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ЗМІСТ

І. ГАЛУЗЕВЕ МАШИНОБУДУВАННЯ. МАТЕРІАЛОЗНАВСТВО. ПРИКЛАДНА МЕХАНІКА

ІІ. ЕЛЕКТРОЕНЕРГЕТИКА, ЕЛЕКТРОТЕХНІКА ТА ЕЛЕКТРОМЕХАНІКА

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MODEL OF OPTIMIZATION OF FUNCTIONING OF MODERN POLYGRAPHIC AND PUBLISHING COMPLEXES

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Analysis of known methods and modern equipment for printing and publishing (sheet rotary machines, roll machines, flat-printing and platen machines for flat impression block, relief, intaglio and digital printing) is conducted in this article. In a result of the analysis article authors have to make a conclusion, that most prospective equipment for automated printing and publishing complexes are: high-performance sheet and roll machines, in that number crucible, flatbed and rotary three-cylinder machines and also single-layer and multi-layer sectional machines, digital laser and inkjet machines. Authors propose a mathematical model of an automated optimization system of functioning of modern printing and publishing companies. In the model are used databases with information about orders (quantity, volumes, content, terms of orders fulfillment, admissible prime value and characteristics of quality of finished products), production capacities of printing and publishing enterprises of the region (destination, quantity and productivity of equipment, its technological capabilities, loading with other orders, service life), as well as additional data about value of transportation and storage of ready products, the possibility and feasibility of transferring orders to other enterprises and more. The elaborated model can be used as a basis for creation of a computer program for automated synthesis and analysis of functioning optimization of modern printing and publishing companies in the region to improve their efficiency, as well as for help customers of printing products in selection of optimal variants of orders fulfillment. The modeling results will allow to rationalize the utilization of enterprises capacity, to reduce the value of finished products, to ensure their proper quality, to avoid of disruptions during of peak periods of enterprises loading, to reduce the value of repair and maintenance of the complex equipment.

Key words: *mathematical model, computerized system, optimal fulfillment, printing, publishing complex, databases, efficiency characteristics.*
F. 5. Fig. 2. Ref. 9.

1. Problem formulation

The printing and publishing industry plays an very important role in the activities of enterprises, which produce books, magazines, newspapers, advertising, labels, as well as in general in business and everyday life. Demand for printed products is constant, but in some periods it can increase sharply. This happens, for example, during the preparation and conduct of election campaigns, promotions and holiday sales (New Year, Christmas, March 8, "Black Friday"). It is likely in such situations that prices for printing services will rise. Besides in these periods can take place some disrupts of timely execution of some orders. To prevent this, it is advisable to use automated systems for optimal distribution of orders between printing and publishing companies in the region to ensure timely and quality orders fulfillment, with material expenses, which do not exceed of average market values for the region, without equipment overloading and without of any work failures [1, 2].

For reliable operation of automated systems there is necessary to collect and process vast amounts of information about orders to be executed in the near future (number, scope, content and timing of each order, admissible value and quality of finished products), information about capacities of printing and publishing enterprises of the region (destination, quantity and productivity of equipment, its technological capabilities, loading with other orders, service life), as well as additional data about value of transportation and storage of finished products, possibility and feasibility of orders transferring to other enterprises, optimal time reserve) [3].

2. Analysis of last researches and publications

At the Fig. 1 is presented a classification of printing machines, which reflects the basic principles of their construction [3].

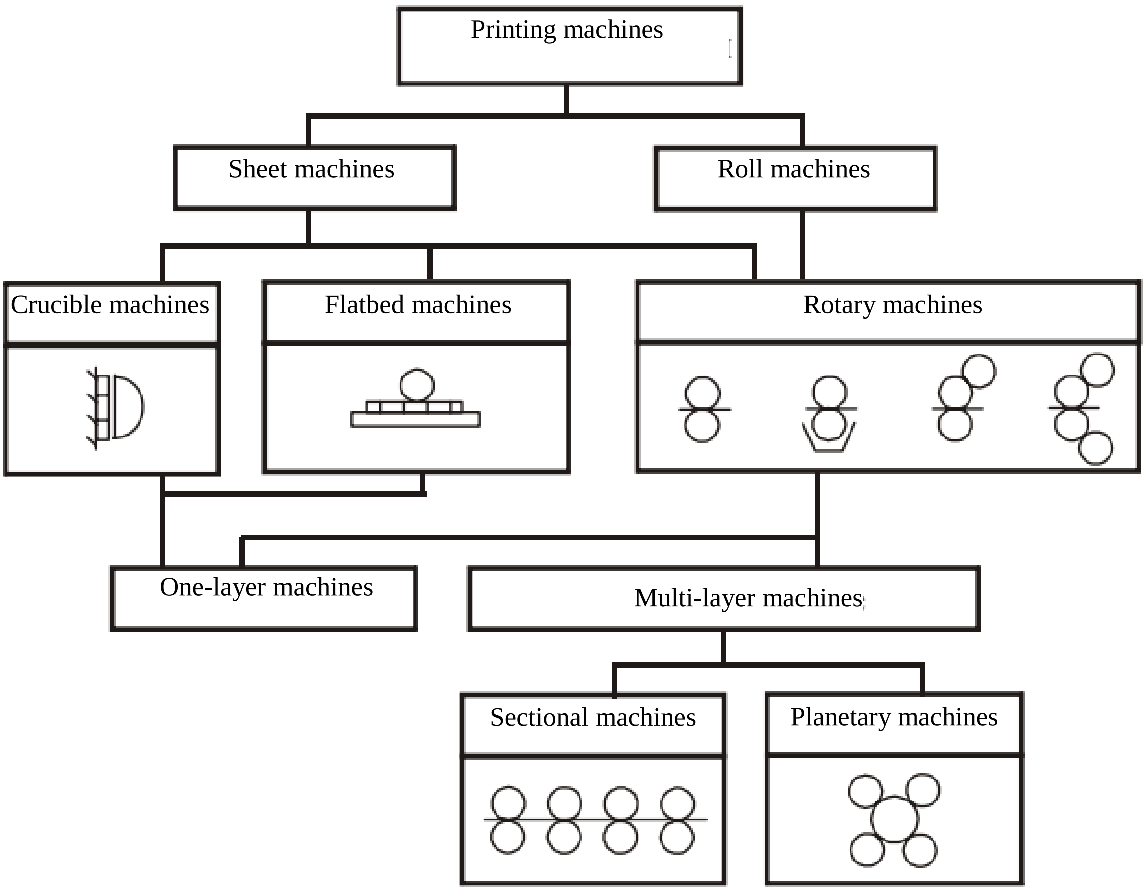


Fig. 1. Classification of printing machines

Depending from kind of the material for printing and from method of its feeding (ribbons, unrolled from coil or sheets, which are fed from a bundle) the printing equipment is divided at rolled and sheet machines.

The next feature classification is form of their printing surface. Executive elements of the rotary printing machines have form of a cylinder. Executive surfaces of printing form of the flatbed machines are located in a plane and an pressing effort creates by a cylindrical surface. Both printing surfaces of the crucible machines are flat.

Depending from the number of ink colors for printing, distinguish multi-layer and single-layer machines. Almost all modern flat-bed and crucible machines are related to the single-layer automatic machines or to the semi-automatic machines for processing of sheet materials. Rotary machines provide automatic printing on sheet or on tape materials. At the same time, both single-layer and multi-layer machines are widely used. Double-sided rotary machines have also wide distribution. Material in these machines is printed simultaneously or sequentially from both sides.

Multilayer sectional machines make up from standard single-layer printing units. Planetary multi-color machines contain one main printing cylinder and several more additional cylinders, located around of main cylinder (Fig. 1).

Flat bed and crucible machines realize relief printing method, rotary machines can work in accordance with relief, offset or intaglio printing methods [4]. Roll-fed rotary machines have the highest operating speed since most of their mechanisms provide continuous unidirectional movement of material with a constant speed. Crucible and flat-bed machines are equipped with a cycle mechanism and with massive printing apparatuses. That leads to significant inertial loads, to decrease of their speed capabilities and courses the lowest speed of printing of this equipment. Sheet-fed rotary presses occupy an intermediate position between web rotary and flat-bed presses in terms of their speed capabilities.

The printing machines can be compared with each other in terms of utilization rates of a cycle – K_c and of utilization of the surface of the printing cylinder – K_d , which can calculate with help of the formulas [3]:

$$K_c = \frac{t_p}{T}, K_{cyl} = \frac{l_{cyl}}{\pi \cdot D_{cyl}} \cong \frac{L_{max}}{\pi \cdot D_{cyl}},$$

where t_p – sheet printing time; T – duration of a kinematic cycle; L_{cyl} – length of a working part of the cylinder surface; D_{cyl} – diameter of the printing cylinder; L_{max} – largest sheet size in the direction of its feeding.

For roll-fed machines $K_c = K_{cyl} = 1.0$; for sheet machines $K_c = K_{cyl} = 0.60\text{-}0.85$; for flat-bed machines $K_c = 0.2 - 0.3$ and $K_{cyl} = 0.3\text{-}0.6$; for crucible machines $K_c \leq 0.1$.

Last time digital printing machines become widespread. This equipment is based on various physical and chemical processes. The vast majority of the digital printers designed for high-performance printing are based on electro-photographic and related technologies. The main types of the digital printing equipment are laser and inkjet printing machines.

In recent years, manufacturers of an electro-photographic dry toner equipment (laser machines) have made significant progress in expanding of the range of printing materials by developing printing mechanisms with transfer of toner through intermediate surfaces. The differences lie in the methods of forming of a latent image, principles of development, technological modes, and the like.

The second group is formed by inkjet technologies, which are realized mainly in large-format printers and in web digital machines. Inkjet printing technologies are divided into two groups: with continuous ink supply and with intermittent ink supply (drop-on-demand).

Based on the results of the fulfilled analysis, it can be concluded, that the regional automated printing and publishing complexes should include as a main equipment the modern high-performance sheet and roll machines (crucible, flatbed and rotary three-cylinder presses, single-layer and multi-layer sectional presses for high-volume printing), as well as laser and inkjet printing machines provide high-performance and high-quality low-volume printing. For such complexes can be developed a mathematical model (presented lower in the article) and a computer program of optimal functioning. At the same time, the use in the complexes of the planetary machines is impractical due to their high complexity and value.

In most cases the production of printed products includes the following three or four separate, but interrelated processes [4]:

1. Processing of a textual and graphic information, preparation of so called originals and artworks, which must be reproduced with help of polygraphic methods. A result of this process are negatives or transparencies, which contained information from printing plates.

2. Manufacturing from the negatives or the transparencies of a set of printing forms necessary for the reproduction of the information.

3. Printing of a circulation (reproduction of the information), that is, obtaining from the printed forms of a certain number of identical printed sheets, notebooks or other printed products.

4. Realization of finishing (varnishing of prints, etc.), stitching or stitching and pallet processes (making brochures, books from separate elements).

The first two processes are often referred to as preparatory stages, the third and fourth processes can be fulfilled as a single process at automated lines.

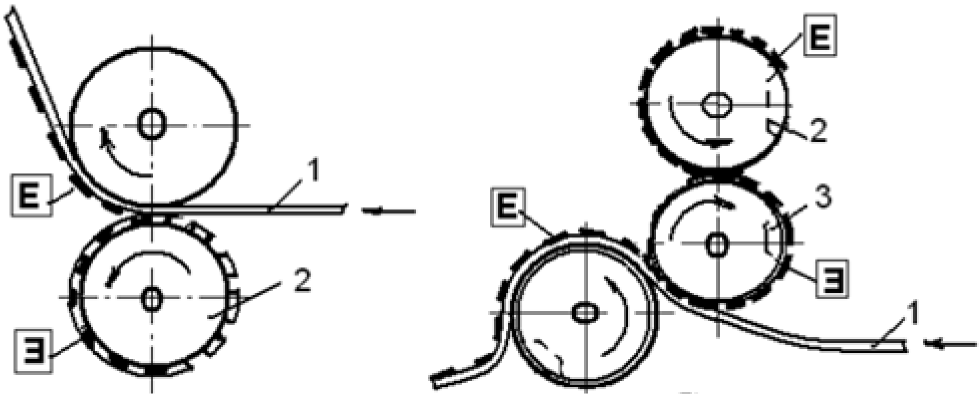
In the printing industry are used three main (classic) types of printing: flat impression block, relief printing and intaglio. According to the generally accepted classification, they differ from each other by principle of separation on printed forms of printed and blank elements [4].

A flexographic printing is a type of the relief printing, which uses spring-elastic printing plates and quickly set low-viscosity inks. A flexographic printing plate is a one-, two- or multi-layer elastic form of the relief printing, made from elastomers (for example, rubber) or from photopolymers.

The transfer of the ink image from various printing plates to the printing material (paper) is usually carried out as a result of the generated pressure. In this case, the printing plate is fixed on one cylinder, and the other connecting cylinder creates the necessary pressure on paper (Fig. 2, a). In the process of printing, ink can be transferred to printed material through an intermediate spring-elastic plate (Fig. 2, b) [4].

In the first case (Fig. 2, a), the paper 1 is directly in contact with the printing form 2 and the ink, as a result of the generated pressure, passes from the printing elements of the form directly to the paper, forming an imprint. In this case, the image on the form must be reversed (mirrored). This ink transfer is widely used in relief printing and in intaglio printing techniques and much less frequently - in flat impression block printing. These printing methods have full names "straight relief printing", "straight intaglio" and "straight flat impression block". But in practice, the word "straight" as usually does not used.

In the second case (Fig. 2, b), the printing form 2 in the process of printing collides with the spring-elastic (rubber-fabric) plate 3, which takes on the ink from the printing elements of the form, and then transfers it to the printing paper 1. In this case, the image on the printing form should be straight (on the rubber-fabric plate - reverse, on paper - straight). This indirect printing is called offset method. It is used primarily for flat impression block, less often for relief printing and even less often for intaglio printing.



a) *b)*

Fig. 2. Schemes of ink transfer from the printing plate to the paper:
a – straight printing; b – offset printing;
1 – paper; 2 - printing form; 3 - spring-elastic (rubber-fabric) plate

If the indirect method of ink transfer is used in relief printing, then such printing is called relief offset, in intaglio - intaglio offset, in flat impression block - offset.

Necessity of use of the offset ink transfer method, primarily in course of flat impression block printing, is due to the fact that in the process of its realization, hydrophilic and oleophilic films of the printing plate collide not with a relatively stiff paper, but with an elastic rubber-fabric plate.

Due to this, the pressure required for printing and the wear of the printing and blank elements of the form are reduced, while circulation life of the printing plate is increased. Other advantages of the offset printing [1 - 4] are: the possibility of using of paper of any density, high productivity of printing devices for realization of the method. The disadvantages of this method are: the use of a limited set of inks, the need to adjust printing machines individually for each order, low profitability in the case of small orders, long terms of orders fulfillment, the impossibility of correcting errors in course of the printing process.

In this regard, last time digital printing becomes more and more wide spread. It is realized directly on paper, without of the use of intermediate forms and stamps. In the case of the digital printing, it becomes possible to obtain high-quality and inexpensive printed products in small or in large volumes and in a short time. In this case, a customer can correct the detected errors even at the printing stage. Disadvantages of the digital printing are: restrictions for the use of gold and silver inks, restrictions for the format of products. But these disadvantages are not so significant, therefore, this particular printing method is, in our opinion, the most promising for modern automated printing publishing complexes with a computerized system of distribution and fulfillment of orders.

At the first stage of elaboration of a mathematical model of an automated system of optimization functioning of printing and publishing complexes is created databases of the automated system.

The databases are the initial information for further automated synthesis and analysis of options for order fulfillment and for selection of the optimal option with the consideration of main efficiency indicators and additional conditions of product customers. There is proposed to divide the entire volume of this information into five databases [5].

Database 1 (DB1) - parameters of orders received on the date t_b

- date of orders completion - t_f (must be the same for all of group orders);
- volumes of orders - $n_1, n_2, ..., n_m$ (where 1, 2, ..., m - serial numbers of orders), pcs;
- orders formats (there can be several different formats) - $A_1, A_2, ..., A_m$;
- admissible value of manufacturing products for each order - $C_1, C_2, ..., C_m$, UAH*;*
- availability or absence of an artwork (in a flowchart of the algorithm and in a computer program for the automated synthesis and analysis of the order execution options, there is proposed to use for designation this quality an abbreviation: *AW +* - if there is the artwork and *AW-* - in case of the artwork absence).

Database 2 (DB2) - parameters of quality of finished products [6] are indicated for each part of each order.

Parameters of a printing and publishing design are:

- format of the set strip (quantity, pcs - n_c, width of columns, mm - b_{c1}, b_{c2}, …, $b_{c.m}$);
- size and typeface (for example, Times New Roman - 12);
- type of a cover and a binder cover: *HG* - hard glossy; *HM* - hard matte; *SG* - soft glossy; *SM* - soft matte;
- specific part of illustrations in each product - *SPI*, %;
- type and weight of printing paper: *PM* - matte paper; *PG* - glossy paper; paper weight, for example P_w = 80 g/sq.m.;

Parameters of printing performance:

- color combination, maximum deviation – C_d, mm;
- tone rendition of single-color illustrations – T_r, points;
- color rendering of multi-color illustrations – $T_{r.m}$, points;
- text contrast - C_t, points;
- maximum deviation of sizes of fields in the edition - D_m , mm;
- dimensions of binding cover edges – D_c, mm;
- deviation from rectangularity of the edition - D_r, mm.

Reliability parameters:

- specific force of tearing out of a sheet under utilization of adhesive binding method of fastening – F_t, N/mm;
- specific breaking force of tearing of a block at a notebooks junction – F_b, N / mm;
- specific effort of tearing out of the block from the cover - $F_{t.c}$, N / mm;
- the maximum permissible load for the block (stacked) or for the rack (multi-tiered) storage – F_l, t/m.;

Parameters of economical use of raw materials:

- coefficient of use of a paper area, $k_{u.p}$,%.

Aesthetic parameters:

- number of colors - n_{cl};
- absence of defects of rejected product - A_d, points;
- aesthetic perception of the publication - E_p, points.

Unification and standardization parameters:

- parameter of the use of standardized design elements in the publication - k_{st}.

Database 3 (DB3) - parameters of an equipment of an automated polygraphic publishing complex.

- the number of the equipment of the complex separately by types of the machines (see Fig. 1), pcs: N_1 - the number of the crucible machines; N_2 - the number of the flatbed printing machines; N_3 - the number of the sheet rotary single-layer machines; N_4 - the number of the sheet rotary multilayer machines; N_5 - the number of the roll-fed rotary single-layer machines; N_6 - the number of the roll-fed rotary multi-layer machines; N_7 - the number of the laser digital machines; N_8 - the number of the inkjet digital machines;
- the number of machines of the complex, separately according to the printing methods, they are realized, pcs: N_{1m} - the number of the machines for the flat impression block printing; N_{2m} - the number of the machines for the relief printing; N_{3m} - the number of the intaglio printing machines; N_{4m} - the number of the machines for the digital printing;
- total productivity of the complex equipment separately for each type of machines, pcs / h: Q_1 - the productivity of the sheet crucible machines; Q_2 - the productivity of the sheet-fed flat-printing machines; Q_3 - the productivity of the sheet rotary single-layer machines; Q_4 - the productivity of the sheet rotary multi-layer machines; Q_5 - the productivity of the roll-fed rotary single-layer machines; Q_6 - the productivity of the roll-fed rotary multi-layer machines; Q_7 - the productivity of the laser digital machines; Q_8 - the productivity of the inkjet digital machines;
- total productivity of the machines of the complex separately by printing methods, they are realized, pcs / h: Q_{1m} - the productivity of the machines for the flat impression block printing; Q_{2m} - the productivity of the machines for the relief printing; Q_{3m} - the productivity of the intaglio printing machines; Q_{4m} - the productivity of the machines for the digital printing;
- formats of the orders printed on the machines of each type, for example, the formats of the sheet crucible machines - F_1: A_1, A_2, ..., A_i ; the formats of the sheet-fed flat-bed printing machines - F_2: A_1, A_2, ..., A_j and so on for all other types;

- formats of the orders that are printed by each of the methods, for example, the formats of the flat impression block printing - F_{1m}: A_1, A_2, ..., A_k ; the relief formats - F_{2m}: A_1, A_2, ..., A_l ; the intaglio printing formats - F_{3m}: A_1, A_2, ..., A_m; the digital printing formats - F_{4m}: A_1 , A_2 , ..., A_n;

- operating and overhead expenses per unit of production (electricity value, salaries of operators and management personnel, depreciation and social deductions, taxes) in case of using of each of the types of the complex machines, UAH / piece : V_1 – the expenses for the sheet crucible machines; V_2 - the expenses for the sheet-fed flat-printing machines; V_3 - the expenses for the sheet rotary single-layer machines; V_4 - the expenses for the sheet rotary multilayer machines; V_5 - the expenses for the roll-fed rotary single-layer machines; V_6 - the expenses for the roll-fed rotary multilayer machines; V_7 - the expenses for the laser digital machines; V_8 - the expenses for the inkjet digital machines;

- the workload of the machines of each type of complex in the period t_f - t_b in % from the total operating time of the equipment in this period, taking into account the preparatory-final time and downtime, associated with equipment maintenance and with organizational and technical reasons [7]: L_1 - the workload for the sheet crucible machines; L_2 - the workload for the sheet-fed flat-printing machines; L_3 - the workload for the sheet rotary single-layer machines; L_4 - the workload for the sheet rotary multi-layer machines; L_5 - the workload for the roll-fed rotary single-layer machines; L_6 - the workload for the roll-fed rotary multilayer machines; L_7 - the workload for the laser digital machines; L_8 - the workload for the inkjet digital machines.

Database 4 (DB4) - the parameters of previous orders, which were carried out efficiently and on time, with using of the equipment of the automated printing and publishing complex.

The list of the parameters of the DB1 are recorded for the each preliminary order, with indication of the order number in the index of each parameter and of its point. In this database is pointed out an actual value of products manufacturing for each order - C_{1f}, C_{2f}, ..., C_{kf} , UAH. So the database 4 consists an information about:

- the workload of machines of each type of the complex during of the order fulfillment in % from the total operating time [8, 9], for example, for order No. 1: L_{1-1} - the workload of the sheet crucible machines; L_{2-1} - the workload of the sheet-fed flat-printing machines; L_{3-1} - the workload of the sheet rotary single-layer machines; L_{4-1} - the workload of the sheet rotary multi-layer machines; L_{5-1} - the workload of the roll-fed rotary single-layer machines; L_{6-1} - the workload of the roll-fed rotary multi-layer machines; L_{7-1} - the workload of the laser digital machines; L_{8-1} - the workload of the inkjet digital machines;

- the number of machines of each type, which were involved in the order fulfillment, for example, for the order No. 1, pcs: N_{1-1} - the number of the sheet crucible machines; N_{2-1} - the number of the sheet-fed flat-printing machines; N_{3-1} - the number of the sheet rotary single-layer machines; N_{4-1} - the number of the sheet rotary multilayer machines; N_{5-1} - the number of the roll-to-roll rotary single-layer machines; N_{6-1} - the number of the roll-fed rotary multilayer machines; N_{7-1} - the number of the laser digital machines; N_{8-1} - the number of the inkjet digital machines;

- the number of the machines of the complex separately by printing methods, they are realized, for example, for the order No. 1, pcs: N_{1m-1} - the number of the machines for flat impression block printing; N_{2m-1} - the number of the relief machines; N_{3m-1} - the number of the intaglio printing machines; N_{4m-1} - the number of the machines for digital printing;

Database 5 (DB5) data about additional conditions and circumstances:

- the value of paper and consumables (paints, toners, etc.) for manufacture of the all parts the orders V_{mp1}, V_{mp2}, ..., V_{mpt}, UAH;

- the value of storage and delivery of the products to the customer, UAH - V_{sd1}, V_{sd2}, ..., V_{sdm};

- data about preparation orders artworks in case of their absence: if the artwork will be prepared by the customer or by a third company, there is need to point out the time of its preparation t_{pm1}, t_{pm2}, ..., t_{pmt}, h; if the artwork will be prepared by workers of the complex, then point out the time t_{pm1}, t_{pm2}, ..., t_{pmt}, h of its preparation and the value of work V_{pm1}, V_{pm2}, ..., V_{pmt}, UAH;

- time reserve t_{r1}, t_{r2}, ..., t_{rt}, h for cases of failures and disruptions in order fulfillment (equipment failure, disruptions in the supply of materials and paper, absence of an operator due to him or her illness, lack of electricity, etc.).

After the databases formation there is need to elaborate a mathematical model for determining of efficiency parameters, synthesis and analysis of functioning options of the printing and publishing complexes.

At the first stage of the automated synthesis and analysis of the functioning options for the printing publishing complex is determined a possibility of fulfilling one or more of the orders, which were received simultaneously on the date t_b according to the options that were used in the system earlier [9].

To do this, after the completion of databases formation is analyzed in an interactive mode or with using of a special computer program the correspondence of the parameters DB1 and DB4 in with help of the formulas

$$n_1 \to \{n_{1f}, n_{2f}, \ldots, n_{pf}\};\ A_1 \to A_{if};\ n_2 \to \{n_{1f}, n_{2f}, \ldots, n_{pf}\};\ A_{21} \to A_{jf} \tag{1}$$

$$n_m \to \{n_{1f}, n_{2f}, \ldots, n_{pf}\};\ A_m \to A_{kf},$$

where n_{1f}, n_{2f}, …, n_{pf} - volumes of the 1st, 2nd, ..., *p-th* orders, which were previously realized with using of the system;

A_{if}, A_{jf}, …, A_{kf} - print formats of *i*-th, *j*-th, ..., *k*-th orders from DB4, which should be similar in format and in volume to the orders n_1, n_2, ..., n_m, which were received.

For similar orders, which were selected from the DB4, according to formulas (1) is checked up the fulfillment of the conditions

$$C_1 \le C_{if};\ C_2 \le C_{jf}, \ldots, C_m \le C_{kf}, \tag{2}$$

where C_1, C_2, ..., C_m - the value of the 1-st, 2-nd, ..., *m*-th received order;

C_{if}, C_{jf}, ..., C_{kf}, - the value of the i-th, *j*-th, ..., *k*-th order from the DB4.

If conditions (2) are fulfilled, then for each part of the received orders if for them were pre-selected variants from DB4 are checked availability of the artwork: *AW* +.

In case of availability for orders from DB1 of the artwork of corresponding variants in the DB4, there is checked up the possibility of their timely fulfillment with using of the equipment specified for the similar orders from the DB4. At this stage there is need to take into consideration availability of this equipment in course of time of order fulfillment. In this case, the conditions are used

$$\frac{n_1}{(t_f-t_b)T_a-t_{pm1}-t_{r1}} \le N_i Q_i(100-L_i);\ \frac{n_2}{(t_f-t_b)T_a-t_{pm2}-t_{r2}} \le N_j Q_j(100-L_j); \ldots; \tag{3}$$

$$\frac{n_m}{(t_f-t_b)T_a-t_{pmm}-t_{rm}} \le N_k Q_k(100-L_k),$$

where T_a – the actual operating time of the equipment of the printing publishing complex during the day, h.

The verification is carried out with using of formulas (3), for each part of each order if for their implementation are used machines of different types. In this case, the durations t_{pm1}, t_{pm2}, ..., t_{pmm} are took into calculations only for orders, which for the moment have not the artworks.

For the other orders, without of corresponding variants from the DB4, select a suitable equipment for printing after completion of development of the artworks and with consideration of the quality parameters from DB2 and of the order formats A_1, A_2, ..., $A_{m\,of}$. For each unit of the selected equipment is realized productivity and availability check with using of the formulas (3). In cases when these conditions are not met, another variant of the machine or of printing method is checked (see database DB3). In course of the selection by printing method in the formulas (3) instead of N_i, Q_i; N_j, Q_j; N_k, Q_k set N_{im}, Q_{im}; N_{jm}, Q_{jm}; N_{km}, Q_{km}. Then, after the selection of the suitable printing method (fulfillment of the condition (3)) in the same way select the type of a suitable machine for printing.

The value check is performed according to the formulas

$$C_1 \le V_{mp1} + V_{pm1} + V_{sd1} + V_1 n_1;\ C_2 \le V_{mp2} + V_{pm2} + V_{sd2} + V_2 n_2, \ldots, \tag{4}$$

$$C_m \le V_{mpm} + V_{pmm} + V_{sdm} + V_m n_m.$$

The components V_{pm1}, V_{pm2}, …, V_{pmm} in the formulas (4) are taken into account only if there are no artworks for the corresponding orders at the time $t = t_b$.

In cases of non-fulfillment of the conditions (4) for one or for several orders, an attempt is made to select an another variant of their fulfillment, first by the condition (3), and then with the help of the condition (4). Before this check, as before, an analysis is carried out according to the data from DB2 and with consideration of the order formats A_1, A_2, ..., A_m.

If, after the checks, there are several acceptable options for some order fulfillment, an optimal option is selected in terms of productivity (conditions (3)) or of implementation value (conditions (4)).

The proposed model can use as a basis for creation of a computer program for automated analysis and synthesis of possible options of fulfillment of printing products orders and for choosing of an optimal variant both for the customer and for the contractor. In addition, optimization of complex equipment operation will reduce operating expenses. The DB4 data can be used for rationalization and planning of maintenance and repair works for the complex machines.

5. Conclusions

1. An urgent task for printing and publishing enterprises of Ukraine and of other countries is to create on their basis production complexes with automated optimization of operation, which will allow to rationalize the utilization of enterprises capacity, to reduce the value of finished products, to ensure their proper quality, to avoid of disruptions during of peak periods of enterprises loading, to reduce the value of repair and maintenance of the complexes equipment.

2. To perform this task in the work was analyzed a classification and basic technological parameters of a modern printing and publishing equipment. This information allows to determine types of the machines, which should be included in the complex. Most prospective equipment for the complex are: high-performance sheet and roll machines, in that number crucible, flatbed and rotary three-cylinder machines, single-layer and multi-layer sectional machines, digital laser and inkjet machines.

3. Main printing methods, which can be used during of complex operation, are analyzed. As a result was made a conclusion about of expediency of using of offset printing for fulfillment of large orders, at the same time, digital printing is more effective for small orders fulfillment.

4. There is developed a databases structure, which contain an initial information for the automated synthesis and analysis of variants of orders fulfillment with help of the printing and publishing complexes and with selection of an optimal variant.

5. The authors offered a mathematical model for definition of main efficiency parameters of orders performance with help of an automated printing and publishing complex. These parameters are: work productivity and value of finished products, with provision of proper quality characteristics and with consideration of additional conditions and circumstances. The developed mathematical model can be used as a basis for creation of a computer program for automated synthesis and analysis of functioning variants of modern printing and publishing complexes and for selection of the optimal variant.

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МОДЕЛЬ ОПТИМІЗАЦІЇ ФУНКЦІОНУВАННЯ СУЧАСНИХ ПОЛІГРАФІЧНО-ВИДАВНИЧИХ КОМПЛЕКСІВ

У статті проводиться аналіз відомих методів та сучасного обладнання для поліграфічної та видавничої діяльності (листових ротаційних машин, рулонних машин, плоскодрукарських і тигельних машин для плоского, високого, глибокого та цифрового друку). В результаті аналізу автори статті прийшли до висновку, що найбільш перспективним обладнанням для автоматизованих поліграфічно-видавничих комплексів є: високопродуктивні листові та рулонні машини, в тому числі тигельні, планшетні і роторні трьохциліндрові, а також одноциліндрові одношарові та багатошарові секційні машини, цифрові лазерні та струменеві машини. Автори пропонують математичну модель автоматизованої системи оптимізації функціонування сучасних поліграфічно-видавничих підприємств. У моделі використовуються бази даних з інформацією про замовлення (кількість, обсяги, зміст, терміни виконання замовлень, допустиму собівартість та характеристики якості готової продукції), виробничі потужності поліграфічно-видавничих підприємств регіону (призначення, кількість і продуктивність обладнання, його технологічні можливості, завантаження іншими замовленнями, термін служби), а також додаткові дані про вартість транспортування та зберігання готової продукції, можливості і доцільність передачі замовлень іншим підприємствам тощо. Розроблена модель може бути використана як основа для створення комп'ютерної програми для автоматизованого синтезу та аналізу оптимізації функціонування сучасних поліграфічно-видавничих підприємств регіону з метою підвищення їх ефективності, а також для допомоги замовникам поліграфічної продукції у виборі оптимальних варіантів виконання замовлень. Результати моделювання дозволять раціоналізувати використання потужностей підприємств, знизити вартість готової продукції, забезпечити її належну якість, уникнути збоїв в пікові періоди завантаження підприємств, знизити вартість ремонту і обслуговування обладнання комплексу.

Ключові слова: *математична модель, комп'ютеризована система, оптимальне функціонування, поліграфія, видавничий комплекс, бази даних, показники ефективності.*

Ф. 5. Рис. 2. Літ. 9.

МОДЕЛЬ ОПТИМИЗАЦИИ ФУНКЦИОНИРОВАНИЯ СОВРЕМЕННЫХ ПОЛИГРАФИЧЕСКИХ И ИЗДАТЕЛЬСКИХ КОМПЛЕКСОВ

В статье проводится анализ известных методов и современного оборудования для полиграфической и издательской деятельности (листовых ротационных машин, рулонных машин, плоскопечатных и тигельных машин для плоской, высокой, глубокой и цифровой печати). В *результате анализа авторы статьи пришли к выводу, что наиболее перспективным оборудованием для автоматизированных полиграфических и издательских комплексов являются: высокопроизводительные листовые и рулонные машины, в том числе тигельные, планшетные и роторные трехцилиндровые, а также одноцилиндровые однослойные и многослойные секционные машины, цифровые лазерные и струйные машины. Авторы предлагают математическую модель автоматизированной системы оптимизации функционирования современных полиграфических и издательских предприятий. В модели используются базы данных с информацией о заказах (количество, объемы, содержание, сроки выполнения заказов, допустимая себестоимость и характеристики качества готовой продукции), производственных мощностях полиграфических и издательских предприятий региона (назначение, количество и производительность оборудования, его технологические возможности, загрузка другими заказами, срок службы), а также дополнительные данные о стоимости транспортировки и хранения готовой продукции, возможности и целесообразности передачи заказов другим предприятиям и многое другое. Разработанная модель может быть использована как основа для создания компьютерной программы для автоматизированного синтеза и анализа оптимизации функционирования современных полиграфических и издательских предприятий региона с целью повышения их эффективности, а также для помощи заказчикам полиграфической продукции в выборе оптимальных вариантов выполнения заказов. Результаты моделирования позволят рационализировать использование мощностей предприятий, снизить стоимость готовой продукции, обеспечить ее надлежащее качество, избежать сбоев в пиковые периоды загрузки предприятий, снизить стоимость ремонта и обслуживания оборудования комплекса.*

Ключевые слова: *математическая модель, компьютеризированная система, оптимальное функционирование, полиграфия, издательский комплекс, базы данных, характеристики эффективности.*

Ф. 5. Рис. 2. Лит. 9.

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