CHAPTER 4. USE OF NEW TECHNOLOGICAL KNOWLEDGE AND PROCESSES

DOI: https://doi.org/10.30525/978-9934-26-160-2-4

The company's own technological assets include:
– previously completed projects;
– standard units and aggregates of own production;
– typical details of own production;
– typical structural and technological elements of details;
– typical and group TP;
– standard technological equipment and tools;
– typical calculation methods and mathematical models of own products;
– typical solutions.

The existing property is updated as new technical solutions are created, suitable for further use.

In addition, they use new technological knowledge and processes through their own development, improvement of traditional technologies, development of the latest work processes and technologies, development of environmentally friendly TP, the use of the latest forms of production organization.

For implementation of perspective own developments, it is necessary, first of all, to organize constant studying of prospects and directions of development of technologies, technological working processes and organizational concepts of production processes.

This work requires large investments, so it is carried out by large, financially and technically powerful enterprises.

Introduction of new technologies requires a creative approach. At the same time, it is a risk that can lead to bankruptcy or economic growth. There are ways to minimize some types of risk or eliminate them completely.

For a company that does not want to lose regular customers, technological innovations are mandatory, associated with risk, but abandoning them is even more risky.

Technological risk can be defined as the possibility of loss of part of its resources or the emergence of additional costs as a result of the development and implementation of new technologies.

The more radical technological innovations, the higher the risk of commercial failure (Table 4.1), and therefore the manufacturer must be prepared for the fact that the market will reject its development.

Table 4.1 – Risk of technology introduction

Market	Technology	Risk
Mastered	Mastered	Minimal
New	Mastered	Increased
Mastered	New	Big
New	New	Maximum

Significant reduction of risk (by 70… 90%) contributes to the compliance of products with consumer requirements.

High-level technologies are built on the basis of significant achievements of basic and applied sciences with a significant increase in costs.

Simple and, moreover, primitive technologies cause the lowest costs due to the "replication" of known technologies, which cannot lead to increased productivity and production efficiency, i.e. the development of production by improving traditional technologies is almost completely exhausted. Timely fundamental changes in the formation of technologies, taking into account the accelerated renewal of products, a significant improvement in its quality while saving all kinds of resources, consistent cost reduction, small series production, greening of technologies based on flexible production systems and integrated industries.

To solve these problems a system technology is designed, which should use such areas of technology improvement:

– transition from intermittent to continuous technologies;

– introduction of waste-free technologies;

– increasing the consumption of products from each unit of area and technological equipment;

– increasing the intensity of technology;

– reduction of material consumption of structures;

– reduction of labour costs;

– increasing the power of devices, etc.

4.1. Improvement of traditional technologies

Improvement of traditional technologies can take place according to the following schemes:

– improvement of the existing TP for this product;

– adaptation of the current TP for another product;

– development of a new TP for a new product.

Improvements in traditional technologies are usually aimed at a specific reduction of resources for the manufacture of a unit of production (resource- and energy-saving technologies).

There are eight most important features that characterize the new technology (Table 4.2).

The first (initial) feature (*A*) – radical innovation, which is expressed by the scale of changes in technology, as well as the level of innovation.

To determine the degree of radical innovation, take into account **the level of novelty (sign *B*)** and the degree of complexity of the **solved technological problem (sign *C*).**

The fourth feature (*D*) – degree of improvement of technology parameters: global, partial, and local.

Global innovation affects the process of social production as a whole, its organization, technology, the nature of workers and so on. Most often, global innovations are manifested in the country or the world. Global innovations include, for example, the creation of new laser technology, the use of robotic technology kits, the introduction of flexible production systems.

The innovations that include the transition from one basic principle, the construction of technology to another, more perfect and more economical should be considered partial. As a rule, this leads to the creation of new technology and revision of existing technological processes. Local innovations usually affect technologies that are developed by borrowing.

According to **the fifth feature (*E*)**, innovations are divided by implementation costs, reliability of technology and other values of the feature.

The sixth feature (*F*) – the effect of the manufacturer, which is formed as a result of the introduction of innovations. This effect can manifest itself in the form of reduction of resource consumption rates, the transition to less scarce raw materials or components, reducing the harmfulness of production.

The seventh feature (*G*) – the source of the idea, which can be prompted by both the sphere of consumption (formation of social needs) and the research and production sphere (the emergence of fundamental scientific ideas).

Finally, the last, **eighth, feature (*H*)**: the compatibility of innovation with the external environment. This feature allows you to assess the changes caused by innovation in the field of production and in the use of innovation.

To assess the level of improvement of a given TP a list of partial improvements is maid and according to the Table 4.2 their level in points for each morphological feature. Making scores, get the overall level of improvement of P_y.

The possible highest level P_y^{max} = 8; the lowest – P_y^{min} = 40.

The most important criterion for the prospects of improving the technological process is its efficiency. However, sometimes this criterion is not enough. A more general assessment is needed, which takes into account other indicators. In this case, the most reliable is an expert assessment.

To do this, depending on the specifics of the work, select 7-15 experts who set the evaluation indicators of improvement.

Each indicator is assigned a significance factor, which shows the weight of this indicator in the need to improve the TP.

Experiments set the evaluation score scale, which sets the scores for each of the indicators (Table 4.3).

Other variants of a point scale are also possible.

The total score is calculated according to the formula:

$$q = \sum_{i=1}^{n} p_i m_i ,$$

where p_i – the score of the i-th evaluation indicator set by the expert;

m_1 – the coefficient of significance of the i-th indicator;

n – the number of evaluation indicators of improvement of TP.

The option of improvement, which received the maximum score, is considered the most promising. Based on the results of an expert assessment of five options for improving TP, it is possible to determine their prospects.

The total scores of each of the options are calculated.

q_1=3·0.35+3·0.40+3·0.25=3,0;

q_2=3·0,35+4·0,40+3·0,25=3,4;

q_3=5·0,35+4·0,40+5·0,25=4,6;

q_4=4·0,35+4·0,40+3·0,25=3,75;

q_5=5·0,35+4·0,40+4·0,25=4,4.

Table 4.2 – Morphological matrix of technology improvement

Morphological features	Value of the feature				
A Radicality (scale of change)	Technology in general	Part of the technology	Element of technology	–	–
B The level of novelty	Based on a new discovery	At the level of the invention	At the level of rationalization proposals	Other	–
C The complexity of the decision	Technology of special complexity	Sophisticated automated	Difficult	Medium difficulty	Not difficult
D The degree of improvement of technical parameters	New qualities (technical capabilities)	Significant improvement	Partial improvement	Improving secondary characteristics	The parameters remained unchanged
E Measure of parameter improvement	Reduce sales costs	Improving reliability	Complex effect	–	–
F Type of effect in production	Reducing resource consumption rates	Switch to cheaper resources	Transition to less scarce raw materials	Reducing the harmfulness of production	Complex effect
G The source of the idea of innovation	Basic research	Own applied research	Exchange of experience	Other	–
H Compatibility in production	Radical changes are needed	Significant changes are needed	Minor changes are needed	No changes are needed	–

Table 4.3 – Evaluation score scale

Evaluation indicator	Coefficient of weight	Criterion of the indicator	Point
Relevance of improvement P_1	0,35	Very relevant	5
		Relevant	4
		Not particularly relevant	3
Economy of TP, P_2	0,40	High, $K_c \geq 7$	5
		Middle $K_c = 3…6$	4
		Low $K_c < 3$	3
Implementation of TP, P_3	0,25	Minor costs	5
		Average costs	4
		High costs	3

Table 4.4 – The results of expert evaluation

Criterion P_i	Variant of improvement of TP				
	1	2	3	4	5
P_1	3	3	5	4	5
P_2	3	4	4	5	4
P_3	3	3	5	3	4

Thus, the expert assessment of the need to improve the TP is ranked as follows: in the first place there is option 3, then there are options 5,4,2,1.

The level of perfection or progressiveness of technologies is determined by the basic technology underlying it and the technological means of its implementation.

4.2. The latest work processes and technologies

Different processing processes due to their combination and change of modes have wide possibilities in ensuring accuracy, increase of reliability and durability of details of machines.

The workflow is the basis for creating the latest (innovative) technology.

Modern industrial production is characterized by the implementation of many technological processes at the limit of their limit capabilities, because the theoretical limitation of accuracy in the processing of materials by the separation of the crystal lattice is the size of the molecule or atom of matter (0.2… 0.4 nm) (1 nm = 0,001 μm).

The higher the requirements for productivity and quality of TP, the more unreliable it becomes.

On the other hand, intensification of processing (increase of working speeds) provides high productivity and efficiency of process and is connected with development of the newest and synthesis of existing methods of processing.

Depending on the achieved accuracy, all work processes can be divided into normal (from 100 to 1 μm), accurate (precision) (from 10 to 0.01 μm) and extremely accurate (ultra-precision) (from 1 to 0.001 μm).

Modern technology of dimensional processing passes from micrometric to manometric range of accuracy.

Accordingly, it became possible by technological methods to control the condition of the surface, to “construct” the surface in accordance with its functional purpose.

Ensuring a high level of products based on traditional technologies is not always possible. In this regard, more and more non-traditional technologies are used, the creation of which precedes the accumulation of achievements in basic and applied sciences.

Unlike traditional, such technologies are called "high", "science-intensive", "precision", "nanotechnology". These terms are used for equipment systems and technologies that provide processing with an accuracy of about 1 μm.

Integrated work processes of accelerated manufacturing of parts or their prototypes are an organic combination of computer technologies of information processing and three-coordinate modelling and modern methods of manufacturing.

This process, that is called **Rapid Prototyping (RP)**, allows to combine in time and space or extremely close the design and manufacture of a typical or single model or a part, reducing the time of their manufacture.

Peculiarities of **RP** processes:

– all prototypes or products are made by direct transition from 3D model to a product without use of usual technological equipment;

– the product or prototype is obtained not by separating the allowance from the workpiece, but by building, adding a layer of material;

– the build-up of material in the process of forming occurs in its transitional phase from liquid or powder to solid state;

– the manufacture of a structural element does not require forms or tools, which means that there are no problems associated with the operation of the tool in the formation of cutting, stamping, forging, etc.;

– no restrictions related to the complexity of the shape of the product (internal cavities, complex internal or external surfaces), the more complex the configuration of the product, the greater the advantage of the process;

– a sharp reduction in time (up to 30-70%) depending on the complexity of the part.

Such technologies are called generative, because the manufacture of products is performed not by a division, separation, but by building up (generation) of material.

The production of high complexity parts and configurations with the possibility of operative adjustment of their geometry with an accuracy of ± 0.2 mm and shortening the cycle of development and manufacture of new products is provided.

Implementation of RP processes is carried out in RP centres, the main components of which are: optical-electronic digital scanning system, 3D CAD – workplace, stereolithographic or other installation.

Various methods of RP-processes are used: by the method of material supply to the product, by the method of phase transition, by the properties of the used material, etc. (Figure 4.1).

For example, according to the most accurate and most common **method of stereolithography**, geometric reproduction of a part is carried out in layers (from 0.05 to 0.2 mm) by dispersion hardening of liquid material (photopolymerization) under the action of a computer-controlled laser according to the configuration of the reproducible layer.

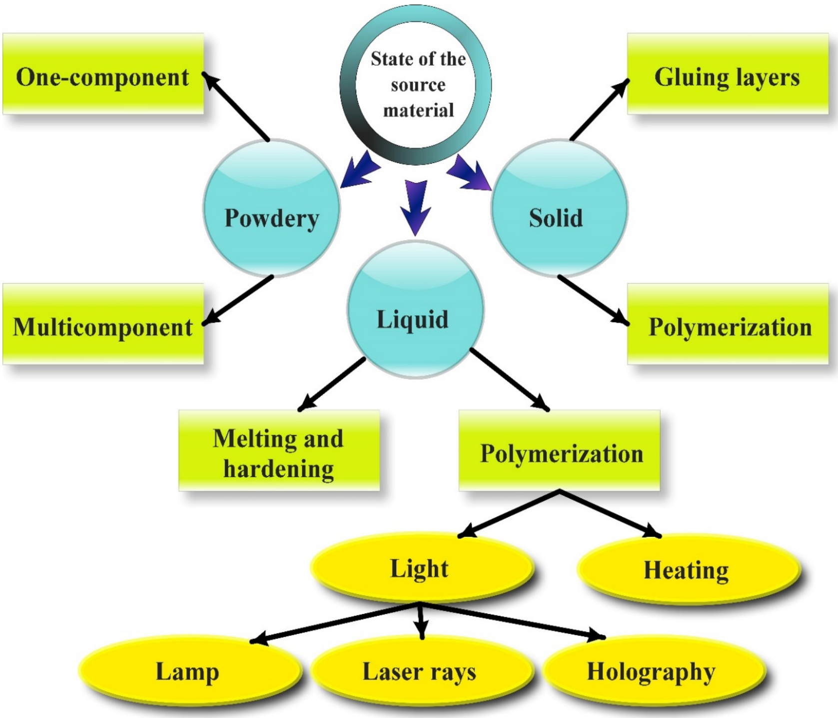

Figure 4.1 – Types of RP processes by the state of the source material and the type of impact on it

According to **the method of selective laser sintering**, the reproduction of a part is performed by local sintering of powders of polyamides, polycarbonates, polystyrene, alloys of nickel and bronze, etc., which are applied in layers on a moving platform.

According to **the method of multiphase hardening**, low-melting metal alloys or powder mixtures of high-quality steel, titanium, ceramics are melted in a special chamber and fed through a nozzle that distributes the jet of metal on the surface. The material hardens in a few seconds. The next hot layer partially melts the previous one, connecting them.

These methods do not exhaust the existing arsenal of RP technologies. There is a constant intensive search for new methods, combining them with already known, new materials and alloys, etc.

It is clear that the use of such technologies requires large investments.

Developed technical systems (products, TP, equipment) are subject to ecological examination. As a component of system technology, the examination includes the following elements:

– qualitative and quantitative determination of the negative and positive effects of the system on a person, his/her environment and life;

– determining the degree of danger of the system for humans and for the environment of its habitat and life;

– forecast of functioning of systems in extreme and emergency situations and definition of possible in these cases damage to a person and habitats of living and vital functions.

The result of the examination is a conclusion on the admissibility of the implementation or development of the system based on a comparison of its utility and losses from its use.

Ecologically oriented processes are those that in their preparation and implementation do not harm the environment: people, soil, fauna and flora, water and air basins, or this damage is reduced to the minimum possible level, which allows their self-healing.

Production, as a component of the system technology of PLC affects the state of the environment (Figure 4.2).

Economic losses consist of costs from emissions into the atmosphere, storage in reservoirs, withdrawal from use and future renovation of areas for storage and disposal of waste, etc.

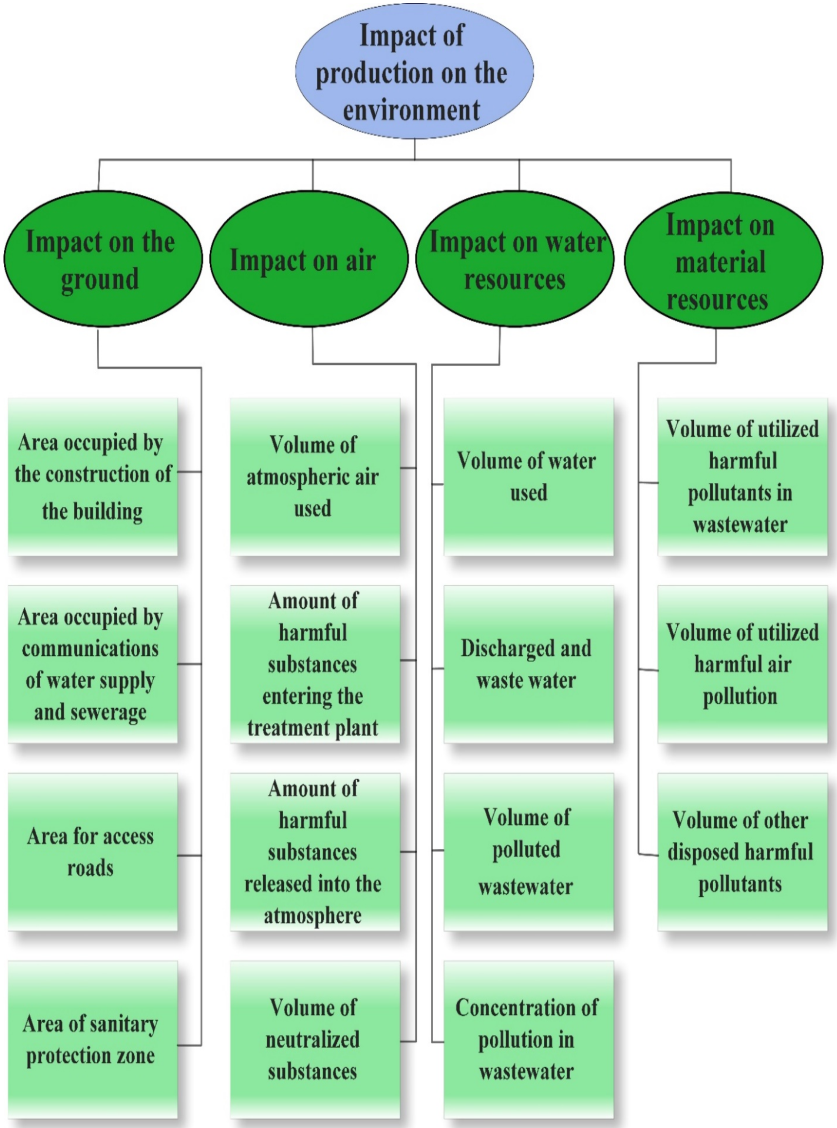

Figure 4.2 – Factors of production influence on the environment

Greening of technologies is called the improvement of technologies in order to improve their environmental performance.

The whole set of works should be carried out on the basis of ISO 14000 standards (in Ukraine ДСТУ ICO 14000).

The existing technology of using lubricating and cooling technological media (LCTM), which is traditionally used in metalworking, is one of the main pollutants of the environment.

Their spraying, spilling, concentration in rags and shavings, simply draining into the sewer cause irreparable damage to nature, pollute water bodies, soil, airspace. The volume of LCTM production is significantly large and reaches hundreds of thousands of tons, and the cost of using LCTM is 12-17% of total production costs.

In addition, up to 30% of severe and chronic skin diseases among workers are also associated with the use of LCTM.

Therefore, **modern directions** of ecological orientation of machining technology are harmonization of LCTM with nature protection requirements, reduction of volume of use or complete exclusion of LCTM from technological processes.

Harmonization of LCTM properties is carried out by its effective neutralization in various ways (thermal, physicochemical, biological).

Elimination of the possibility of harmful effects of LCTM on the body of workers is achieved by a set of preventive measures, personal protective equipment, strict observance of safety precautions.

Reducing the use of LCTM as a type of LCTM is achieved by minimizing its supply directly to the cutting area through a nozzle, cutting tool or various dosing devices.

Complete exclusion of LCTM from technological processes is realized by the use of so-called “dry” cutting and covering of working surfaces of tools by special antiadhesive films.

Minimization of lubrication and “dry” cutting due to their technical, environmental and economic advantages have a great potential for use and are a real alternative to cutting with a large amount of LCTM.

High-speed machining (HSM) by milling is one of the modern and important directions of technology development. The basic principle of HSM: small section of a cut (<10% of diameter of mills): speed of cutting and giving is 5-10 times higher than at usual processing cutting speed v = 1500-3000 m/min, speed of rotation n = 15000-50000 rpm, giving S = 40–60 m/min, tooth feed S_z = 0.01D.

The feed rate exceeds the rate of thermal conductivity, so the bulk of the heat (75%) is removed with chips, 20% − through the tool and 5% − through the workpiece.

It is possible to mill hardened steels without fear of loosening the surface layer.

Machine tools must have a height of geometric accuracy, high static and dynamic stiffness, temperature stability, free chipping, backlash-free movement of parts.

Tool – two-toothed cutters for free placement of chips in the grooves, large positive front corners. Use monolithic cutters made of fine hard alloys and with plates of cubic boron nitrite or polycrystalline diamonds.

Auxiliary tool – balanced (beating – a few microns on the cutting edge – a maximum of 10 microns).

Heat clamping chucks, heat-shrinkable scurvy, which can work up to 100,000 rpm.

The main task is to select all the gaps between the tool and the spindle.

Cooling – blowing air under high pressure with a lubricating mist. Lubricant – vegetable origin, not harmful to health. CAM – the system must ensure the uniformity of the removable layer, the smoothness of the tool, no abrupt change in the trajectory (otherwise, the failure of Pi).

The control program has a great complexity and volume of CAM − the system must have a high read speed for timely calculations and correction.

Advantages:

– reduction of the production cycle by 50%;

– increase in productivity;

– high quality of processing (as after grinding);

– increasing the life of the tool and the machine tool due to the uniformity of the cutting force;

– processing of hardened and difficult-to-process materials HRC 50 and above;

– processing of complex workpieces;

– for a load of 120 hours per week, the cost of HSM equipment pays off quickly.

The given some examples certainly do not exhaust all variety of new highly effective methods and means of the newest technologies which should be used in technological preparation of modern mechanical assembly production.

Among the fundamentally new ones there are vibration and shock-pulse cutting, cutting with advanced plastic deformation, cutting in a special technological environment, including in the environment of cooled ionized gases, cutting with the supply of lubricating and cooling technological medium under high pressure, etc.

A new level of finishing is achieved on the basis of tribotechnology. Due to the combined action of diamond-abrasive, deforming and antifriction tools, control of both geometric and physical-mechanical parameters of the surface is provided. This increases the resource, for example, friction pairs by 3… 10 times.

Workflows such as plasma-mechanical, hydro-beam provide high productivity, especially for the processing of composite materials and plastics, and environmental friendliness and fire safety due to the lack of temperature exposure.

Good results are achieved by combined grinding methods based on traditional and electro-erosion processing methods, a combination of ultrasonic and electro-erosion processing, various modifications of laser processing, etc.

4.3. Technological management

Now there is a new stage of technological development of production, which is to combine the technology of design, manufacture and operation of products in the systematic creation of new technological methods that would provide the necessary operational properties of products and their effective implementation.

Further intensification of manufacturing processes, resource-saving, high technologies and processes require non-traditional approaches to their development and implementation.

The increase in the range of products, reducing the time of their obsolescence, due to market dynamics, has led to the creation of new production systems that provide automated production of a wide range of products in small batches in accordance with specific consumer requests to ensure timely delivery.

This requires fundamental changes in both technology and organized production: the development of new technologies, accelerated renewal of existing processes, improving the organization of small businesses that can better focus on market demands and a radical change in management methods. The transition from traditional management of technological resources on the basis of experience or volitional decision to a modern system approach based on sound knowledge of the object of management, helps to increase the level and competitiveness of technology and products, improve the quality of management decisions.

In these conditions, a significant role should be played by a modern technology manager, whose main task is to organize people and technology into an efficient working system.

This takes into account not only the features of individual technological processes, materials, equipment, tools, modes, but also such limiting factors of market management methods as the degree of innovation and investment, the state of the environment, risk, etc.

Therefore, for the technologist-manager and organizer for effective management of both technological resources and individual object it is important to clearly and systematically present and identify patterns and trends, properties of the control object, to flexibly respond adequately to rapidly changing and sometimes unpredictable market situation.

Management of the introduction of technological innovations in the technical and production sphere, enrichment and protection of the technological potential of the enterprise, monitoring and other types of technological activities, including the competence and experience of employees are called **technological management**.

Management provides acceleration of introduction of the newest technologies, increase of their efficiency and constant growth of new technological knowledge.

The main functions of technology management are:

– stimulation of research and technological developments;

– use of internal and external factors of technology development;

– determining the optimal time to start using new technologies;

– ensuring the sale of new technologies in the markets;

– management and control of research and technological development;

– development of programs of technical re-equipment of production;

– coordination of actions of various divisions (research, production, marketing, personnel, etc.) for the decision of technological tasks;

– strengthening the innovative potential of industries;

– optimal choice of ways to obtain the necessary technologies and experience;

– technological training of employees;

– patent protection of existing technological potential, etc.

Technological management includes both general functions inherent in the management of any field, and specific functions that reflect the specifics of technological resource management

The set of general functions of technological management includes: goal setting, planning, development and decision-making, organization of decision execution, operational impact on the object of management, employee motivation, control of decision execution and employee activity.

Specific functions of technological management (Figure 4.2): inventory and assessment of technological heritage, optimization of technological processes, enrichment and protection of technological potential, technological monitoring.

Technological management does not allow the loss of valuable opportunities for the enterprise.

CONCLUSIONS

1. The system process aimed at the qualitative improvement of new products, technologies, organizational forms is called innovation.

2. There are technical, technological, socio-economic and managerial innovations.

3. The ability to innovate is characterized by the readiness of all types of enterprise resources.

4. There are technical, organizational, financial, and human capacity for innovation.

5. The life cycle of an innovation consists of the stages of the product life cycle.

6. There are traditional, opportunistic, imitational, dependent and offensive strategies of enterprise innovation policy.

7. The life of the business world, market relations, fierce competition require systematic, purposeful development and implementation of innovations.

8. Design preparation of production involves the design of a new product or modernization of an existing one, as well as the development of design projects and re-equipment of the enterprise or its individual units and consists of a number of stages.

9. Technical task – is a complete list of all technical, operational and production requirements and restrictions that the created product must meet, i.e., its functional (official) purpose.

10. Functional purpose of the product – the most precise and clearly defined set of functions for which the product is intended.

11. The functional purpose consists of a general part (main function) and clarifications, which clarify it as much as possible and specify the numerical values of indicators with tolerances.

12. To ensure the safety and efficiency of the product, test samples are tested.

13. Functional design is the process of creating the principle of operation of a technical object as a system of interconnected simple functions. The functioning of the technical system is the implementation of a function that meets the conditions of a particular situation.

14. The formation of functions is performed according to certain rules and requires the division of the object into independent elements – the material carriers of functions.

15. The process of transition from a functional to a technical description of an object is called the technical design.

16. Each TS (machine) is a set of elements: parts, connections, mechanisms and components united by different types of connections.

17. Each machine, as well as its separate element carries out the functional purpose by means of a number of surfaces belonging to its details.

According to their functional purpose, they are divided into four types: executive surfaces, main and auxiliary bases and free surfaces.

18. All types of connections are laid in the TS in the process of its creation in the form of dimensional connections.

A set of calculation and analytical procedures for identifying and constructing diagrams of dimensional connections of TS or its part is called dimensional analysis, which has a well-developed functional structure.

19. TS can be represented as a set of coordinate diagrams built on the main and auxiliary databases of parts with superimposed dimensional relationships.

The dimensional connections of TS and its components form a system of spatial dimensional chains.

20. Technological preparation of production provides technological readiness of the enterprise for release of a new product.

21. Technological processes must be developed taking into account a set of principles for building technical systems.

22. The method of modular technology is based on the development of TP from a set of unified design and technological solutions, each of which provides the manufacture of a certain structural element of the part. However, this requires the creation of clear and unambiguous relationships between the modules of the surfaces of the part and technological processes, the creation of a database of TP for processing SM, as well as modular technological equipment.

23. An indicator of the comparative effectiveness of different options of TP are the consolidated costs of options.

24. Development of the technological process of machining is a difficult complex multifactor technical and economic task, the purpose of which is to ensure the required quality of the part with proper productivity and efficiency of production.

25. A clear definition of the functional purpose of the machine, the specification of its functions is the basis for sound development of manufacturing processes of all its parts.

26. The technological process is built by considering the part as a set of interconnected elementary surfaces, for which the elementary technological processes of their processing are determined, from which technological operations are formed and their sequence is determined.

27. The more radical technological innovations, the higher the commercial risk, which reduces the compliance of innovations with consumer requirements.

28. TP improvement can be done by improving the existing TP for a given product, adapting the existing TP for another product and developing a new TP for a new product.

29. There is a great variety of new highly efficient methods and tools of the latest technologies that should be used in the technological preparation of modern machining.

30. Management of implementation of technological innovations, provision and protection of technological potential of the enterprise, monitoring and other expenses of technological activity is called technological management which reflects specificity of management of technological resources.