of components and materials;
- production support, interaction with the Assembly production during Assembly/ installation
- preparation of design and operational documentation;
- participation in building, testing, and commissioning the operation, as well as in work on the modernization of the designed products.

TRENDS

- Growing demand for the production of innovative products of domestic engineering.
- Changing consumer preferences.

PROFESSIONAL skills and abilities

- Client orientation.
- Artistic skills.
- Programming/ robotics/ artificial intelligence.
- Systems thinking.
- Ability to manage projects and processes.

▶ 1.5

# RADIO PHOTONICS DEVICE DESIGN ENGINEER

THE HORIZON of appearance ▶ 2030-2035

## NOVELTY of the profession

- Radiophotonics is a new stage in radio electronics and radio engineering development, based on the Foundation of Photonics and microelectronics technology

## KEY competence

- Telecommunications Photonics, radio electronics.
- Wave optics, Microwave optoelectronics

- A specialist engaged in research in radio photonics, design, and development of ultra-high-speed optoelectronic devices with unattainable parameters for traditional electronics.
- Promising radio photonics areas currently include transmission of a satellite, cellular and wireless signals, the transmission of microwave signals in enterprises, optical signal processing lines, radar, etc.

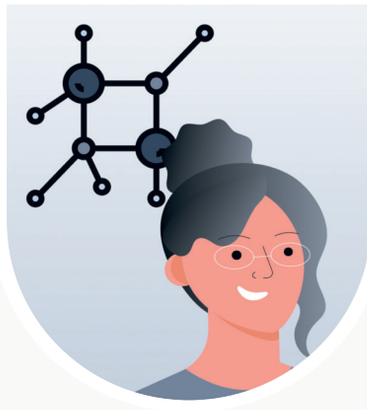
## TRENDS

- Expanding the scope of application of the latest technologies and construction materials in mechanical engineering.
- Growing demand for the production of innovative products of domestic engineering.

## PROFESSIONAL skills and abilities

- Client orientation.
- Cross-industry communication skills.
- Systems thinking.
- Ecological thinking.

▶ 1.6



# SPECIALIST IN NANOTECHNOLOGY

THE HORIZON of appearance ▶ 2025-2030

## NOVELTY of the profession

- Nanotechnology's novelty is a new science field in creating and using materials and devices characterized by nanostructure.

## KEY competence

- Nanotechnology, materials science.
- Mechanics, instrumentation, optics, electronics.
- Fundamentals of physics, physical chemistry, and mathematical modeling.

- A Specialist who is engaged in scientific research in the field of nano-engineering, designing nanoscale objects and structures created by nanotechnology methods.
- Nanotechnologies and nanomaterials are used today in various fields of science. In mechanical engineering, they are used in the space industry, modern electronic equipment, supercomputers, electronic circuits at the molecular level, nanorobots, molecular rotors, etc.
- Students are already being trained in this area in some universities. In the future, specialists with nanotechnology knowledge will be in demand at all levels of the production chain- from research institutes, engineering departments to small laboratories at a specific enterprise. And when they are in mass demand, it will be necessary to separate their functions and allocate particular professions, such as nano-engineer, nanotechnologist, a researcher in nanotechnology and nanomaterials, etc.

## TRENDS

- Expanding the scope of application of the latest technologies and construction materials in mechanical engineering.
- Growing demand for the production of innovative products of domestic engineering.

## PROFESSIONAL skills and abilities

- Client orientation.
- Systems thinking.
- Programming/ robotics/ artificial intelligence.
- Project management skills.

► 1.7

# SPECIALIST IN PREDICTIVE DIAGNOSTICS

THE HORIZON of appearance

► 2025

NOVELTY of the profession

- Changing the concept of planned repair of industrial equipment to preventive (predictive) diagnostics

KEY competence

- Fundamentals of stationary and mobile diagnostics.
- General knowledge of robotics, radio engineering, and electronics.

- A specialist who develops the concept and program to build monitoring systems and predictive diagnostics of production equipment manages measures to improve equipment reliability based on data from monitoring and Analytics systems.

Their responsibilities include:

- installation and configuration of predictive monitoring systems;
- centralized monitoring of sensors, monitoring systems, inter-device communication, IoT, etc., and the performance of industrial equipment to quickly detect malfunctions and improving the reliability of operation;
- analysis and processing of the results of automated systems for monitoring the state of equipment, preparation of conclusions on the state of technological equipment and systems;
- identify the causes of deviations of the diagnosed parameters, identify defects that are the causes of variations;
- making suggestions about the need to disable equipment to prevent accidents and conduct additional condition monitoring.

TRENDS

- Growing demand for the introduction of industrial robots in machine-building enterprises.
- Expanding the scope of application of the latest technologies in mechanical engineering.

PROFESSIONAL skills and abilities

- Client orientation.
- Systems thinking.
- Programming/ robotics/ artificial intelligence.
- Project management skills.

# 2. «INNOVATIVE MATERIALS»

▶ 2.1

# 3-D PRINTING MATERIALOGIST

THE HORIZON of appearance

▶ already required

NOVELTY of the profession

- When manufacturing a product or part on The 3D printer, the profession's novelty uses materials that differ significantly from traditional materials. Developments in this area do not stop. Since 3D printing is one of the main trends, the development of materials for this technology is a promising material science area.

KEY competence

- Materials science and fundamentals of metallographic analysis.
- Fundamentals of methods of selective laser melting, selective electron beam melting, direct laser material deposition, and their capabilities.

- Specialist involved inwith research and development in the latest materials used for 3D printing with specified technological and functional properties.
- Tests parts made from the developed materials under conditions as close as possible to the actual application conditions.

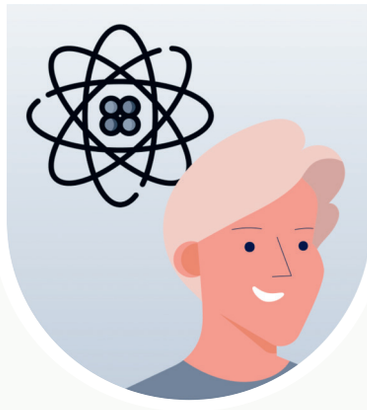
TRENDS

- Shorter start-up times for new products.
- High level of wear and tear of production facilities in mechanical engineering.
- Expanding.

PROFESSIONAL skills and abilities

- Lean production.
- Client orientation.
- Cross-industry communication skills.
- Systems thinking.
- Ecological thinking.

► 2.2



# SPECIALIST
## IN NANOPHOTONICS AND METAMATERIALS

THE HORIZON of appearance ► 2030-2035

NOVELTY of the profession

- Nanophotonics is a new scientific field that combines knowledge in optics, laser physics, materials science, physical chemistry, solid-state physics, and chemistry.

KEY competence

- Optics, nanotechnology, materials science.
- Fundamentals of surface physics, laser physics, condensed matter physics.
- Fundamentals of physical chemistry, solid-state physics, and chemistry.

- Specialist engaged in scientific research in creating materials with a negative refractive index that can control the direction of light and its penetration speed. These materials can be effectively used in laser-optical instrument making, creation of electronic and optoelectronic equipment.
- For example, using such materials in a new generation of computers will significantly improve their performance by replacing electronic devices with optical components.

TRENDS

- Expanding the scope of application of the latest technologies and construction materials in mechanical engineering.
- Growing demand for the production of innovative products of domestic engineering.

PROFESSIONAL skills and abilities

- Client orientation.
- Systems thinking.
- Ecological thinking.

# 3. «INTERNET OF THINGS AND BIG DATA.»

▶ 3.1

# CYBERSECURITY SPECIALIST (INDUSTRIAL)

THE HORIZON of appearance ▶ 2025

## NOVELTY of the profession

- The rapid pace of the emergence of new and more complex programs for hacking information bases of enterprises requires more robust protection of an increasing number of smart devices connected to the network (robotic systems, monitoring sensors, automated control systems, etc.).

## KEY competence

- Traditional methods of protection no longer guarantee complete security from hacker attacks.
- Programming.
- Basics of information database protection.

- A specialist who ensures the security of the company's information systems from unauthorized interference with the purpose of extortion, theft, or destruction of information.

Their responsibilities include:

- developing measures to ensure the security of information and the leakage of confidential information;
- research of existing information security methods and development of proposals for their improvement;
- forecasting potential sources of threats, as well as assessing the risks and possible damage from cyber-attacks for the enterprise and promptly neutralizing the consequences when they occur;
- instruct staff on information security rules and monitor compliance with these rules.

## TRENDS

- The growing need for digitalization of mechanical engineering enterprises.
- Increase the volume of digitized industrial data.
- An increase in the number of cyber attacks and the amount of damage they cause to industrial enterprises.

## PROFESSIONAL skills and abilities

- Client orientation.
- Systems thinking.
- Cross-industry communication skills.
- Ability to manage projects and processes.

▶ 3.2

# BIG DATA ANALYST (INDUSTRIAL)

THE HORIZON of appearance ▶ 2025

## NOVELTY of the profession

- The need for in-depth analysis of a large volume of industrial data with a complex and heterogeneous structure, obtained from various sources, including connected smart devices and monitoring sensors.
- Forecasting based on predictive Analytics of risks and opportunities for the development of the enterprise and the industry.

## KEY competence

- Programming, machine learning, mathematical statistics.
- Multivariate and predictive analysis.
- Basics of data visualization.

- Using mathematical statistics and predictive analysis methods, a specialist forms an assessment of the current state and forecast of further development of the enterprise, potential risks, and opportunities based on data coming from various sources: monitoring sensors, CNC machines, robotic systems, etc. Develops the company's business solutions.

Their responsibilities include:

- developing the concept of data collection, ensuring the completeness and reliability of the information, building a chain of its relationships;
- analysis, structuring of the received data, preparation of summary analytical reports,
- analysis of the company's performance, risks, and opportunities ways out of the crisis;
- development of solutions for business optimization, development of business solutions based on the analysis and forecasting of consumer behavior.

## TRENDS

- The growing need for digitalization of mechanical engineering enterprises.
- Increase the volume of digitized industrial data.

## PROFESSIONAL skills and abilities

- Client orientation.
- Systems thinking.
- Cross-industry communication skills.
- Ability to manage projects and processes.

# TRANSFORMING PROFESSIONS IN MECHANICAL ENGINEERING

7.2.

# 7.2.
# TRANSFORMING PROFESSIONS IN MECHANICAL ENGINEERING

It is impossible not to notice how much the labor market has been undergoing a transformation in recent years. Not only have new platforms emerged in the digital space that offer knowledge and find employees but also the requirements of employers have changed significantly and the list of professional competencies required for job seekers has expanded.

The root cause of the ongoing changes is large-scale digitalization and automation of all sectors of the economy, without exception, the introduction of artificial intelligence and the Internet of things. This will lead in the near future to the labor market dominated with trends to move away from dominated by a tendency to move away from strict requirements for specialization, to a combination of various professional competencies and the demand for skills to work at the intersection of different professions. Possession of skills in related professions, as well as knowledge in the IT field, will become the leading drivers of the competitiveness of professionals in the next 10-15 years.

In the field of domestic mechanical engineering, the transformation will affect almost all professions, but the most significant changes will be observed in relation to the professions listed in this section.

2020

01

## DESIGN ENGINEER

## DIGITAL DESIGN ENGINEER

- A specialist engaged in the design and engineering of parts and assemblies various mechanisms, machines, equipment, and devices for serial or customized production.

### TRIGGER

- Implementation of 3D modeling technologies.
- Creation of digital twins.
- Using reverse engineering techniques.

### DIFFERENCE

- The development of product design and design documentation is currently carried out using modern programs and technologies, such as object modeling (creating a digital double).
- Reduction of terms of designing of products.

2020

02

## PROCESS ENGINEER

## PROCESS ENGINEER 02

- A specialist who develops technological processes of production, products manufactured by the enterprise, taking into account the sequence of production stages, industrial equipment, and automation tools used to reduce material and labor costs.
- Carries out the control over observance of the established production technology.

### TRIGGER

- Production automation.
- Implementation of robotic systems.
- Increased production flexibility.

### DIFFERENCE

- Large-scale automation of production, the introduction of robotic systems, and intelligent monitoring sensors will change production's technological process.
- The specialist must be able to quickly rebuild the production process when changing the range of products.

2020

03

## MATERIAL SCIENTIST

## COMPOSITE ENGINEER

- A specialist who studies the composition of materials, their chemical, physical and other characteristics.
- Develops and tests new types of materials, determines their production technology.
- Generates suggestions for replacing traditionally used materials with new ones.

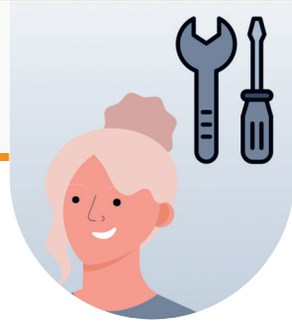
### TRIGGER

- Use of materials with improved performance (e.g. composites).
- Development of «smart» materials, for example, able to restore shape.

### DIFFERENCE

- The specialist must have in-depth knowledge of the development of new materials, their properties, and applications.

2020



04

## MECHANICAL ENGINEER

## MECHANICAL ENGINEER 2.0

- A specialist who ensures the smooth operation of equipment develops plans for preventive and routine repairs and measures to improve the process's efficiency, equipment maintenance, and repair work.

### TRIGGER

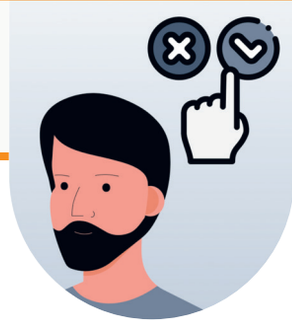
- Increasing complexity of production equipment.
- Implementation of robotic systems.
- Use of monitoring sensors.

### DIFFERENCE

- The specialist performs remote centralized monitoring of monitoring sensors, ensuring uninterrupted operation of industrial equipment.
- The complexity of industrial equipment requires a specialist to improve their maintenance and repair skills continually.

2025

05



## QUALITY CONTROL TECHNICIAN

### QUALITY CONTROL TECHNICIAN 2.0

- An employee of the company responsible for quality control of products by the requirements of GOST, ISO, and other regulatory documents and standards.
- Performs monitoring and analysis at all stages of product production, including tracking feedback from customers.

#### TRIGGER

- Implementation of smart sensors.
- Improvement of control technologies.
- Implementation of radio frequency identification technology.

#### DIFFERENCE

- The product quality control process is being improved through the introduction of intelligent sensors.
- Automation and implementation of robotic systems significantly reduce the number of defects.
- RFID tags installed on the finished product will allow you to track technical failures in the product even after being sold.

2025

06

## WELDER

### THE OPERATOR OF WELDING EQUIPMENT

- A specialist who is well versed in the types of alloys and their welding features, using various types of welding, such as manual, electric, laser, etc., connects individual metal parts into a single structure.

#### TRIGGER

- Complication of welding equipment.
- Introduction of automation and robotization at the welding stages.

#### DIFFERENCE

- Almost all branches of mechanical engineering require welding work. In the future, the number of jobs that use manual welding will be reduced – welding machines and even robotic installations will be introduced.
- When automating or robotizing welding operations, the welding equipment operator will only control the welding process and quality.

2025

07

REPAIRMAN

## MODULAR REPAIR OPERATOR

- A worker whose primary responsibilities are related to the installation, adjustment, commissioning, and repair of industrial equipment.
- A worker is engaged in the assembly and disassembly of machine components and mechanisms, eliminating equipment defects detected during

### TRIGGER

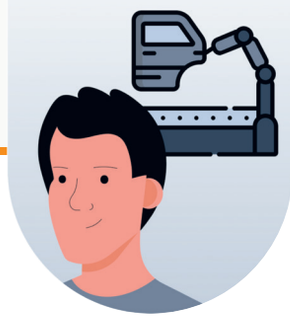
- Increasing complexity of production equipment.
- Improvement of diagnostic and repair methods.
- Industrial equipment becomes flexible and modular.

### DIFFERENCE

- The employee will detect malfunctions and defects in the equipment using monitoring sensors. They will carry out complex equipment repairs, using artificial intelligence devices to obtain prompt and complete information about each mechanism.

2025-2030

08



COLLECTOR

## THE OPERATOR OF AUTOMATIC ASSEMBLY LINES

- Deals with the Assembly of different products: cars, mechanisms and their units, instruments, etc. The entire tool or machine's serviceability depends on the assembler's work quality, so the assembler must strictly perform the Assembly according to the relevant documentation.

### TRIGGER

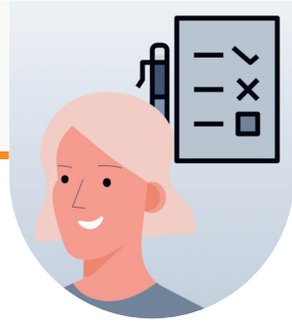
- Assembly line automation.
- Implementation of robots at the stages of product assembly.

### DIFFERENCE

- The amount of manual labor of assemblers will gradually decrease, and there will be a demand for skills in working on automated Assembly lines.
- The introduction of robots at the stages of product Assembly will require re-qualification of assemblers as operators of robotic Assembly lines.

2020

09



## PRODUCT TESTER

## DIGITAL PRODUCT TESTER

- A specialist is responsible for preparing and testing products before launching them into mass production, following the technical and design documentation for the products' requirements.
- Generates comments on detected malfunctions and defects based on the results of research and suggestions for their elimination.

### TRIGGER

- Implementation of object modeling technology — creation of digital twins.
- Implementation of virtual and augmented reality technologies.

### DIFFERENCE

- The specialist will have the skills to work with digital doubles.
- Be able to test a physically existing product in real-world conditions and its prototype in digital or virtual space.

2020

10

## INSPECTOR

## FLAW DETECTOR 2.0

- In the field of non-destructive testing, the activity aims to detect the degree of wear of industrial equipment, its components, and parts, manufacturing defects, various types of defects, such as cracks, corrosion damage, etc.

### TRIGGER

- Implementation of monitoring sensors.
- Improvement of control technologies.

### DIFFERENCE

- The tools used by the specialist to check products for defects and defects are becoming more complex, which requires the development of new skills.
- When detecting a malfunction in the equipment or a defect in the product, monitoring sensors notify you of this with a particular signal.

2030

11

## MOVERS IN WAREHOUSES AND PRODUCTION

## MOVERS IN WAREHOUSES AND PRODUCTION 2.0

- A worker engaged in loading and unloading operations using various moving items, including large and heavy ones.
- Performs installation and dismantling of equipment.

### TRIGGER

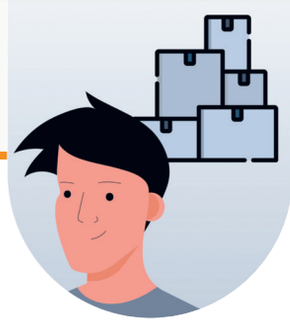
- Loading and unloading automation.
- Implementation of robots.

### DIFFERENCE

- Manual labor of movers will be gradually reduced.
- Movers will be re-qualified as equipment operators with skills in managing automated and robotic loading and unloading devices.

2030

12



## STOREKEEPER

## DIGITAL WAREHOUSE MANAGER

- An employee who is responsible for accounting and inventory of inventory items in the warehouse-raw materials, materials, components, finished products, etc
- Ensures the acceptance of goods and materials, effective placement in the warehouse, safety, configuration, and demand delivery.

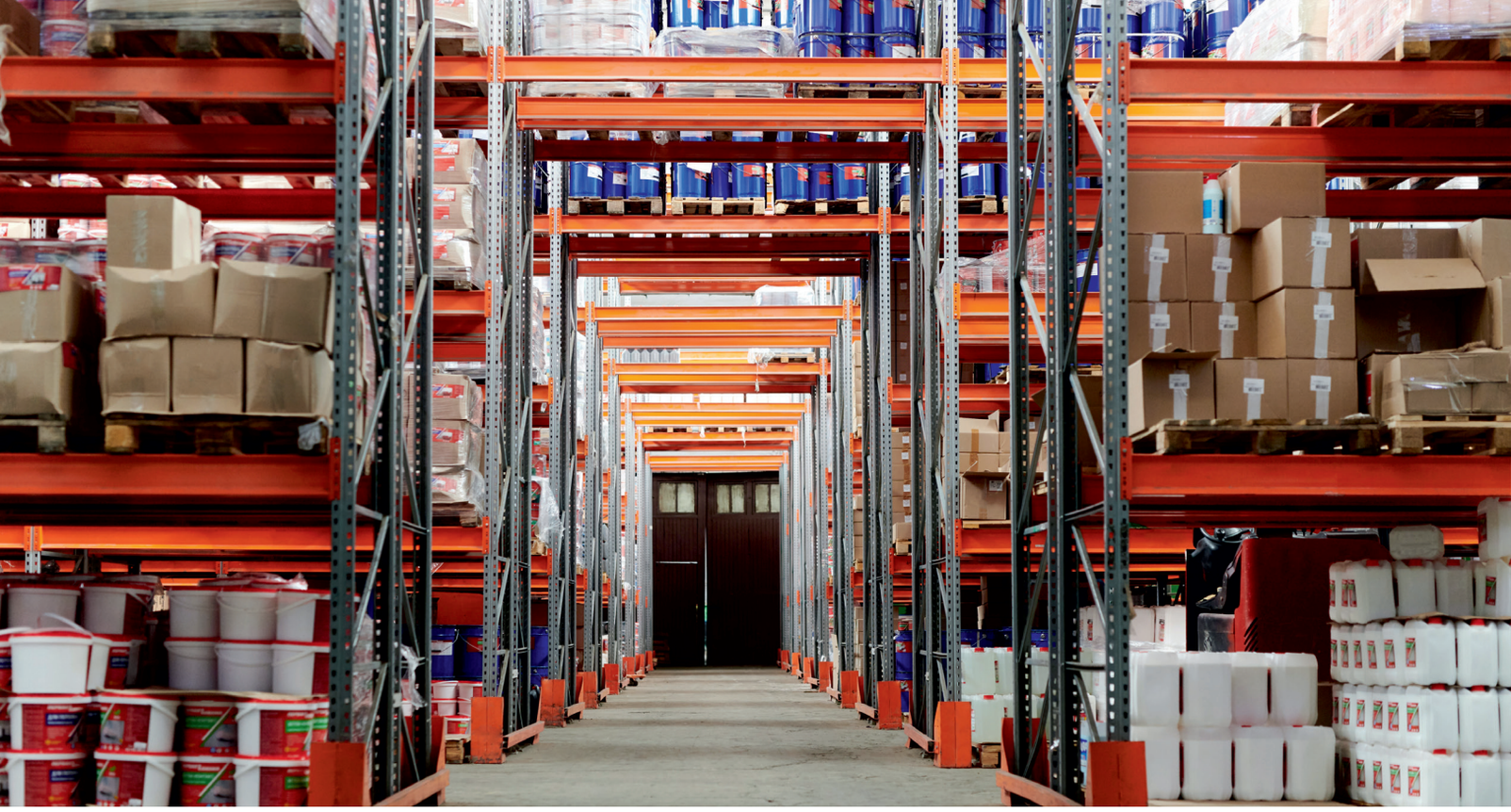
### TRIGGER

- Implementation of Internet of Things devices (scanners, sensors, RFID tags).
- Digitization of warehouse assets.
- Warehouse accounting automation.

### DIFFERENCE

- The warehouse will be equipped with intelligent scanners, sensors, and RFID tags placed on all warehouse assets to automate and simplify warehouse accounting.
- The share of manual labor will be reduced. The warehouse will turn into a digital one.

Source: Results of the foresight session in the mechanical engineering industry.



2020

13

## MACHINE OPERATOR, TURNER, MILLER

## MACHINE OPERATOR WITH CNC

### TRIGGER

- Replacement of at least 30 % of machine tools with CNC machines.

- Machine operator - a skilled worker who makes various parts for repair on select machines.
- A Turner is a worker who makes parts on a lathe, i.e., a machine where the workpiece usually performs the main rotational movement. It produces mainly cylindrical parts.
- Milling worker – a worker who makes parts on a milling machine where the tool's main rotational movement is performed. It mainly processes flat and shaped surfaces.

### DIFFERENCE

- The work will be performed on CNC machines.
- The machine operator, Turner, and the milling machine operator decided where the tool and workpiece interact.
- The operator will select and/or create programs for processing the workpiece.
- At the point of contact between the tool and the workpiece, all decisions will be made automatically.

# DISAPPEARING PROFESSIONS IN MECHANICAL ENGINEERING

# 7.3.

# 7.3.
# DISAPPEARING PROFESSIONS IN MECHANICAL ENGINEERING

In a 2018 speech at the World Economic Forum in Davos, Oliver Kann[75] stated that the labor market will change significantly in the coming years. The process of transformation of the labor market will be influenced by the large-scale spread of robots, digitalization and automation of processes in all spheres of the economy.

According to Oliver Kann, by 2022 this trend will affect 29-42% of professions, and 75 million people in the world will lose their jobs. At the same time, he noted that 133 million new jobs will appear, but which will require a higher level of professional qualifications from applicants.

In order to always remain in demand in the labor market, it is necessary to consciously approach the choice of your future profession, to study the trends influencing the development of the machine-building industry, because in the next 10-15 years a number of professions in this area will gradually disappear.[76]

Some of the professions will not disappear completely, they will remain in separate enterprises, however, these professions will not be in great demand on a large scale.

[75] Oliver Kann - Expert, Member of the Executive Committee of the World Economic Forum 2018.
[76] URL: https://utalents.ru/news/2019/09/17/professii-budushchego-kak-podgotovitsya-k-izmeneniyam-na-rynke-truda.

▶ 2030

▶ 1

## NORM SETTER

- Maximum automation of calculated labor costs for various types of work performed in the production.
- Control over the use of working hours will be transferred to innovative devices.

▶ 2025

▶ 2

## ACCOUNTANTS
AND ASSISTANT ACCOUNTANTS

- Automation of accounting will allow freeing up most of the staff whose work is associated with calculations using specific algorithms.

▶ 2035

▶ 3

INVENTORY
## CLERK

- All inventory items in the enterprise will be equipped with RFID tags that will be read intelligent scanners that will automate the inventory process.

▶ 2035

▶ 4

WAREHOUSE ACCOUNT
## MANAGER

- Smart sensors, scanners, and RFID tags will create a digital warehouse and automation of warehouse accounting.


13
Kerana bukan
semua orang gemar
bertukang
favourite pastime

▶ 2035

▶ 5

## MARKER

- All inventory items arriving at the company's warehouse will be equipped with RFID tags, which will be put down automatically by the manufacturing companies.

▶ 2030

▶ 6

## UNSKILLED
### WAREHOUSE WORKER

- Automation of warehouse operations, the introduction of remotely controlled loading and unloading machines and robots.

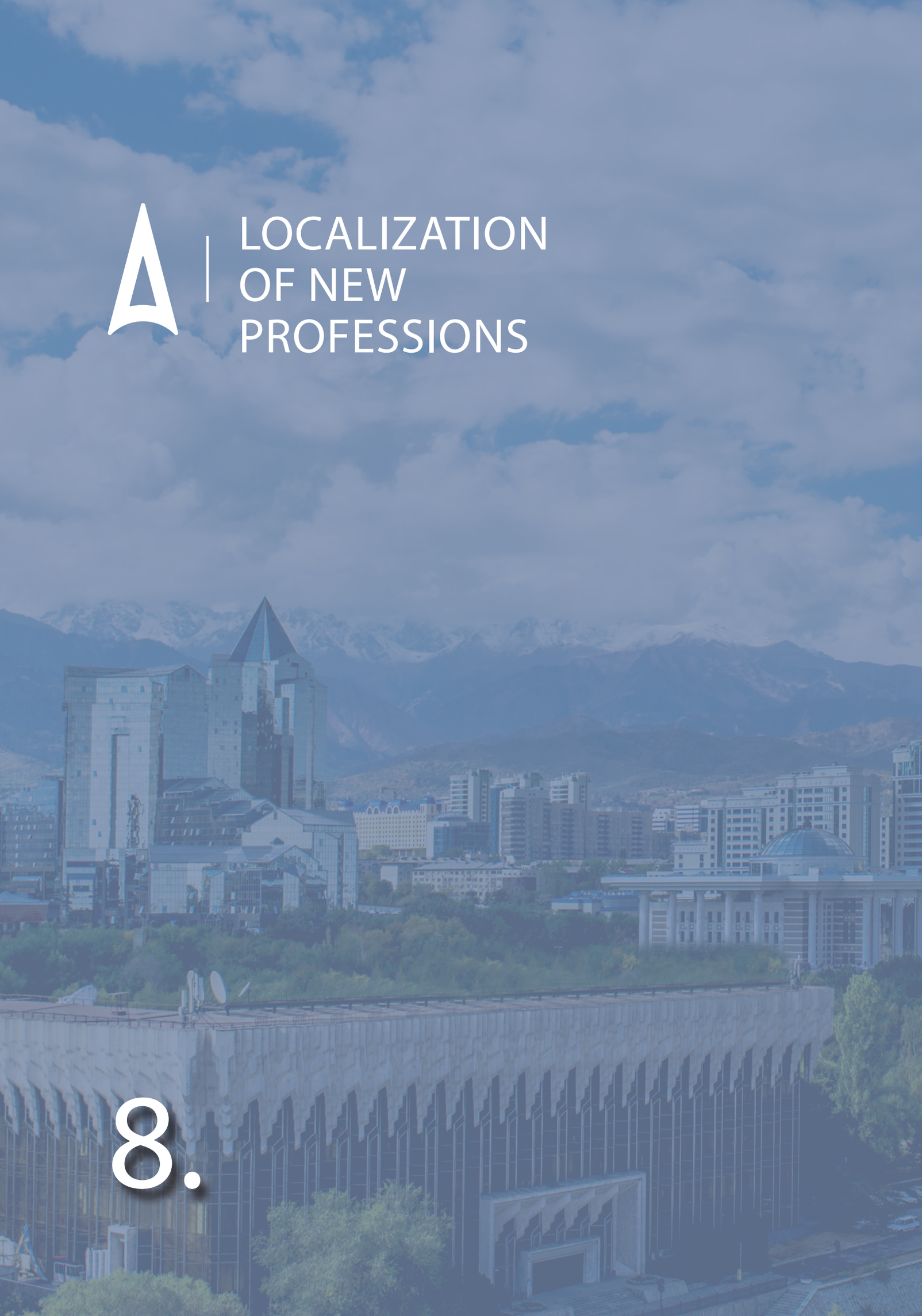
▶ 2035

▶ 7

## DRIVER
### (IN-STORE AND WAREHOUSE)

- Introduction of crewless vehicles, maximum automation, and robotization of production processes, eliminating the need for in-house or warehouse managed transport.

Source: Results of the foresight session in the mechanical engineering industry.



# LOCALIZATION OF NEW PROFESSIONS

# 8.

Table 8.1

***Major/key universities identified for the localization of new professions in the engineering industry.***

| No. | Higher educational institution | Rating | Amount new professions |
|---|---|---|---|
| 1 | Toraighyrov University | 3.64 | 6 |
| 2 | M. Dulatov Kostanay University of Engineering and Economics | 3.43 | 1 |
| 3 | Sh. Yessenov Caspian State University of Technologies and Engineering | 3.42 | 2 |
| 4 | Karaganda State Technical University | 3.29 | 11 |
| 5 | Dulaty University | 3.24 | 8 |
| 6 | D. Serikbayev East Kazakhstan Technical University | 3.097 | 7 |
| 7 | M. Kozybayev North Kazakhstan State University | 3.095 | 6 |
| 8 | Zhangir Khan West-Kazakhstan Agrarian-Technical University | 3.013 | 3 |
| 9 | M. Auezov South Kazakhstan University | 3.006 | 7 |
| 10 | Shakarim State University (Semey) | 2.93 | 2 |
| 11 | Sh. Ualikhanov Kokshetau State University | 2.91 | 1 |
| 12 | Satbayev University | 2.79 | 11 |
| 13 | Eurasian Innovative Universit | 2.76 | 1 |
| 14 | Karaganda State Industrial University | 2.72 | 5 |
| 15 | Eurasian Technological University | 1.87 | 0 |
| 16 | Kazakh National Agrarian University | 1.34 | 2 |
| 17 | Kazakh University of Railway Transport | 1.31 | 3 |

SOURCE: Rating of «Educational programs of universities in the specialty «Mechanical engineering».[77]

[77] URL: https://atameken.kz/uploads/content/files/Mechanical engineering(2).pdf.


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Table 8.2

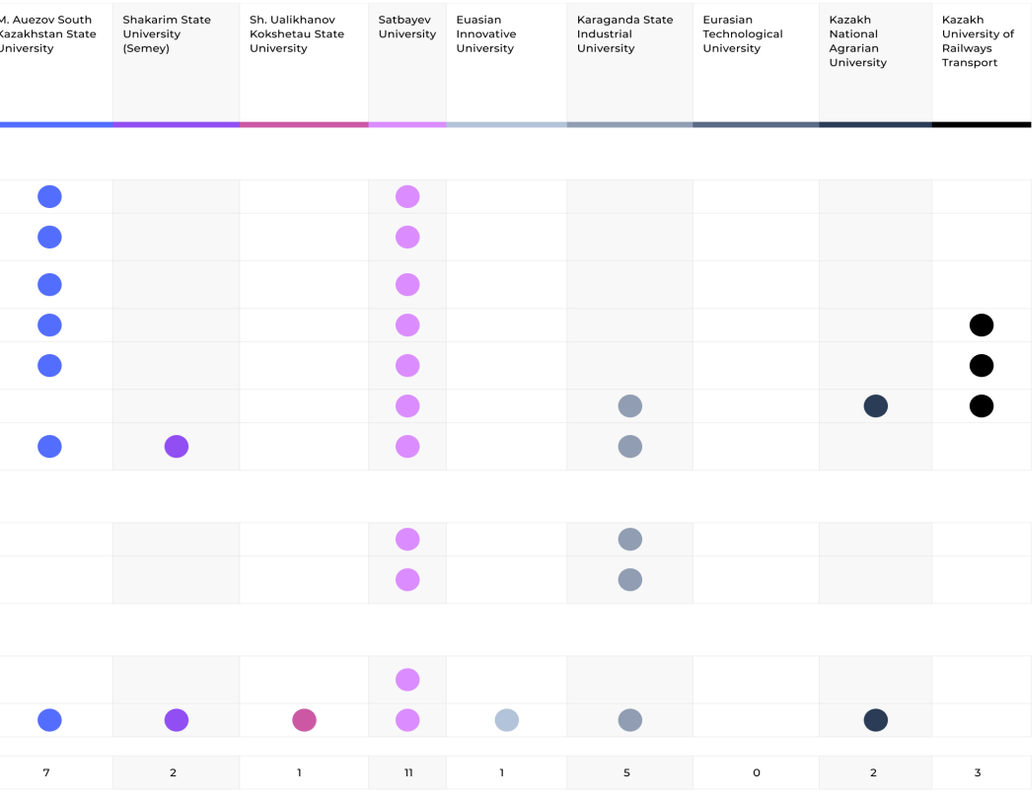
***The list of the faculties required for the localization of new professions in the engineering industry of the Republic of Kazakhstan***

| No. | Profession | List of faculties and departments required to localize new professions in the industry |
|---|---|---|
| 1 | «VIRTUAL REALITY TECHNOLOGIES AND ARTIFICIAL INTELLIGENCE» | |
| 1.1 | Specialist in virtual prototyping | 5B071200 — Mechanical Engineering<br>5B070500 — Mathematical and computer modeling |
| 1.2 | Design engineer of reverse engineering (reverse engineer) | 5B071200 — Mechanical Engineering<br>5B071600 — Instrument making<br>5B070500 — Mathematical and computer modeling |
| 1.3 | Industrial Robotics Design Engineer | 5B072400 — Technological machines and equipment (by industry)<br>5B071600 — Instrument making<br>5B071900-Radio engineering, electronics and telecommunications |
| 1.4 | Domestic Robot Design Engineer | 5B071200 — Mechanical Engineering<br>5B071600 — Instrument making<br>5B071900 — Radio engineering, electronics and telecommunications |
| 1.5 | Radio Photonics Device Design Engineer | 5B071200 — Mechanical Engineering<br>6M074000 — Nanomaterials and nanotechnology (by fields of application)<br>5B071900 — Radio engineering, electronics and telecommunications |
| 1.6 | Specialist in nanotechnology | 5B071200 — Mechanical Engineering<br>6M074000 — Nanomaterials and nanotechnology (by fields of application)<br>5B071000 — Materials science and technology of new materials |
| 1.7 | Specialist in predictive diagnostics | 5B071200 — Mechanical Engineering<br>5B070200 — Automation and control<br>5B071900 — Radio engineering, electronics and telecommunications |


| No. | Profession | List of faculties and departments required to localize new professions in the industry |
|---|---|---|
| 2 | «INNOVATIVE MATERIALS» | |
| 2.1 | 3D printing materialogist | 5B071200 — Mechanical Engineering<br>5B071000 — Materials science and technology of new materials |
| 2.2 | Specialist in nanophotonics and metematerials | 5B071200 — Mechanical Engineering<br>6M074000 — Nanomaterials and nanotechnology (by fields of application)<br>5B071000 — Materials science and technology of new materials |
| 3 | «INTERNET OF THINGS & BIG DATA» | |
| 3.1 | Specialist in cybersecurity (industrial) | 5B071200 — Mechanical Engineering<br>5B100200 — Information security systems |
| 3.2 | Big Data Analyst (Industrial) | 5B071200 — Mechanical engineering<br>5B070200 — Automation and control<br>5B070400 — Computer engineering and software |

# TABLE 8.3
## LOCALIZATION MAP OF NEW PROFESSIONS IN THE UNIVERSITIES OF THE REPUBLIC OF KAZAKHSTAN

| № | Name of the profession | Toraighyrov University | M. Dulatov Kostanay University of Engineering and Economics University | Sh. Yessenov Caspian State University of Technologies and Engineering | Karaganda State Technical University | Dulaty University | D. Serikbayev East Kazakhstan State Technical University | M. Kozybayev North-Kazakhstan State University | Zhangir khan West Kazakhstan Agrarian-Technical University |
|---|---|---|---|---|---|---|---|---|---|
| **Direction "Technologies of virtual reality and artificial intelligence"** | | | | | | | | | |
| 01 | Specialist in virtual prototyping | | | | ● | | ● | | |
| 02 | Design engineer of reverse engineering (reverse engineer) | ● | | | ● | | ● | ● | ● |
| 03 | Industrial robotics design engineer | ● | | ● | ● | ● | ● | ● | ● |
| 04 | Domestic robot design engineer | ● | | | ● | ● | ● | ● | ● |
| 05 | Radio Photonics Device Design Engineer | ● | | | ● | ● | ● | ● | |
| 06 | Specialist in nanotechnology | | | | ● | ● | | | |
| 07 | Specialist in predictive diagnostics | ● | | | ● | ● | ● | ● | |
| **Direction "Innovative materials"** | | | | | | | | | |
| 01 | 3D printing materialogist | | | | ● | ● | | | |
| 02 | Specialist in nanophotonics and metamaterials | | | | ● | ● | | | |
| **Direction "Internet of Things and Big Data"** | | | | | | | | | |
| 01 | Specialist in cybersecurity (industrial) | | | | ● | | | | |
| 02 | Big Data analyst (industrial) | ● | ● | ● | ● | ● | ● | ● | |
| | **Total:** | 6 | 1 | 2 | 11 | 8 | 7 | 6 | 3 |


M. Auezov South Kazakhstan State University
Shakarim State University (Semey)
Sh. Ualikhanov Kokshetau State University
Satbayev University
Euasian Innovative University
Karaganda State Industrial University
Eurasian Technological University
Kazakh National Agrarian University
Kazakh University of Railways Transport
7
2
1
11
1
5
0
2
3

# CONCLUSION

# CONCLUSION

Mechanical engineering, being a priority branch of industrial and innovative development of any country, is characterized by a high technology level and a high level of multiplicative impact on the economy's related sectors.

First of all, the development of mechanical engineering affects the country's economic independence and security.

This is why it is essential to assess and understand what this industry is doing today, what direction it is moving in, and what plans it is building for the future. This is precisely what we tried to figure out with the help of machine-building industry experts.

The result of the joint work was the Magazine that You are now holding in your hands. As a result of systematizing a large amount of information obtained during the foresight sessions, supported by in-depth interviews with leading industry experts and a survey of experts using the questionnaire method, a vision has been formed for the current state of the domestic engineering industry, as well as its development prospects for the next 10-15 years.

According to industry experts, the domestic machine-building industry is going through difficult times today: there is a severe lag in the implementation of innovative technologies that are relevant on the world market; there is a high level of depreciation of main production capacities, and the scale of dependence on imports is not reduced.

And as a result, there was a shortage of qualified specialist personnel because of young people's reluctance to master working specialties.

For the development of mechanical engineering in Kazakhstan today and in the next decade, the most significant impact will be driven by trends related to digitalization, the introduction of innovative technologies, the use of the latest materials, the need for intra-industry cooperation, and highly qualified personnel.

Digitalization of production and management processes will bring machine-building enterprises to a higher level of development. Modern materials will make it possible to produce competitive products with improved operational and structural characteristics. New mechanisms of intra-industry interaction will increase the efficiency of the machine-building complex as a whole.

The fourth industrial revolution opened up an incredible number of innovative technologies for machine builders. According to industry experts, additive technologies and monitoring sensors that monitor the equipment's performance will play an essential role in the next 10-15 years in the domestic engineering industry.

The introduction of digital modeling and 3D printing will significantly change the design, testing, and production processes of products while considerably reducing new products' launch time. With smart sensors' help, operators will remotely monitor industrial equipment, quickly identifying problems and failures in their work.

The introduction of these innovations will allow enterprises in the industry to improve quality, reduce both the time of production and production waste, which will immediately affect enterprises' economic efficiency.

It is worth noting that the large-scale robotization of domestic engineering, from the industry's expert community's point of view, is aimed at the long term. However, the global trend to reduce the average cost of robotic equipment and reduce their payback period on the one hand, and the growth of competition for the right to enter the world market of mechanical engineering products on the other, will require industry players to radically reconsider their position and start making confident steps towards the robotization of their

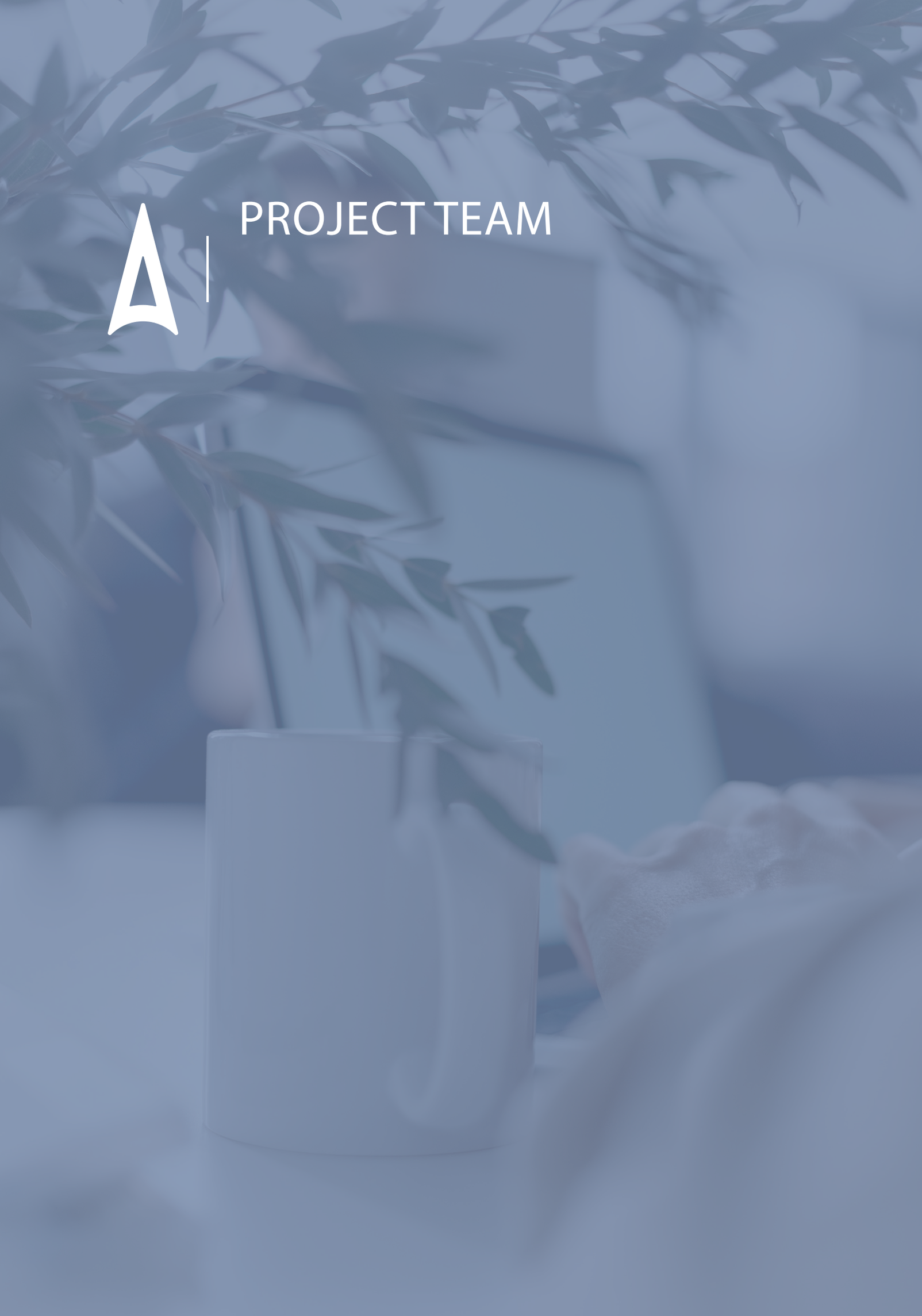
production sites.

Industry experts pay great attention to the qualification of personnel of machine-building enterprises, training, and retraining. The technological transformation of machine-building enterprises will help reduce manual labor, freeing up much-unskilled personnel. The increasing complexity of technologies will require employees to develop new skills and competencies. Simultaneously, individual technological innovations will require the emergence of new professions that industry experts within this framework. We tried to predict the project and a qualitatively new system of training them. A generation of specialists will soon come to enterprises, which will differ significantly from those who worked yesterday and even those who work today. They will have higher requirements for their workplace, working conditions, and pay.

Along with this, the new generation of specialists will have a great responsibility for developing mechanical engineering of the future in Kazakhstan. Their professionalism and active life position will determine how much the industry can do strengthen its role in the global market, what level of technological development the sector will achieve, and what competitive products it will be aimed at.

Therefore, even today, when choosing a profession, the younger generation should be aware of how much mechanical engineering will change in the future and how much they can personally do for this.

# PROJECT TEAM



# THE RESEARCH TEAM OF THE PROJECT

* Members of the research team who worked on the project titled «Atlas of new professions and competencies of the machine-building industry of the Republic of Kazakhstan»

| | |
|---|---|
| 1. Madenov Baurzhan Eserkegenovich | Head of the project team |
| 2. Kurganbaev Yerdos Turemuratovich | Deputy head of the project team |
| 3. John A. Sweeney | International expert |
| 4. Imanberdiev Rasouljan | International expert |
| 5. Abuov Bauyrzhan | National expert |
| 6. Aitmagambetov Chingiz Rashidovich | National expert |
| 7. Matchanov Yerzhan | National expert |
| 8. Aysautov Askar Sadykovich | National expert |
| 9. Abdykaparov Baurzhan | National expert |
| 10. Syzdykov Teleutai Usenovich | National expert |
| 11. Sabitova Almira Sabitovna | National expert |
| 12. Tumasbaev Amirkhan Keneshanovich | National expert |
| 13. Shaimerdenova Sabina | National expert |
| 14. Shortan Sayat Shortanuli | National expert |
| 15. Burabaev Altay Kudaibergenovich | National expert |
| 16. Abubakirov Bauyrzhan | National expert |
| 17. Sagnaeva Ainur | National expert |
| 18. Malikova Makpal Tattinbekovna | Junior consultant |
| 19. Taimagambetova Mahabat Bauyrzhanovna | Junior consultant |
| 20. Kaldybekov Suindik Usenovich | Junior consultant |

# ANPIC TEAM OF INDUSTRY EXPERTS IN THE MECHANICAL ENGINEERING INDUSTRY

* List of industry experts who registered and participated in the foresight session of the ANPIC of the mechanical engineering industry.

1. Agaev Ismail
2. Ajdabulov Erdana
3. Ajnabekova Saule
4. Akbaev Erbol
5. Aklevkova Ol'ga
6. Alimbekov Bauyrzhan
7. Alimov Ruslan
8. Apsalyamova Il'nura
9. Arapov Batyrbek
10. Arinova Dinara
11. Ahmadiev Rustam
12. Ahmetzyanov Kamil'
13. Ahmetova Gul'zhajnat
14. Bajmankulov Daryn
15. Beklemishev Pavel
16. Borodin Vyacheslav
17. Bulatov Galym
18. Burabaev Altaj
19. Garkusha Tat'yana
20. Gel'manova Zoya
21. Daurenbekova Umut
22. Dem'yanenko Evgenij
23. Dzhartybaev Nurbek
24. Doskenov Talgat
25. Dusenov Maksut
26. Ekimov Sergej
27. Ermenov Damir
28. Esil'gil'dinova Ajnur
29. Zhilkibaeva Saltanat
30. Zhylkajdarov Bekzhan
31. Zaitov Ersultan
32. Zaitova Svetlana
33. Zulkajyruly Mejramhan
34. Ibragimova Zaure
35. Il'in Igor'
36. Iskakov Nurken
37. Kabdolov Artur
38. Kabylbekov Rinat
39. Kaztuganova Gulsara
40. Karmanov Darhan
41. Kozlov YUrij
42. Korenev Sergej
43. Kuanyshbekova Asem
44. Kurmangaliev Timur

45. Kushaliev Dauren
46. Liholobov Evgenij
47. Lukash Ekaterina
48. Mateshov Arman
49. Mekeev Akzhigit
50. Moldagaliev Arman
51. Mosendz Artur
52. Mukashev Arman
53. Myrzaliev Darhan
54. Nespbaev Amir
55. Nurpeisov Kuandyk
56. Nurshinov Erbol
57. Omarov Denis
58. Pecherskij Vladimir
59. Popova Natal'ya
60. Porotikov Aleksej
61. Prudnikova Ol'ga
62. Pchelinceva Ekaterina
63. Rahmatulin Maksim
64. Rahymtaj Nursaya
65. Savinkin Vitalij
66. Samsonov Vladimir
67. Sejdullaeva Orynkul
68. Sejtkazenova Kazira
69. Sejtkulov Abdumalik
70. Sejthanov Azamat
71. Sembekova Nurgul'
72. Starikova Tamara
73. Sultanov Arman
74. Suhov Evgenij
75. Suhodol'skij Aleksandr
76. Sylejmen Gulzhajna
77. Temirbaev Askar
78. Teterya Vladimir
79. Tulembaev Alizhan
80. Turagulov Rasul
81. Turdaliev Auezkhan
82. Turkova Svetlana
83. Urazova Aliya
84. Hajdarov Dmitrij
85. Chernenok Valentina
86. Sharipbaeva Dinara
87. Shelkunov Vyacheslav
88. Shomanov Adil'zhan
89. Yurchenko Vasilij
90. Yusupov Erzhan

# INDUSTRY EXPERTS REPRESENTED THE FOLLOWING COMPANIES:

- 3D Galam LLP
- AI SPC LLP
- Aircraft repair plant No. 405 JSC
- Almaty heavy engineering plant JSC
- Almaty Technological University
- Alstom Kazakhstan LLP
- Aluminum of Kazakhstan JSC
- ASIA AUTO JSC
- Association of electric machine builders National chamber of entrepreneurs of the Republic of Kazakhstan OUL
- Committee for industrial development and industrial safety of the Republic of KAZAKHSTAN
- D. Serikbayev East Kazakhstan Technical University
- DLC Automation LLP
- ERG Service LLP
- Inkar-1 LLP
- Isoplus Central Asia LLP
- Kamkor locomotive LLP
- Kamkor locomotive LLP
- Kamkor Service LLP
- Kamkor Wagon LLP
- Kazakhstan aviation industry LLP
- Kazakhstan Engineering NC JSC
- Kazarmatura Plant LLP
- Kazinsop LLP, Group of companies Qazaq National Product
- Kirov machine-Building plant JSC
- KPF Tehsnabelektriks LLP
- Lokomotiv-2030 LLP
- Mehlitkom LLP
- MehLitLom CLR
- National Agency for Technological Development JSC
- NC «Kazakhstan engineering JSC
- NEXT TIME Public Fund
- Petropavlovsk heavy machinery plant JSC
- Qazaq National Product LLP
- Research Institute» Gidropribor JSC
- Saiman Corporation LLP
- Saryarkaavtoprom LLP
- Semey Engineering LLP
- Taldykorgan Plant LLP Electric Devices
- Temirzhol Zhondeu LLP
- Temirzholenergo LLP
- Track equipment repair LLP
- Tulpar car building plant LLP
- Tynys JSC
- Union of machine builders of Kazakhstan OUL

- Ural plant «Zenit» JSC
- Ural ship repair plant LLP
- Ust-Kamenogorsk industrial valve plant JSC

## PROJECT PARTNERS:

Министерство индустрии и инфраструктурного развития РК


Edit Mode


EMTg-3310-007
Characteristics:
Rated Output 310
Rated Torque 1.337
Input 120-230
Current 5.3
Speed 4300
Weight 0.91
Torque
Power
1000
2000
3000
4000
5000
RPM
EMTg-1337-01
205
335
Side view
06AG
05AG
EM-2
RT01
EM-1
RT03
TR31
BA31
01
Torque
Power
1000
2000
3000
4000
5000
RPM
Agency
GRDNKF
No.
EMTg-1337
Developer
John M.
Date
11/27/17