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METHODS OF DESIGNING PACKAGING PRODUCTION BY GRAVURE PRINTING

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Modern methods of designing and organising industrial production systems are considered. Attention is focused on the most important factors of design, organisation and optimal production management. This ensures the most effective use of labour, material and financial resources of the enterprise, reducing the cost price and improving the quality of products. The main goals and methods of production organisation and directions of work related to their implementation, which can be used in the design of packaging enterprises, are described. The characteristics of production types and the relationship between functional subsystems of design and production organisation are given. Modern forms of production organisation are described. The design of modern packaging production is characterised by an integrated system covering all its stages - research, design, construction, technological preparation, organisation of production, and production of packaging products.

Keywords: *methods, design, forms and types of organisation, packaging, gravure printing, production.*

Problem statement. In recent decades, the packaging industry has undergone significant positive changes and achieved intensive development. This was facilitated by progressive technologies, computerization and automation of processes, which rapidly entered packaging production, as well as the need for various packaging to meet the needs of industry and the population. The complex of measures aimed at the rational combination in space and time of technological processes with the elements of the system of modern packaging production is increasingly oriented towards rational methods of labour organisation. All this contributes to increasing production efficiency, improving the use of material and human resources, and ensuring product quality following global standards and consumer requirements[1-4]. Manufacturers of packaging products face the primary task of rational organisation of production. Their actions are aimed at integrating a complex of disparate components of the production process into a complete and highly efficient production system, all elements of which are optimally combined according to their functions and goals. The tasks of production organisation and optimal management are the most important factors in the development of the packaging industry as one of the important segments of the acceleration of scientific and technical progress. After all, they ensure the most complete and effective use of labour, material and financial resources of the enterprise, reduction of the cost price and improvement of

product quality, an increase of labour productivity and production efficiency, significant reduction of the duration of the “methodology - design - production - implementation” cycle. Therefore, it is urgent to solve the problem of choosing rational methods of enterprise design for the production of high-quality packaging from various materials [5,6].

Analysis of recent research and publications. As is known, the main purpose of production organisation is to ensure high economic and social efficiency of enterprise functioning. At the same time, with its general goal – the production and sale of material goods to meet the needs of customers – the enterprise strives to achieve many separate goals: economic, social, technical and technological, environmental, etc. The **production organisation system** is a set of organisational forms, methods and rules, the implementation of which ensures the rational functioning of the elements of the production system and their interaction in the production process [7-9].

Researchers [10] single out individual functions of organisational activity during the formation of the production organisation system, grouping them into subsystems. This targeted integration approach involves the division of production into subsystems based on the set of elements and the functions they perform. The classification given in Table 1 combines the directions of production activities, the main goals of the organisation and the methods of realizing these goals.

However, this classification of productions has a generalized nature and does not reflect the specifics of printing enterprises intended for the production of packaging.

The authors [11] distinguish three types of production organization:

- 1) element-by-element – all elements of the production process must correspond to each other, which is the starting point of its organisation;
- 2) spatial – related to a certain level of organization of workshops and areas and the corresponding level of the production structure of the enterprise;
- 3) time section of production organisation - the optimal combination in time of the start and end of individual production processes that are connected.

It is difficult to disagree with such a division, but the choice of the production organisation method is important. According to the definition, the production organisation method is a way of carrying out the production process, a set of means and methods of its implementation. Some authors elaborate on this concept and believe that “methods of production organisation are a set of techniques and operations for manufacturing products or providing services, which are performed with a certain combination of elements of the production process” [12]. Other researchers define the method of production organisation as “a certain way of carrying out the production process, which involves a set of appropriate measures and techniques for its implementation”, focusing on the choice of options for the implementation of any production [13]. For the production organization method, the interrelationship of the sequence of technological process operations with the order of equipment placement and the degree of continuity of the production process is particularly important.

Table 1

The main goals of the production organisation and directions of work for their implementation

Areas of activity	The main goals of the production organization	Directions of work on the realization of the goals of the production organization
1	2	3
Production and supply of products to consumers	Satisfaction of consumer demand, and supply of products under orders and contracts. Implementation of production plans for the nomenclature, assortment and quality of products	The organisation of marketing research; operational production planning; production processes; material and technical support of production; sales and marketing of products
Improving the quality and ensuring the competitiveness of products	Development of new types of products and improvement of manufactured products following market requirements. Ensuring the stability of production of high-quality products, reducing shortages	The organisation of marketing research; production preparation and development of new types of products; work on product quality assurance and technical control organisation; metrological support
Rational use of production resources	Increasing the productivity of employees. Improving the use of fixed assets and production facilities. Reduction of the duration of the production cycle and inventories of goods and material values. Rationalization of information flows	The organisation of the work of employees, the functioning of work tools, and the movement of labour objects in production. Organisation of information flows
Scientific, technical and organisational development of production	Improving the production and technical base of enterprises and raising the level of production organisation	Implementation of assembly works and executing plans for technical development and improvement of production organisation
Improvement of economic relations at the enterprise	Creation of conditions to ensure the unity of the interests of society, the collective and its members	Granting economic independence to divisions of enterprises and establishing settlement relations between them
Social organization of the enterprise team	Creation of conditions for improving the quality of working life and intensification of creative activity of employees	The organisation of employees' work. Involvement of them in solving tasks of the organization and production management

There are three methods of production organization: non-flow (single); flow; automated [13]. Flow production involves the processing of work items along the established shortest route with a fixed time. Its main feature is a stable range of homogeneous products. In flow production, the main principles of highly efficient organization of the production process and, above all, the principles of continuity are most fully expressed.

Flow methods are used in conditions of production of significant volumes of products for a long time, mainly in mass and large-scale production. Flow production is a higher form of implementation of mass production with such characteristic features as the division of the technological process into operations and their fixation by specific workplaces; precisely defined duration of technological operations; placement of workplaces in the sequence of the technological process of manufacturing the product (subject principle of placement). The main structural link of flow production is the flow line. The flow lines are characterized by the number of workplaces, speed and takt, that is, the time interval during which the products (selection or semi-finished product) are manufactured. Indicators of loading workplaces, which determine the expediency of using flow production, are important in the design of production facilities. It is considered expedient to have a lower limit of 80-85% workload in mass-flow production and 70-75% in serial-flow production.

Automatic flow lines are popular - a set of machines that automatically, without human intervention, perform specified technological operations, covering logistics transportation, quality control, product storage, etc. The role of the employees is limited to supervising the debugging and control process.

The method of production organisation characterizes the degree of compliance with the basic principles of rational organisation of the production process, and the degree of specialization and the scale of production determine the type of production organisation. Therefore, the following types of production organization are distinguished: single, individual, serial and mass. A characteristic feature of the division of production into organizational types is the level of specialization of workplaces, which is quantitatively measured by the coefficient of consolidation of operations K_i and shows the ratio of the totality of operations for the production of a unit of production to the total number of workplaces. The authors [14] present the following general classification of production types and their characteristics (Table 2).

In general, all these methods of production organization can be applied to printing enterprises for the production of packaging, which have most of the characteristic features. However, the specifics of manufacturing packaging products require an in-depth study of production organization methods, in particular at the stage of their design.

The aim of the research. The purpose of the work was to analyse the methods of designing printing productions and choosing rational forms of organization of technological processes to ensure the efficiency of their functioning in the process of manufacturing packaging products of appropriate quality.

Presentation of the main research material. Undoubtedly, packaging is an important tool of the manufacturer, the “face” of the product. The effectiveness of sales and the amount of profit depends on how carefully the images and inscriptions on the package are thought out. Accordingly, packaging production must take into account both the technological capabilities of modern printing equipment and the requirements of consumers. The design of modern productions focuses on the types of designed products. Today, consumer, transport, production and special packaging are distinguished. Accordingly, the design of consumer packaging should take into account the requirements

of consumers and the goods for which it is intended. Transport packaging is intended for the transportation of various goods, therefore, when designing productions, it is necessary to pay attention to the influence of external factors, which depend on the durability of packaging, containers, and especially food, pharmaceuticals, drugs, etc. The design of production packaging, which is used in factories and workshops for various internal processes, requires its own characteristics. A separate group is made up of special packaging, the design of production of which takes into account the specific requirements of goods, etc.

Table 2

Characteristics of production types

Characteristics	Type of production		
	Single	Serial	Mass
1. Nomenclature of manufactured products	big	limited	small
2. Sustainability of the nomenclature	absent	significant	significant
3. Issue volume	small	average	big
4. Consolidation of operations by workplace	absent	partial	complete
5. Applied equipment	universal	specialized	special
6. Applicable tools and technological equipment	universal	universal and specialized	special
7. Qualification of employees	high	average	mostly low
8. Product cost	high	average	low
9. Production specialization of workshops and departments	technological	mixed	substantive, detailed
10. Technological process	route	typical	operating
11. Production structure of the enterprise	difficult	moderately difficult	simple
12. Labour intensity of products manufacturing	high	average	low
13. Specialization of workplaces	$K > 40$	large series: $1 < K \leq 10$ average series: $10 < K \leq 20$ small series: $20 < K \leq 40$	$K = 1$

Any type of packaging product is decorated with a certain printing technique: offset, screen, flexographic, digital, or gravure printing. One of the advanced technologies, Full HD Flex is an alternative to rotogravure printing. It allows the reproduction of screens with high resolution in combination with significantly improved colour transfer of solid tone and provides the widest range of tonal gradations. Improved mechanical properties and precisely defined surface of halftone dots allow to achieve consistently high print

quality, including for large runs. HD flex + varnish provides high-quality flexographic printing and, due to the objects highlighted with varnish, gives the packaging a unique and more expensive appearance. Selective varnish focuses attention on selected elements that need to be emphasized in layouts. “Cold Seal” – cold welding – an innovative technology without the use of high temperatures during packaging. This type of technology is used for Flow-Pack type packaging, as well as packaging products that should not be exposed to high temperatures. First of all, these are confectionery products made of chocolate or with its content (chocolate bars, large chocolate candies, waffles, cookies and rolls in chocolate, glazed curds). Cold welding is used in most cases for such products. Gravure printing technology, thanks to the high screen ruling and printing with metal rollers provides the possibility of uniform ink transfer while working at high speeds with a wide range of colour reproduction of images on different packaging materials, which makes it unique for obtaining high-quality printing. The advantage of such printing is the possibility of printing in one run, Cold seal (cold varnish), selective varnishing, as well as the possibility of manufacturing Retort packaging for sterilization in an autoclave.

Let’s consider methods of designing packaging production using gravure printing for decoration. As part of the production process, there are groups of processes that differ in content, principles and methods of organisation. Accordingly, several subsystems are distinguished within the system of production organisation, which take into account the peculiarities of these production processes. The complex of subsystems include functional subsystems: organisation of production preparation and development of new product release, organisation of main production processes, organisation of production infrastructure, organisation of works to ensure product quality, organisation of material support of production, and organisation of product sales (Fig. 1).

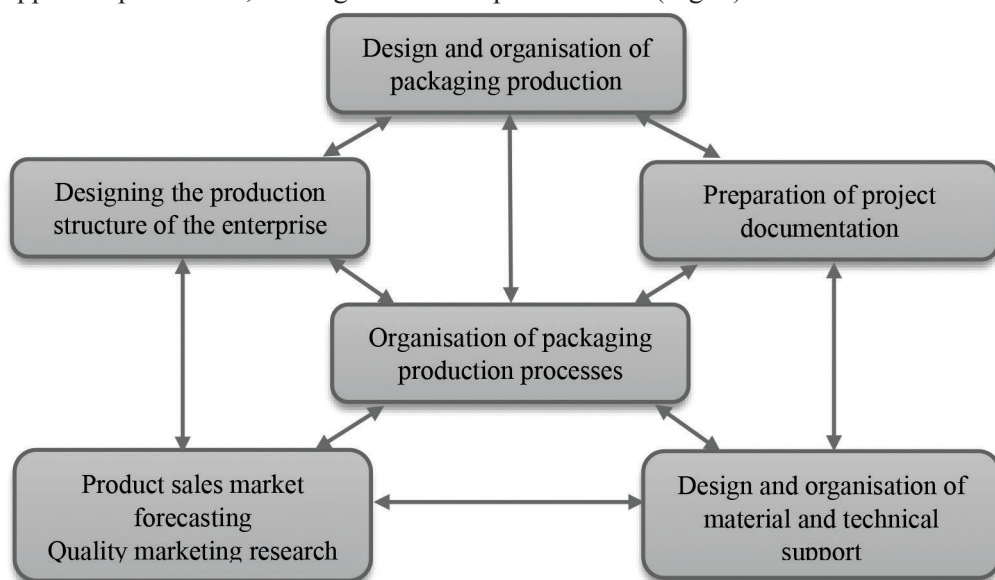


Fig. 1. Interrelationship of functional subsystems of design and organisation of packaging production

The organisation of production at the enterprise involves certain levels: at work-places (optimal combination of work tools, work items, workforce); organisation of work between production areas; the organisation of production processes performed by workshops is aimed at their functioning as a single entity. It should be taken into account that the organisation of any production process is carried out by the form most characteristic of this or that production; the type of production, which reflects its specific features; the method of production organisation, determining the “mass” or scale of product production per unit of time.

Therefore, when designing production facilities, it is necessary to take into account the characteristics of printing equipment, flow lines, its dimensions, the number and volume of products planned for production, and the number of service personnel (workers, engineering and technical workers of various ranks, etc.). When designing, it is also necessary to take into account the sequence of execution of technological processes that are planned for the manufacturing of products: a room for preparing the layout of the packaging and developing an exclusive packaging design; premises for printing on packaging and its decoration using appropriate modern technology, including lamination, embossing with or without foil, varnishing, flocking, die-cutting, etc. Separate rooms should be allocated for the placement of materials, semi-finished products, and finished products. In addition, when designing production facilities, laboratories should be designed to control various characteristics of materials and finished products, which should be equipped with modern control and measuring devices. The company conducts control of semi-finished products at each stage of the production process: control of pre-press preparation of original layouts, materials for the production of printing forms, production of semi-finished products, resistance of packaging to aggressive environments, etc. The design takes into account the use of production equipment, technologies and materials that affect or ensure environmental safety, under the best global standards, the rational use of natural resources, the reduction of the amount of production waste and their timely disposal. Modern design of packaging production should be oriented towards environmental policy related to the supply of appropriate components and materials, design, development, and production of environmentally safe products by the enterprise.

The general scheme of the technological production system includes the analysis of target functions, forecasting (technology, quality, product sales market, technology development), and design of technological equipment. In addition, management systems for the organization of production, and forms of specialist training, taking into account production conditions, are being designed (Fig. 2).

Such forms of organization as concentration, specialization, cooperation, combination and diversification, which are characteristic of modern market conditions, can be used for the design of packaging production. Thus, concentration is the process of focusing the manufacturing of products on a limited number of enterprises and in their production divisions. The level of concentration depends, first of all, on the volume of packaging production, the power of machines, units, devices, flow lines, and the size and number of technologically homogeneous productions.

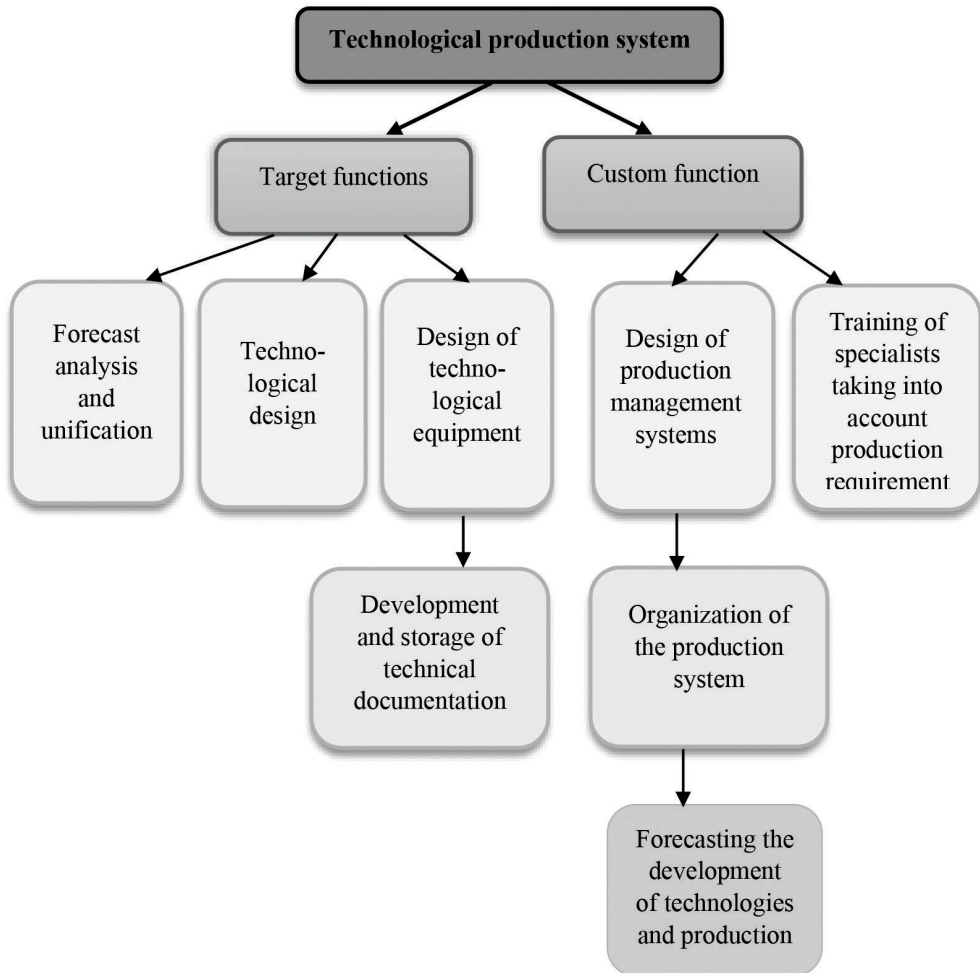


Fig. 2. General scheme of the production design system

The design of packaging production is characterized by specialization, which shows the concentration at the enterprise and in its production divisions of the production of homogeneous, one-type products, for example, packaging made of cardboard, corrugated cardboard, film materials, metals, glass, polymer materials, etc. When designing, it is necessary to distinguish between technological, subject and detailed specialization.

Technological specialization involves the separation of enterprises to perform certain operations or stages of the production process (for example, prepress, and printing processing). Subject specialization involves the concentration of production at the enterprise of finished types of packaging products from the same type of materials (for example, packaging from cardboard or film materials, etc.). A type of subject is detailed specialization, based on the production of semi-finished products. In the process of production design, it is important to provide for compliance with the conditions of standardization, unification and typification of processes. In the conditions of competition,

in several cases, the diversification of production, which allows expanding the product range, is more attractive for the enterprise. Specialization in the production of a limited range of products, aimed at meeting clearly defined market needs, is characteristic of relatively small enterprises. When designing packaging production, cooperation is important, which involves production connections of enterprises, workshops, and sites that jointly participate in the production of products. It is based on detailed and technological forms of specialization. It contributes to the full loading of production capacities and the elimination of problem areas and ensures the improvement of the results of the enterprises as a whole. Combination methods involve the joining of successive stages of production; integrated use of raw materials; joint processing of waste, etc.

The design of modern packaging production is characterized by complex automation as an integrated system covering all its stages - research, design, technological preparation, organization of production, and manufacturing of products. High requirements for packaging must be met in the conditions of rapid change of products and reduction of their serialization, expansion of the nomenclature while increasing the total volume of manufactured products, and shortening of the time from the receipt of the application to the manufacture of a new product. Therefore, production must be flexible, i.e. able to be dynamically restructured to produce new products without significant costs.

The concept of flexible production requires a new approach to the design of technological processes and production areas. The problems of flexible integrated production are solved with the involvement of the principles of group production, the economic and organizational basis of which is the subject specialization of departments and workshops, and the technological component is the unified group form of construction of technological processes.

The flexibility of the system state is in its ability to function successfully under various external and internal changes. External changes are associated with the appearance of a new assortment of products, the use of more advanced technology, and the improvement of the qualifications of service personnel. Internal changes or problems are determined by the presence of interruptions in the management system of technological and material flows, a decrease in the quality of processing.

Conclusions. Thus, the methods of modern production design should primarily be based on the latest scientific and practical achievements of the packaging industry and be determined by the principles of system analysis, which are laid down in the creation of methodical, mathematical, software, linguistic, information and technical support, which include the principle of system unity, decomposition, modality, openness, standardization, ergonomics, integration.

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МЕТОДИ ПРОЄКТУВАННЯ ВИРОБНИЦТВА ПАКОВАНЬ СПОСОБОМ ГЛИБОКОГО ДРУКУ

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Розглядаються сучасні методи проектування та систем організації промислових виробництв. Акцентується увага на найважливіших чинниках проектування, організації та оптимального управління виробництвом. Адже саме вони забезпечують найбільш ефективно використання трудових, матеріальних і фінансових ресурсів підприємства, зниження собівартості та підвищення якості продукції. Описані основні цілі та методи організації виробництва, напрямки роботи щодо їх реалізації, які можуть бути використанні в проектуванні пакувальних виробництв. Наведена класифікація виробництв, яка виокремлює їх за видом діяльності та основними цілями організації. Описані ймовірні напрями роботи щодо реалізації цілей організації виробництва. Наведено характеристики види виробництв та взаємозв'язок функціональних підсистем їх проектування та організації. Виокремлено три види організації виробництва: елементний (усі елементи виробничого процесу відповідають один одному); просторовий (пов'язаний з певним рівнем організації підрозділів та відповідним рівнем виробничої інфраструктури підприємства); часовий розріз організації виробництва (оптимальне поєднання в часі початку і закінчення окремих виробничих процесів, пов'язаних між собою). Описані сучасні форми організації виробництв. Тому розрізняють такі типи організації виробництва: одиничний,

індивідуальний, серійний і масовий. Характерною ознакою поділу виробництва на організаційні типи є рівень спеціалізації робочих місць, який кількісно вимірюється коефіцієнтом закріплення операцій K і показує відношення сукупності операцій для виготовлення одиниці продукції до загальної кількості робочих місць. Розроблена узагальнена схема системи проектування виробництв. Для проектування сучасних пакувальних виробництв характерна інтегрована система, що охоплює всі його стадії - дослідження, проектування, конструювання, технологічну підготовку, організацію виробництва, виготовлення пакувальної продукції

Ключові слова: *методи, проектування, форми і типи організації, пакування, глибокий друк, виробництво.*

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