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СЪДЪРЖАНИЕ / ОГЛАВЛЕНИЕ

CONTENTS

OF DECISION MAKING UNDER CONDITIONS OF UNCERTAINTY OF FORMATION AND INTELLECTUAL ANALYSIS OF LIBRARY-MUSEUM-ARCHIVAL-INFORMATION DATA SET

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Abstract. *Formation, description and intellectual analysis of a complex data set, which is an example of a problem-oriented library-museum-archival-information dataset on nobelistics, is carried out under conditions of uncertainty due to the ambiguity of attribution of each element to this dataset. The possibility of modeling decision making in these conditions is shown, the best of which is the optimal formation, description and intellectual analysis of a complex set of problem-oriented data. A typical information situation is used for modeling, when the decision-making body has knowledge of the a priori probability distribution on the state elements of the dataset. For each of the seven variants of information situations a set of criteria for making optimal decisions is selected; each criterion is mathematically described. The developed information model of data formation on user's request in the field of nobelistics is presented and described, which reflects really functioning subject-oriented library-museum-archival-information dataset on nobelistics of the International Nobel Information Center, consisting of: Nobel Research Library, Museum of the Nobel Family and Nobel Prize Laureates, Archive of the Nobel Family and Nobel Prize Laureates, electronic databases on nobelistics. The data is generated in such a way that the user receives search results in the form of factographics, factologics, and documents in various formats. The database management system controls the results of each act of information search according to six quality elements: relevance, pertinence, accuracy, completeness, clarity, consistency.*

Key words: *formation, description and intellectual analysis of data, library-museum-archival-information dataset on nobelistics, uncertainty conditions, decision-making, models*

I. INTRODUCTION

The peculiarity of decision-making processes is to take into account the presence of a person, a collective of persons, and a decision-making body that seeks to achieve some goal on the basis of their preferences about values and with the help of automated decision support systems (ADSS). In the theory of decision making, the most preferable solution is considered to be the one that is consistent with the structure of preferences of the decision-making body, as well as with the information it has about the decision-making problem. In this case, the theory makes it possible to build normative procedures that help the decision-making body to formalize its preferences, and decision making is reduced to a comparison of those properties of the solutions that are the basis for evaluation [1-3].

The quality of the decision-making process is in direct dependence on the completeness of taking into account all the factors that are essential to the consequences of the decisions made. Often these factors are subjective in nature, inherent in both the decision maker (DM) and any decision-making process. Hence the conditions of uncertainty in decision-making: the decision-

making body has less information than is necessary for the expedient organization of its actions in the decision-making process. Directly with the conditions of uncertainty we face when it is necessary to carry out the formation, description and intellectual analysis of data, which is a complex problem-oriented library-museum-archival-information set (LMAIS) on nobelistics of the International Nobel Information Center (INIC), functioning in real time [4-12]. Uncertainty arises due to the ambiguity of attributing each element of nobelistics to this dataset.

Our experience allows us to propose the following classification of uncertainties:

1) essence uncertainty (lies in the essence of the studied objects and/or processes);

2) uncertainty generated by the total number of objects (elements, processes) included in the situation under study;

3) uncertainty caused by the lack of information and data on its reliability due to technical, social or other reasons;

4) uncertainty caused by too high or inaccessible payment for certainty;

5) uncertainty generated by the decision-making body due to its lack of experience and knowledge of factors affecting decision-making;

6) uncertainty related to limitations in the decision-making situation (limitations on time and space elements of parameters characterizing decision-making factors);

7) uncertainty caused by the behavior of the environment influencing the decision-making process.

Thus, in decision-making processes there are a number of situations that have a certain degree of uncertainty and require for their description such a mathematical apparatus, which would a priori include the possibility of formalizing uncertainties and would allow performing the actions necessary to achieve the goal [7-10].

Historically, the first was the apparatus of probability theory, according to which the uncertainty of a situation is described by some normalized measure characterizing the possibility of occurrence of predetermined random outcomes (elements or subsets of some set).

A natural extension of probabilistic methods for describing uncertain situations was game theory [13-15], in which uncertainty was generated by conflict and opposing interests of players bound by the rules of the game, and statistical decision theory [16], in which a passive environment or “nature” was chosen as one of the players, whose behavior was characterized by given laws of probability distribution. These theories are extreme cases of different degrees of uncertainty gradation or information situations.

Another class of uncertain situations is based on the concept of vague (fuzzy) set introduced by L. Zadeh [17]. This apparatus is adequate for describing such situations that do not have strictly defined boundaries, so it is used for the work of artificial intelligence. Schemes for constructing a general mathematical apparatus describing a wide class of uncertain situations are given in [18-20]. A widely known and widespread is the static model of decision making based on the game-theoretic concept [21], applicable in many real situations of ad hoc selection of options, plans, tuples, actions, alternatives, strategies, etc., associated with the uncertain influence of the environment on the situation of their selection by the decision-making body.

The idea of combining information resources of libraries, museums, archives and electronic repositories into a single LMAIS with the help of modern information technologies emerged long ago [22, 23]. It is based on the analysis of the requirements of scientific information users (scientists and specialists) who need to get a complete and accurate answer to their request regardless of the massive where the sources they are looking for are located and in what format they function: in the form of library or archival documents, museum exhibits or electronically in the global network. This idea is partially realized in the Internet, but due to many known reasons problem-oriented search in scientific documents is still extremely inaccurate and incomplete [24-30].

II. MAIN TEXT

1. Materials and methods

A convenient example for modeling and testing the performance of information retrieval

models is the LMAIS, in which all four problem-oriented arrays function simultaneously and interconnected: Nobel Research Library (NRL), Museum of Nobel Family and Nobel Prize Laureates (MNF&NPL), Archive of Nobel Family and Nobel Prize Laureates (ANF&NPL), and many electronic databases (DB) on nobelistics [31, 32]. INIC has many years of experience in providing scientists and specialists with the help of problem-oriented massive on nobelistics in the local execution of retrieval technology.

The purpose of this study is to develop a data model to implement networked information retrieval in LMAIS on nobelistics. Based on this model, it is planned to develop an information retrieval system on nobelistics, which in any retrieval uses all information resources available in INIC.

2. Initial modeling conditions

When studying static models of decision making under uncertainty, we proceed from the scheme assuming the presence of: 1) a set of mutually exclusive decisions $\Phi = \{\varphi_1,...,\varphi_m\}$ of the control body U, one of which it needs to make; 2) a set of mutually exclusive states $\Theta = \{\theta_1,...,\theta_n\}$ of the environment C, but in what particular state the environment C is (or will be) the control body U does not know; 3) the control body U is evaluated by a functional $F = \{f_{jk}\}$, $\varphi_k \in \Phi$ characterizing its "gain" or "loss" when choosing a decision $\varphi_k \in \Phi$, if the environment C will be (or is) in the state $\theta_j \in \Theta$. In our case, the environment C is a complex dataset of LMAIS, and we consider the optimal formation, description and intelligent analysis of data as a gain.

Under this scheme, the quantitative side of the theory of decision making in conditions where the environment "behaves" in an antagonistic way with respect to the choice of decisions by the control body U (state of uncertainty) is usually called game theory [21]. In the case of "passive" environment ("passive nature"), about which the control body U knows the probability distribution $p = \{p_1,...,p_n\}$ on $\Theta = \{\theta_1,...,\theta_n\}$, it is accepted to call games with nature or static decisions. These cases of environmental behavior can be called extreme cases. In the general case, there is a significant gradation of situations that determine the behavior strategy of the environment C.

The definition and classification of these situations form the basis of the theory of decision-making under uncertainty, since they partially allow us to solve the well-known problem of choosing a decision-making criterion by developing for each situation a set of such criteria.

Our approach to the decision-making process of the U governing body is as follows:

1) formation of a set of decisions Φ and a set of states of the environment Θ;

2) determination and setting of the main efficiency and utility indicators included in the calculation of the evaluation functional $F = \{f_{jk}\}$;

3) determination by the control body U of the situation characterizing the behavior strategy of the environment C;

4) selection of a decision-making criterion from the set of criteria characterizing the situation defined by the control body U;

5) making an optimal decision according to the selected criterion or its correction (if the optimal decision is not the only one or in case of refusal of the optimal decision by the control body U).

The formal component of the decision-making process under conditions of uncertainty consists in the production of calculations of performance indicators included in the definition of the evaluation functional $F = \{f_{jk}\}$, and in the production of calculations to find the optimal solution $\varphi^o \in \Phi$ (or a set of such solutions $\overline{\Phi} \in \Phi$) according to a given decision-making criterion. Algorithms of calculation of efficiency indicators and decision-making criteria with the use of modern computer systems constitute the *mathematical support* of the static process of decision-making under conditions of uncertainty. Algorithms of formation on the basis of application of information means and modern computer systems of the information picture in the control body U, characterizing the strategy of

behavior of the environment *C* and providing the definition of the situation constitute the *information support* of the static process of decision-making in conditions of uncertainty.

Let us define the main elements of static models of decision-making processes.

Under the situation of decision making we understand $\{\Phi, \Theta, F\}$, where $\Phi = \{\varphi_1, ..., \varphi_m\}$ is set of decisions of the control body *U*; $\Theta = \{\theta_1, ..., \theta_n\}$ is set of states of the environment *C*, which can be in one of the states $\theta_j \in \Theta$; $F = \{f_{jk}\}$ is evaluation functional (matrix of evaluation functional) defined on $\Theta \times \Phi$ and taking values from R^1, at that $f_{jk} = f(\theta_j, \varphi_k)$. In the extended form, the situation of decision making is characterized by a matrix, the elements f_{jk} of which are quantitative evaluations of the taken decision $\varphi_k \in \Phi$ under the condition that the environment *C* is in the state $\theta_k \in \Theta$:

	φ_1	...	φ_k	...	φ_m
θ_1	f_{11}	...	f_{1k}	...	f_{1m}
...	...	...	...	...	...
θ_j	f_{j1}	...	f_{jk}	...	f_{jm}
...	...	...	...	...	...
θ_n	f_{n1}	...	f_{nk}	...	f_{nm}

Such concepts as efficiency, utility, losses, risk, etc. are closely related to the category of estimated functional. The choice of the form of expression of the evaluative functional depends on the purpose and objectives of management of the object *O*, the availability of methods for obtaining and calculating the effectiveness of tasks solved by the management object *O* and the management body *U*, the time of the process of preparation and decision-making, etc. More often two forms of expression of the evaluative functional used F, defining utility, value, etc. or losses, damages, risk, etc. The evaluative functional F has a positive ingredient if the decision-making body *U* proceeds from the condition of achieving $\max_{\varphi_k \in \Phi}\{f_{jk}\}$. In this case, for the positive ingredient we will use the notation $F = F^+\{f_{jk}^+\}$. For a negative ingredient *F*, the governing body *U* assumes the condition of achieving $\min_{\varphi_k \in \Phi}\{f_{jk}\}$ when making the decision. In this case $F = F^-\{f_{jk}^-\}$.

The identification of positive and negative ingredients is characteristic of actively directed systems. These are the systems that provide the solution of the problems of attributing each element of nobelistics to LMAIS. One can note a number of interesting situations in which, for example, the ingredient of a passively directed system can be determined from the condition of reaching $\lambda \min_{\varphi_k \in \Phi}\{f_{jk}\} + (1-\lambda)\max_{\varphi_k \in \Phi}\{f_{jk}\}$ ($0 \le \lambda \le 1$), and we have $F = F^+$ with $\lambda = 0$, and we have $F = F^-$ with $\lambda = 1$.

The definition of the evaluative functional in the form of F^+, is usually used to express the categories of utility, gain, efficiency, probabilities of achieving target events, etc., in contrast it is F^- used to express loss, regret, damage, risk, etc. Note that when forming the evaluation functional, the expression of the ingredient is determined by the management and decision-making purpose of the *U* body. It is clear that the positive form of expression of the ingredient of the evaluation functional is more often used. However, in some cases a negative value is necessary.

The regret function is a linear transformation of a positive or negative value of an ingredient of the evaluation functional to relative units of measurement. Such transformation sets the starting point of the evaluation functional "zero" for each state of the environment θ_j: 1) for F^+ the case of a fixed state of the environment $\theta_j \in \Theta$ the value is found $l_j = \max_{\varphi_k \in \Phi} f_{jk}^+$ and the regret function is defined in the form

$r_j(\varphi_k) = l_j - f^+_{jk}$; 2) for F^- the case of a fixed state of the environment $\theta_j \in \Theta$ the value is found $L_j = \min_{\varphi_k \in \Phi} f^-_{jk}$ and the regret function is defined in the form $r_j(\varphi_k) = f^-_{jk} - L_j$.

The regret function has a negative form of the evaluation functional F^-, $r_j(\varphi_k) \geq 0$, and $r_j = 0$ for at least one solution φ_k at $\forall\ \theta_j \in \Theta$.

Let us introduce decision-making situations, which are formalized by the model in the form of a tuple $\{\Phi, \Theta, F\}$, which makes it possible to define various information situations. By an *information situation* I we understand a certain degree of uncertainty in the choice of the environment *C* of its states from a given set Θ, which is available to the control body *U* at the time of decision making. Let us define a classifier of information situations characterizing the "behavior" of the environment *C* in the decision-making process when choosing its states $\theta_j \in \Theta$.

Let us introduce *7 information situations*:

I_1 is the first information situation characterized by a given distribution of a priori probabilities on the elements of the set Θ;

I_2 is the second information situation characterized by a given probability distribution with unknown parameters;

I_3 is the third information situation characterized by the given systems of linear order relations on the components of the a priori distribution of the states of the environment *C*;

I_4 is the fourth information situation characterized by an unknown probability distribution on the elements of the set Θ;

I_5 is the fifth information situation characterized by antagonistic interests of the environment *C* in the decision-making process;

I_6 is the sixth information situation characterized by "intermediate" between I_1 and I_5 cases of environment's choice of its states;

I_7 is the seventh information situation characterized by a fuzzy set of states of the environment *C*.

These situations are generalized characteristics of the levels of uncertainty of the states of the environment *C*. Different gradations of uncertainty in each information situation are used in the study of decision-making criteria.

Under the *decision criterion* $\chi \in K$ we will understand an algorithm that determines for each decision-making situation $\{\Phi, \Theta, F\}$ and information situation I the only optimal solution $\varphi^o \in \Phi$ or a set of such solutions $\overline{\Phi} \subset \Phi$, which we will call *equivalent* according to the given decision criterion. The decision-making criterion can be regarded as a preference operation on the set of solutions Φ, taking into account the element of uncertainty of possible states $\theta_j \in \Theta$ of the environment *C*, ordering the set of solutions Φ into a transitive sequence in the order of preference.

Thus, any information situation is I characterized by a set of decision criteria $K_{I_i} = \{\chi_{si}\}$ ($i = 1,\ldots, 7$). For example, for the first information situation the composite criteria are Bayesian, maximum likelihood, modal, minimum variance, etc. (Table 1).

Table 1
Correspondence of decision-making criteria to information situations

No	Characterization of information situation	Decision-making criteria
1	The distribution of a priori probabilities on the elements of the set Θ is specified	1. Bayes criterion 2. Maximum likelihood criterion 3. Modal criterion 4. Minimum variance criterion 5. Criterion of minimum entropy of mathematical expectation 6. Modified criterion
2	The probability distribution with unknown parameters is specified	1. Parametric Bayes criterion 2. Parametric criterion of maximum likelihood of the estimated functional (EF) 3. Parametric criterion of minimum variance of the EF 4. Parametric modal criterion 5. Parametric criterion of maximum entropy of the mathematical expectation of the EF
3	The system of linear order relations on the components of the a priori distribution of the state of the medium is specified	Determines the type of order relationship, is set by the decision-making body *U* based on the information at its disposal, its experience, the situation and the conditions of the decision-making environment
4	The probability distribution on the elements of the set Θ is unknown	1. Criterion for maximal measures of Bayesian sets 2. Maximum of the integral Bayesian value of the EF 3. largest integral potential 4. Bernoulli-Laplace criterion 5. Khomenyuk criterion 6. Gibbs-Janes criterion
5	Antagonistic interests of environment *C* in the decision-making process	1. Wald criterion 2. Savage's criterion 3. Uncertainty function
6	Intermediate cases of environment *C*'s choice of its states	1. Hurwitz criterion 2. Hodges-Lehman criterion 3. Menges criterion 4. Schneeweiss criterion
7	Fuzzy set of environment states	1. Bringing the subjective probability distribution of the values of the components of the belonging function components 2. Criterion of the type of probability distribution type of the EF values 3. Criterion of type of dispersion of EF values 4. Modal type criterion

In a given situation $\{\Phi, \Theta, F\}$, the decision making problem is that the decision authority U must choose one decision that is optimal according to the chosen criterion. The axiomatic decision making problem is characterized mainly by three factors: $\{I, K_I, A\}$, where I is an information situation; K_I is a set of decision criteria corresponding to the information situation I; A is a system of axioms for analyzing decision criteria. The *axiomatic approach* in the analysis of decision-making criteria is understood as a method of selecting the most acceptable axioms (postulates), which allow the management body U to investigate the problems of decision-making in the uncertainty of finding a suitable decision-making criterion. Decision making in this situation $\{\Phi, \Theta, F\}$ is largely facilitated by the possibility of determining the information situation I, as well as the establishment of a system of axioms for selecting the criterion $K_{I_i} = \{\chi_{si}\}$ ($i = 1, \ldots, 7$).

To date, axiom systems do not exist for all information situations, and the choice of criterion in given information situation based on the existing axiom system can be ambiguous. The ambiguity of criterion selection is determined by the incompleteness of the axiom system. Despite the presence of these features that hinder the resolution of the decision-making problem, we note that each of the information situations under consideration is characterized by a "potential" criterion that reflects the main tendencies of decision-making in this or that information situation.

The main tendency of the research of the decision-making problem consists in detailing and classifying information situations, on the one hand, and in developing criteria for these information situations with some elements of research of their positive and negative sides in the issues of efficiency of functioning of the management object O and the management body U.

3. Let us consider the first information situation.

This information situation I_1 characterizes the case when the decision-making body U has knowledge of the a priori probability distribution

$$p = (p_1, \ldots, p_n), \quad p_j = P\{\theta = \theta_j\}, \quad \sum_{j=1}^{n} p_j = 1$$

on the elements $\theta_j \in \Theta$ of the states of the environment C. This situation is the most common information situation identifying the "behavior" of the environment C in most practical decision-making tasks under "risk" conditions. Its introduction into the decision-making processes allowed to effectively use constructive methods of probability theory in the development of statistical decision theory.

In practical problems, the calculation of a priori distribution p of medium states C is carried out either by processing extensive statistical material or by analytical methods based on the formulation of hypotheses of medium behavior with the subsequent use of basic axioms, theorems and methods of probability theory. Both ways are approximate, because in practice, due to a number of limitations (in terms of cost, expenses, time and space) there are difficulties in obtaining and processing statistical material, the formulated system of hypotheses of the behavior of the medium is inherently incomplete, and when using "working" hypotheses it is necessary to make appropriate assumptions (for example, about the independence of events) to the detriment of the physics of the process in order to carry out the calculation p. Among the various concepts of probability, such an a priori distribution p is commonly referred to as an *objective probability*.

However, in a number of statistical decision-making processes, due to the complexity of the "behavior" of the environment C, the lack of collection and processing of statistical material, the use of analytical methods, etc., the decision-making body U, relying on its experience or on the opinion of a group of experts, prefers to use the concept of probability p, developed on the basis of the idea of the degree of certainty about a given factor, feature, symptom, characterizing the properties of the "behavior" of the environment.

This definition of a priori distribution, which made the concept of probability a matter of opinion, was called *subjective probability*. This is what happens every time a staff member introduces a new element into one of the LMAIS structures.

Taking into account possible errors and inaccuracies, as well as the ambiguity of opinions of the group of experts when calculating the a priori distribution, we synthesize optimal decisions on the a priori distribution $p=(p_1,...,p_n)$, taking values from the flat set $\Delta_n=\left\{p:0\le p_j\le 1,\sum_{j=1}^{n}p_j=1\right\}$.

Let us consider the basic criteria for decision making in an information situation I_1 characterized by the probability distribution $p_j=P\{\theta=\theta_j\}$, $\sum_{j=1}^{n}p_j=1$ of the states $\theta_j\in\Theta$ of the environment *C*. Let a decision situation $\{\Phi,\Theta,F\}$ be given in which the evaluation functional $F=\{f_{jk}\}$ belongs to the class of F^- either F^+ from set Φ, and Θ are given in the form of $\Phi=\{\varphi_1,...,\varphi_m\}$, $\Theta=\{\theta_1,...,\theta_n\}$.

1. *Bayes criterion*. The essence of this criterion is to maximize the mathematical expectation of the estimated functional, transforming the formulas of a priori probabilities into a posteriori ones. Optimal solutions $\varphi_{ko}\in\Phi$ (or a set of such optimal solutions) are those solutions for which the mathematical expectation of the estimated functional reaches the largest possible value:

$$B^+(p,\varphi_k)=\max_{\varphi_k\in\Phi}B^+(p,\varphi_k)=\max_{\varphi_k\in\Phi}\left[\sum_{j=1}^{n}p_jf_{jk}^+\right]=\sum_{j=1}^{n}p_jf_{jko}^+$$

If the maximum is achieved on several solutions of Φ, the set of which we denote by $\overline{\Phi}$, then such solutions will be called *equivalent*.

$$B^+(p,\varphi_k)=\sum_{j=1}^{n}p_jf_{jk}^+$$

The value is called the value of the Bayes estimator for the solution $\varphi_k\in\Phi$. The great popularity of this criterion in the information situation I_1 is explained by the fact that the Bayes criterion is closely related to the axioms of utility theory (axiom of Neumann and Morgenstern), in which the total utility is defined as the mathematical expectation of private utilities. If the evaluation functional is given in the form of F^-, then *min* is used instead of the operation *max* of the mathematical expectation. If the valuation functional is given in regret or risk, the corresponding value $B^-(p,\varphi_k)$ is usually called the *Bayesian risk* for the solution $\varphi_k\in\Phi$.

2. *Criterion for maximizing the probability of distribution of the estimated functional*. We fix the value of α, satisfying the inequalities $\alpha_1<\alpha<\alpha_2$, where $\alpha_1=\min_k\min_k f_{jk}^+$, $\alpha_2=\max_k\max_k f_{jk}^+$, ($j=1,...,n$, $k=1,...,m$).

For each solution $\varphi_k\in\Phi$ we determine the probability $P(f_{jk}^+\ge\alpha)$ that the value of the estimated functional is not less α for the state of the environment $\theta_j\in\Theta$ and the solution $\varphi_k\in\Phi$. The essence of this criterion is to find a solution $\varphi_{ko}\in\Phi$ (or a set of such solutions $\overline{\Phi}$) for which $P(f_{jk}^+\ge\alpha)=\max_{\varphi_k\in\Phi}P(f_{jk}^+\ge\alpha)$. When using this criterion, the control body *U* proceeds from a specific value of α, and considers as optimal those solutions $\varphi_{ko}\in\Phi$ for which this condition is met.

For fixed α and φ_k, the inequality $f_{jk}^+\ge\alpha$ defines the set of states of the

environment $\Theta_{\alpha,k}$. Then the probability $P\left(f_{jk}^{+} \geq \alpha\right)$ is

$$P\left(f_{jk}^{+} \geq \alpha\right) = P\left(\theta \in \Theta_{\alpha,k}\right) = \sum_{\theta_j \in \Theta_{\alpha,k}} p\left(\theta = \theta_j\right)$$

In this criterion, the magnitude α is given by the control body *U*. Therefore, the set $\overline{\Phi}$ depends on α, i.e. $\overline{\Phi} = \overline{\Phi}(\alpha)$. For two values of α^{*} and α^{**}, such that $\alpha_1 \leq \alpha^{*} \leq \alpha_2$, $\alpha_1 \leq \alpha^{**} \leq \alpha_2$ and $\alpha^{*} \leq \alpha^{**}$, we have $\overline{\Phi}\left(\alpha^{**}\right) \subseteq \overline{\Phi}\left(\alpha^{*}\right)$. Furthermore $P\left(f_{jk}^{+} \geq \alpha^{*}\right) \geq P\left(f_{jk}^{+} \geq \alpha^{**}\right)$.

f the evaluation functional is given in the form of $F = F^{-}$, then for each decision $\varphi_k \in \Phi$ the probability of $P\left(f_{jk}^{-} \leq \beta\right)$ is defined and the application of the criterion consists in selecting decisions φ_{ko} or $\overline{\Phi}(\beta)$, for which $P\left(f_{jk}^{-} \leq \beta\right) = \max_{\varphi_k \in \Phi} P\left(f_{jk}^{-} \leq \beta\right)$, where the value of β such that $\alpha_1 \leq \beta \leq \alpha_2$ is given by the decision authority *U*.

3. *The criterion of minimum variance of the estimated functional*. For each solution $\varphi_k \in \overline{\Phi}$ we define the mean value $B^{+}(p,\varphi_k)$ of the estimated functional and the variance σ_k^2 in the form of $B^{+}(p,\varphi_k) = \sum_{j=1}^{n} p_j f_{jk}^{+}$, namely

$$\sigma_k^2 = \sigma^2(p,\varphi_k) = \sum_{j=1}^{n} \left[f_{jk}^{+} - B^{+}(p,\varphi_k)\right]^2 p_j$$

Dispersion σ_k^2 characterizes the dispersion of the random value of the value of the estimated functional for the solution φ_k with respect to the mean value $B^{+}(p,\varphi_k)$. The essence of this criterion is to find a solution φ_{ko} (or a set of solutions Φ) for which $\sigma^2(p,\varphi_{ko}) = \min_{\varphi_k \in \Phi} \sigma^2(p,\varphi_k)$.

The main disadvantage of this criterion is that the variance at the solution $\varphi_{k1} \in \Phi$ may be smaller than at the solution $\varphi_{k2} \in \Phi$, i.e. $\sigma_{k1}^2 \leq \sigma_{k2}^2$ while $B^{+}(p,\varphi_{k1}) < B^{+}(p,\varphi_{k2})$. This suggests that the criterion of minimum variance of the estimated functional is, on the one hand, in some sense of the word an auxiliary criterion, and on the other hand, if it is accepted, it is necessary to further define this criterion by slightly modifying the form of σ_k^2, for example, in one of the following ways:

$$\sigma_{(p,\varphi_k)}^2 = \sum_{j=1}^{n} \left[f_{jk}^{+} - \max_{\varphi_s \in \Phi} B^{+}(p,\varphi_s) \right]^2 p_j$$

$$\sigma_{(p,\varphi_k)}^2 = \sum_{j=1}^{n} \left[f_{jk}^{+} - \frac{1}{m} \sum_{s=1}^{m} B^{+}(p,\varphi_s) \right]^2 p_j$$

If the evaluation functional is given in the form $F = F^{-}$, then the solution φ_{ko} to the minimum of the evaluation functional is found from the condition $\sigma^2(p,\varphi_{ko}) = \min_{\varphi_k \in \Phi} \sigma^2(p,\varphi_k)$, where the value $\sigma^2(p,\varphi_{ko})$ is determined in one of the following ways:

$$\sigma^2(p,\varphi_k) = \sum_{j=1}^{n} \left[f_{jk}^{-} - B^{-}(p,\varphi_k)\right]^2 p_j ,$$

$$\sigma^2(p,\varphi_k)=\sum_{j=1}^{n}\left[f_{jk}^{-}-\min_{\varphi_s\in\Phi}B^{-}(p,\varphi_s)\right]^2 p_j$$

$$\sigma^2(p,\varphi_k)=\sum_{j=1}^{n}\left[f_{jk}^{-}-\frac{1}{m}\sum_{s=1}^{m}B^{-}(p,\varphi_s)\right]^2 p_j$$

4. *Modal criterion*. The essence of this criterion is that the control body U proceeds from the most probable state of the environment. Suppose that there is a single value of $p_{j_1}=\max_{\theta_j\in\Theta}P(\theta=\theta_j)$.

Using this criterion, the control body U assumes that the environment is in the state $\theta_{j_1}\in\Theta$ and the optimal φ_{ko} or $\overline{\Phi}$ is determined from the condition $f_{j_1k_0}^{+}=\max_{\varphi_k\in\Phi}f_{j_1k}^{+}$. If it turns out that the maximum $P(\theta=\theta_j)$ is achieved at a priori probabilities $p_{j_1}, p_{j_2},\ldots, p_{j_s}$, then the optimal solution φ_{ko} (or $\overline{\Phi}$) is determined from the condition $\frac{1}{s}\sum_{\gamma=1}^{s}f_{j_\gamma k_0}=\max_{\varphi_k\in\Phi}\frac{1}{s}\sum_{\gamma=1}^{s}f_{j_\gamma k}^{+}$.

The main drawback of this criterion is the possibility that if we take two solutions φ_{k1} and φ_{k2}, for which $f_{j_1k_1}^{+}>f_{j_1k_2}^{+}$, then according to this criterion the solution φ_{k1}, i.e. $\varphi_{k1}\rhd\varphi_{k2}$, is preferred. However, it may turn out that $B^{+}(p,\varphi_{k1})<B^{+}(p,\varphi_{k2})$.

The main advantages of this criterion are:

1) sufficiency of identifying only the most probable states of the environment, and it is not necessary to know the quantitative values of the probabilities of realization of these states;

2) determination (calculation) of the estimated functional only for the most probable states of the environment, which increases the speed of decision making many times. It should be noted that when setting the evaluation functional F in the form F^{-}, the operation max is replaced by min.

5. *Criterion of minimum entropy of the mathematical expectation of the estimated functional*. Suppose that $f_{jk}^{+}>0$ for all j and k. Let us define the entropy of the mathematical expectation of the estimated functional for the solution $\varphi_k\in\Phi$ as follows:

$$H(p,\varphi_k)=-\sum_{j=1}^{n}\left(\frac{p_j f_{jk}^{+}}{\sum_{j=1}^{n}p_j f_{jk}^{+}}\right)\ln\left(\frac{p_j f_{jk}^{+}}{\sum_{j=1}^{n}p_j f_{jk}^{+}}\right)$$

The essence of this criterion is to find a solution φ_{ko} (or $\overline{\Phi}$) from the condition $H(p,\varphi_{ko})=\min_{\varphi_k\in\Phi}H(p,\varphi_k)$. In case of non-fulfillment of the condition $f_{jk}^{+}>0$ for all j and k, a transition from the values f_{jk}^{+} of the evaluation functional to the risk (regret, loss) of the form

$$\tilde{f}_{jk}^{-}=\max_{\theta_j\in\Theta}\;{}_{k\in\Phi}\;f_{jk}^{+}-f_{jk}^{+}$$

At that the solution φ_{ko} is found from the condition of entropy minimum $\varphi_k\in\Phi$ of the mathematical expectation of the estimated functional of the form $H(p,\varphi_{ko})$ at $\tilde{f}_{jk}^{-}>0$:

$$H(p,\varphi_k)=-\sum_{j=1}^{n}\left(\frac{p_j\tilde{f}_{jk}^{-}}{\sum_{j=1}^{n}p_j\tilde{f}_{jk}^{-}}\right)\ln\left(\frac{p_j\tilde{f}_{jk}^{-}}{\sum_{j=1}^{n}p_j\tilde{f}_{jk}^{-}}\right)$$

6. *Modified criterion*. We fix the value of λ, satisfying the condition $0 \le \lambda \le 1$. For each of $\varphi_k \in \Phi$ we define the value of $\chi(p,\varphi_k) = (1-\lambda)\left[B^+(p,\varphi_k)\right]^2 - \lambda\sigma^2(p,\varphi_k)$, where denotes $B^+(p,\varphi_k) = \sum_{j=1}^{n} p_j f_{jk}^+$, $\sigma^2(p,\varphi_k) = \sum_{j=1}^{n}\left[f_{jk}^+ - B^+(p,\varphi_k)\right]^2 p_j$.

The essence of the modified criterion is to find a solution φ_{ko} (or a set of solutions $\overline{\Phi}$) from the condition $\chi(p,\varphi_{ko}) = \max_{\varphi_k \in \Phi} \chi(p,\varphi_k)$.

Note that in two particular cases $\lambda = 0$ and $\lambda = 1$ this criterion coincides with the Bayes criterion and with the criterion of minimum variance of the evaluation functional.

Let's introduce two values

$$\lambda^* = \min_{\varphi_k \in \Phi} \frac{\left[\sum_{j=1}^{n} p_j f_{jk}^+\right]^2}{\sum_{j=1}^{n} p_j \left(f_{jk}^+\right)^2} \qquad \lambda^{**} = \max_{\varphi_k \in \Phi} \frac{\left[\sum_{j=1}^{n} p_j f_{jk}^+\right]^2}{\sum_{j=1}^{n} p_j \left(f_{jk}^+\right)^2}$$

Obviously, the values λ^* and λ^{**} are such that the inequalities $0 \le \lambda^* \le \lambda^{**} \le 1$ are satisfied.

Lemma 1. If a quantity λ satisfies the condition $0 \le \lambda \le 1$, then $\chi(p,\varphi_{ko}) \ge 0$ for any $\varphi_k \in \Phi$.

The proof of this statement follows from the fact that

$$\chi(p,\varphi_k) = (1-\lambda)\left[\sum_{j=1}^{n} p_j f_{jk}^+\right]^2 - \lambda\sum_{j=1}^{n}\left[f_{jk}^+ - \sum_{l=1}^{n} p_l f_{lk}^+\right]^2 p_j =$$

$$= \left[\sum_{j=1}^{n} p_j f_{jk}^+\right]^2 - \lambda\sum_{j=1}^{n} p_j \left(f_{jk}^+\right)^2 \ge 0$$

because $\lambda \le \left[\sum_{j=1}^{n} p_j f_{jk}^+\right]^2 \Big/ \sum_{j=1}^{n} p_j \left(f_{jk}^+\right)^2$ for any solution $\varphi_k \in \Phi$ at $\lambda \in \left[0, \lambda^*\right]$.

As a corollary to the lemma, we obtain that $(1-\lambda)\left[B^+(p,\varphi_k)\right]^2 \ge \lambda\sigma^2(p,\varphi_k)$ at $\lambda \in \left[0, \lambda^*\right]$, i.e., at these values λ the modified criterion is more sensitive to the Bayesian criterion of maximizing the average payoff $B^+(p,\varphi_k)$, than to the criterion of minimizing the variance $\sigma^2(p,\varphi_k)$.

Lemma 2. If a quantity λ satisfies the condition $\lambda^{**} \le \lambda \le 1$, then $\chi(p,\varphi_{ko}) \le 0$ for any $\varphi_k \in \Phi$.

The proof of this statement follows from the fact that

$$\chi(p,\varphi_k) = (1-\lambda)\left[\sum_{j=1}^{n} p_j f_{jk}^+\right]^2 - \lambda\sum_{j=1}^{n}\left[f_{jk}^+ - \sum_{l=1}^{n} p_l f_{lk}^+\right]^2 p_j =$$

$$= \left[\sum_{j=1}^{n} p_j f_{jk}^+\right]^2 - \lambda\sum_{j=1}^{n} p_j \left(f_{jk}^+\right)^2 \le 0$$

since $\lambda \le \left[\sum_{j=1}^{n} p_j f_{jk}^{+}\right]^2 \Big/ \sum_{j=1}^{n} p_j \left(f_{jk}^{+}\right)^2$ for any solution $\varphi_k \in \Phi$ at $\lambda \in \left[0, \lambda^*\right]$.

As a corollary to this lemma, we obtain that $(1-\lambda)\left[B^{+}(p,\varphi_k)\right]^2 \le \lambda\sigma^2(p,\varphi_k)$ at $\lambda \in \left[\lambda^{**},1\right]$, i.e., at these values λ the modified criterion is more sensitive to the criterion of minimizing the variance of $\sigma^2(p,\varphi_k)$, than the Bayesian criterion of maximizing the average payoff.

If the value of $\lambda \in \left[\lambda^*,\lambda\right]$, the values $\chi(p,\varphi_{ko})$ are sign-variable at $\varphi_k \in \Phi$, i.e., we cannot talk about the priority of the Bayesian maximization criterion $B^{+}(p,\varphi_k)$ or the minimization criterion $\sigma^2(p,\varphi_k)$.

The following point estimates can be proposed for selection λ in the interval $\lambda \in \left[0,\lambda^*\right]$: $\hat{\lambda}_{\alpha}^{*}(p) = \left(\frac{n}{n-1}\right)^{\frac{\alpha}{2}} \lambda^* \rho^{\alpha}(p)$. Here α is an arbitrary non-negative number; $\rho(p)$ is the distance from $p=(p_1,\ldots,p_n)$ to the midpoint $\left(\frac{1}{n},\ldots,\frac{1}{n}\right)$ of the flat set

$$\Delta_n = \left\{ p : 0 \le p_j \le 1 \ \ (j=1,\ldots,n), \sum_{j=1}^{n} p_j = 1 \right\},$$

equal to $\rho(p) = \left[\sum_{j=1}^{n}\left(p_j - \frac{1}{n}\right)^2\right]^{1/2} = \left(\sum_{j=1}^{n} p_j - \frac{1}{n}\right)^{1/2}$.

The point estimates $\hat{\lambda}_{\alpha}^{*}(p)$ satisfy the following two axioms: 1) $\hat{\lambda}_{\alpha}^{*}(p^0) = 0$ at $\rho(p^0) = 0$, i.e., in the case of uniform distribution $p^0 = \left(\frac{1}{n},\ldots,\frac{1}{n}\right)$, the modified criterion coincides with the Bayes criterion; 2) $\hat{\lambda}_{\alpha}^{*}(p^*) = \lambda^*$ at $\rho(p^*) = \max_{p\in\Delta_n} \rho(p) = \left(\frac{n-1}{n}\right)^{1/2}$, i.e., in the case of degenerate distribution p^* (one of the components of which is equal to one, the rest are zero), the variance $\sigma^2(p,\varphi_k) = 0$ for any $\varphi_k \in \Phi$.

Thus, if decision authority U believes that the value λ in the modified criterion $\chi(p,\varphi_{ko})$ satisfies the inequalities $0 \le \lambda \le \lambda^*$, then using the point estimate $\hat{\lambda}^{*}_{\alpha}$, a decision is made from the maximum $\chi(p,\varphi_{ko})$ over condition $\varphi_k \in \Phi$ for $\lambda = \hat{\lambda}_{\alpha}^{*}(p)$.

Partial cases of point estimates $\hat{\lambda}^{*}(p)$ at $\alpha = 0,1,2$ are the values of $\hat{\lambda}_0^*(p) = \lambda^*$,

$$\hat{\lambda}_1^*(p) = \sqrt{\frac{n}{n-1}}\rho(p)\lambda^*,$$

$$\hat{\lambda}_2^*(p) = \frac{n}{n-1}\rho^2(p)\lambda^*$$

For selection $\lambda \in \left[\lambda^{**},1\right]$, we used point estimates of the form $\hat{\lambda}_{\alpha}^{**}(p) = 1 - \left(\frac{n}{n-1}\right)^2 \rho^{\alpha}(p)\left(1-\lambda^{**}\right)$ with non-negative α. The values $\hat{\lambda}_{\alpha}^{**}(p)$ satisfy the following two axioms: 1) $\hat{\lambda}_{\alpha}^{**}(p^0) = 1$ at $\rho(p^0) = 0$, i.e., in the case of uniform distribution $p^0 = \left(\frac{1}{n},\ldots,\frac{1}{n}\right)$, the modified criterion coincides with the minimum variance

criterion; 2) $\hat{\lambda}^{**}_{\alpha}(p^*)=\lambda^{**}$ at $\rho(p^*)=\max_{p\in\Delta_n}\rho(p)=\left(\frac{n-1}{n}\right)^{1/2}$, i.e., in the case of degenerate distribution p^*, the variance $\sigma^2(p^*,\varphi_k)=0$ for any $\varphi_k\in\Phi$, and the optimal decision is made by Bayes' criterion.

Thus, if decision authority U believes that the value λ in the modified criterion $\chi_{\Delta}(p,\varphi_k)$ satisfies the inequalities $\lambda^{**}\le\lambda\le 1$, then using the point estimate $\hat{\lambda}^{**}_{\alpha}(p)$, a decision is made from the maximum $\chi(p,\varphi_k)$ over condition $\varphi_k\in\Phi$ for $\lambda=\hat{\lambda}^{**}_{\alpha}(p)$.

Particular cases of point estimates $\hat{\lambda}^{**}_{\alpha}(p)$ at $\alpha=0,1,2$ are $\hat{\lambda}^{**}_{0}(p^*)=\lambda^{**}$,

$$\hat{\lambda}^{**}_{1}(p)=1-\sqrt{\frac{n}{n-1}}\rho(p)(1-\lambda^{**}),$$

$$\hat{\lambda}^{**}_{2}(p)=1-\frac{n}{n-1}\rho^2(p)(1-\lambda^{**}).$$

The following point estimates can be proposed for selection $\lambda\in[\lambda^*,\lambda^{**}]$:

$$\hat{\lambda}_{\alpha}(p)=\lambda^*+\left(\frac{n}{n-1}\right)^{\frac{\alpha}{2}}\rho^{\alpha}(p)(\lambda^{**}-\lambda^*)$$

, where $\alpha\ge 0$, where , and the point estimates satisfy the following two axioms: 1) $\hat{\lambda}_{\alpha}(p^0)=\lambda^*$ at $\rho(p^0)=0$, i.e. in the case of uniform distribution $p^0=\left(\frac{1}{n},\ldots,\frac{1}{n}\right)$, the Bayes criterion is given greater preference in the modified criterion; 2) $\hat{\lambda}_{\alpha}(p^*)=\lambda^{**}$ at $\rho(p^*)=\max_{p\in\Delta_n}\rho(p)=\left(\frac{n-1}{n}\right)^{1/2}$, i.e. in the modified criterion, the criterion of minimum variance $\sigma^2(p,\varphi_k)$ is given greater preference, and $\sigma^2(p^*,\varphi_k)=0$ for any $\varphi_k\in\Phi$, and the decision is made by the Bayes criterion.

Thus, if decision authority U believes that the value of $\lambda\in[\lambda^*,\lambda^{**}]$, then according to the modified criterion a decision is made from the maximum condition $\chi(p,\varphi_k)$ at $\lambda=\hat{\lambda}_{\alpha}(p)$.

Particular cases of point estimates $\hat{\lambda}_{\alpha}(p)$ at $\alpha=0,1,2$ are $\hat{\lambda}_{0}(p)=\lambda^{**}$,

$$\hat{\lambda}_{1}(p)=\lambda^*+\sqrt{\frac{n}{n-1}}\rho(p)(\lambda^{**}-\lambda^*),$$

$$\hat{\lambda}_{2}(p)=\lambda^*+\frac{n}{n-1}\rho^2(p)(\lambda^{**}-\lambda^*).$$

The derivation of the above point estimates is based on the use of the estimate $\beta+\gamma\rho^{\alpha}(p)(\delta_0+\delta_1+\delta_2\lambda^{**})$, whose coefficients are chosen in such a way that the above axioms are satisfied for each of the three cases of location.

7. <u>*Conditional decisions*</u>. Let us compare the set K_I of previously considered decision-making criteria $K_I=\{\chi^1_1,\ldots,\chi^{n_1}_1\}$ to the information situation I_1. From the set of decision criteria, the control body U selects one criterion, which is conditionally called the *main criterion*, and restrictions are imposed on the other decision criteria. Therefore, the decision made by the control body U on the main criterion under given restrictions on the other criteria from the set K_I, let us call a conditional decision. Both for optimization problems and for decision making, it is typical to set constraints either in the form of inequalities $c^l_1\le\chi^l_1\le C^l_1$, or in the form of equalities $\chi^l_1=c^l_1$.

It should be noted that since the search for an optimal solution is reduced to a finite number of options, setting a constraint in the form of an exact equality is in most cases not quite correct

and leads to the absence of a conditional solution. In contrast, constraints in the form of inequalities are more natural and allow the decision-making body to conduct a kind of analysis to establish "reasonable" limits of values c_1^l and C_1^l from lower and upper limits of values of the criterion χ_1^l. For example, a book can be included in the LMAIS only if it mentions at least one Nobel Prize winner or member of the Nobel family (lower criterion).

Thus, if $\chi_1^s \in K_I$ is the main criterion, the conditional solutions are found from the following problem:

$$\chi_1^s(\varphi_{ko}) = \underset{\varphi_k \in \Phi}{\text{opt}}\ \chi_1^s(\varphi_k)$$

$c_1^l \le \chi_1^l \le C_1^l$, ($l = 1,..., r$; $l \ne s$). A special case of the formulated problem of finding conditional solutions is the case considering of a set a subset $\overline{K}_I \subset K_I$ instead a set K_I.

Example. Let $\overline{K}_I = \{\chi_1^1, \chi_1^2\}$, where $\chi_1^1 = B^+(p,\varphi_k)$, $\chi_1^2 = \sigma^2(p,\varphi_k)$, and the vector of a priori distribution $p = (p_1,...,p_n)$ is given, and χ_1^1 is the main criterion. The bounded solution φ_{ko} is found from the condition

$$B^+(p,\varphi_{ko}) = \max_{\varphi_k \in \Phi} B^+(p,\varphi_{ko}),$$

$c_1 \le \sigma^2(p,\varphi_k) \le C_1$, where c_1, C_1 are given positive constants. Note that it is possible to define a class of conditional solutions without identifying the main decision criterion directly as a solution of the system of inequalities $c_1^l \le \chi_1^l(\varphi_k) \le C_1^l$ ($l = 1,..., r_1$).

The obvious statement is that, according to the constructed Table 1, *decision making in each static information situation* leads to the necessity to develop targeted methods depending on the considered criteria. This does not apply to the issues of decision making in dynamics.

4. Structural model of data formation

On the basis of intellectual analysis of mathematical models of information situations we have developed a structural model of data formation.

Data in the local LMAIS on nobelistics in the INIC are presented in the following amount: about 10 thousand books and brochures in the NRB, more than 6 thousand exhibits in the MNF&LNP, more than 100 thousand sheets of documents in the ANF&LNP, 20 databases of electronic documents on nobelistics with the volume of 2 Tbytes. It is more than enough for formation of information problem-oriented system with high level of accuracy and completeness of search in all directions of nobelistics.

For formation of accurate queries on nobelistics a special thesaurus is initially developed, terms of which are easily transformed into key words, entered in the search query. Other keywords are not perceived by the system. In the description of each element of the system (book, brochure, museum exhibit, archival document, etc.) a specially developed classification technology is used, the main parameter of which is the surname (and names) of each of the thousand Nobel Prize winners. It is by this parameter that any new element is placed in the LMAIS, it must necessarily be associated with at least one surname of a Nobel laureate.

Let us present an information data structural model with information flows (Fig.1) in the process of providing information search on nobelistics. Information objects (entities) here are elements of the subject area - documents, which are either search objects themselves, or represent secondary data about the search objects, which is carried out with the help of database management system (DBMS).

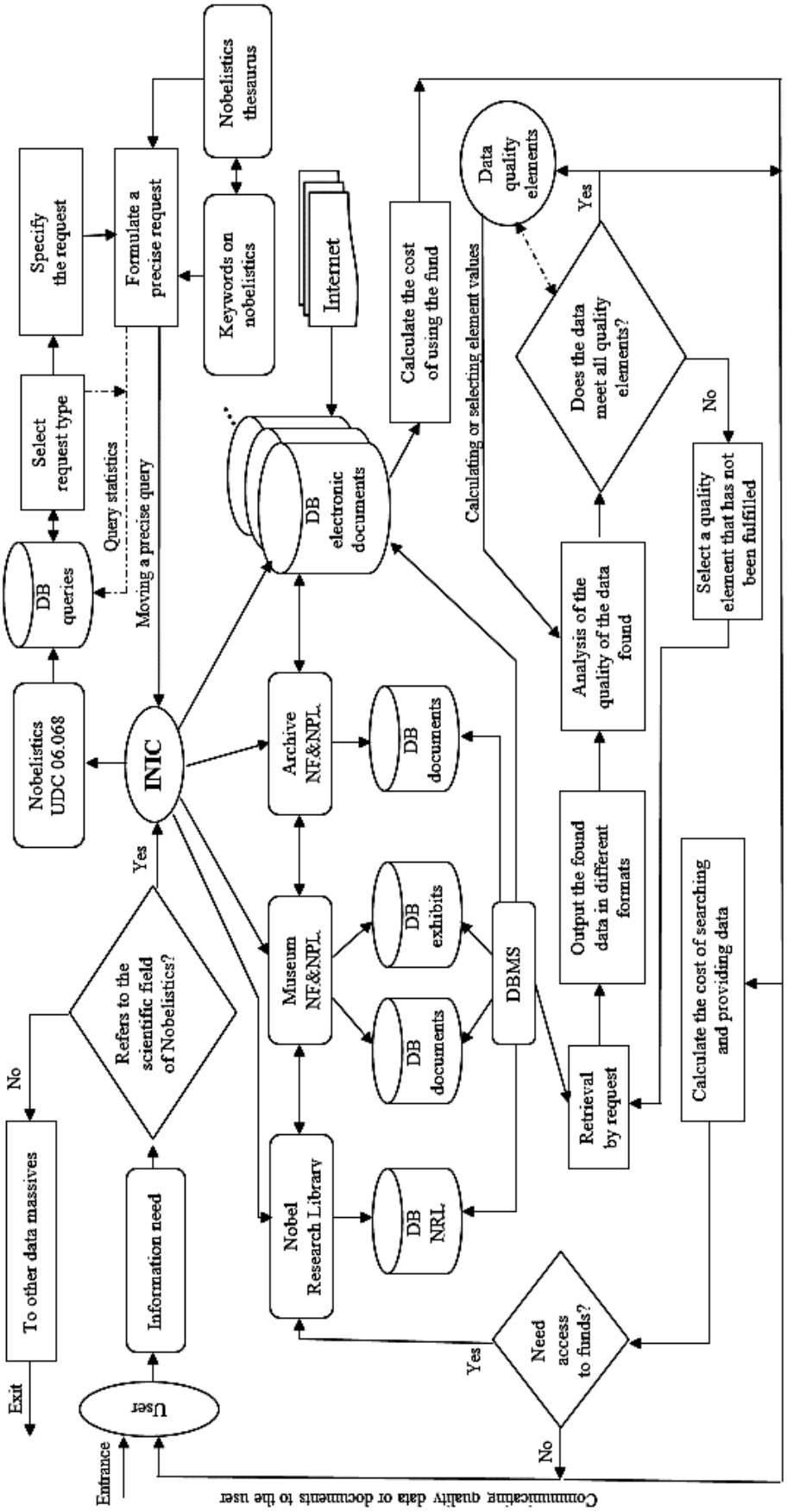

Figure 1. Structural model of data formation in the LMAIS of INIC

In this model, the data are shaped and placed so that the search results for any query in the field of nobelistics can be:

1) factographics or factologics data obtained from the INIC database;

2) documents (books, archival documents, museum exhibits), which the user studies and completes the search for the sought information independently.

Nobelistics data obtained from the Internet undergo a thorough expert check for reliability and correction or screening if they represent misinformation (according to our observations, more than 70% of cases are unreliable).

For each result, LMAIS calculates the search cost using a pre-entered algorithm. Each search operation is evaluated by a set of six main elements of search quality: relevance, pertinence, accuracy, completeness, clarity, consistency. The first four elements are calculated as indicators based on the entered parameters, the last two are selected based on a fuzzy scale. If the user is not satisfied with the value of any quality element, the information retrieval system changes the query and repeats the search. Only after sufficient values of all six quality elements of the search, the data or documents are transferred to the user and the service cycle is completed.

III. CONCLUSION

The proposed model of data formation and information retrieval based on the problem-oriented array on nobelistics allowed to bring the relevance, pertinence, accuracy and completeness of the search to 0.9-1.0, and clarity and consistency to the value “very high”. Such results are unlikely to be achieved if the search array is not problem-oriented and if the data are generated in such a way that the total number of documents in the array is unknown.

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TECHNICAL AND ECONOMIC CHARACTERISTICS OF THE ORGANIZATIONAL FORMS OF THE PRODUCTION PROCESS

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Abstract *The form of organization of the production activity determines the characteristics of planning of the production process in time and space. The forms of organization exist in direct and interconnected relation to the type of production. The type of process predetermines the manner of interconnection of the production factors in the special units of different rank (workplace, section, department, workshop, etc.). This paper examines a comparative technical and economical characterization of the forms of organization of the technological production that are applicable in practice.*

Key words: *Production process, Forms of organization, Type of production*

I. INTRODUCTION

The form of organization of production determines the characteristics of planning of the production process in time and space. In the individual company, each form of organization of production has "right to life" and suitable field of application, i.e. this is matter of free choice on the part of the production management. The forms of organization exist in direct and interconnected relation with the type of production. The type of process predetermines the manner of interconnection of the production factors in the special units of different rank (workplace, section, department, workshop, etc.). The organization of the production process in space is determined by the placement and layout of the equipment, as well as by the specialized sections and workshops for production and depends on the type of production, quantity and manufacturing technology. Based on the above in practice there are four main forms of organization of production: individual, grouped, subject and assembly.

The information taken into account for making the decision which form of organization and type of production to be chosen, is as follows:

- Type of manufactured production – produced presently or planned for production
- in the future and the technology of its production;
- Raw materials supply for the production, including assortment and quality of the raw materials, potential suppliers, etc.;
- Applied technology of production and its main exploitation parameters in quantitative and qualitative aspect;
- Nomenclature of manufactured products and basic requirements for its quality and cost competitiveness;
- Suitable type of production in the enterprise.

II. MAIN TEXT

SELECTING THE FORM OF ORGANIZATION OF PRODUCTION

1.Individual form of organization of production

The individual form of organization is applicable in case of a custom manufacturing method with specific customers, with requirements regarding the quality of the product in specified small quantities. The knowledge, skills and production experience of the worker play key role in determining the production costs. Because of the use of non-expensive universal machines in such form of organization of

production there is great flexibility and opportunity to adapt to the changes in the market. The individual organization allows all or almost all operations related to the manufacturing of the product to be performed by one worker.

***Disadvantages of the individual organization of production**:*

- Long duration of the technological cycle;
- Low labor productivity;
- Irrational use of available equipment and production areas, etc.

The advantages of the individual form include comparatively small investment, high quality of the product, as well as the feeling of fulfillment of the worker. The application of the individual form of organization in modern conditions is limited mostly to production of test samples, specialized tools, spare parts, fashion clothes, accessories, i.e. individual production.

2.Grouped form of organization of production

The grouped form of organization is usually applied in *individual and small-scale type of production*. In terms of layout, it is characterized by the construction of production units from technologically uniform machines – grouped sections, for example turning sections, milling sections, etc. The operations of the technological process are performed in different technologically specialized units.

When applying the grouped form of organization, the operations are sequentially combined in time with advancement of the semi-finished products individually or in batches.

The production cycle has a long duration, because there is no parallel work on the products from the batch and moreover there are longer transportation times and waiting time for the machines in the technologically specialized units to be available for processing of the batches.

This determines the highly interrupted nature of the production process. Figure 1 shows an image of technologically separated sections in grouped form of organization [1].

Characteristics of the grouped form of organization of production:

- The machinery and equipment are universal;
- The workers are highly qualified;
- Low level of specialization of the workspaces;
- The production process is interrupted;
- The production cycle of the products is of relatively longer duration.

Advantage of the grouped form of organization:

- High level of flexibility, because the universality of the equipment and qualification of the workers allows for seamless transition from the production of one type of product to the production of another type;
- The duration of the production cycle of the product is shorter compared to the one of the individual form of organization of production;
- There is no psychological overload of the workers, because the work in the workshop is varied.

Disadvantages of the grouped form of organization:

- The performance of technological operations is related to transportation of the processed products (blanks) from one section to another section with protracted, often crisscrossing and reverse movements, which prolong duration of the production cycle, complicate and increase the cost of the in-house transport;
- The advancement of the products in batches delays the timely supply of the consecutive sections and workplaces and cause interruptions of the technological process;
- The frequent change of the type of the manufactured production causes low labour specialization, respectively – low performance;
- Irrational use of the production space.
- Details are accumulated and semi-finished products at the individual workplaces, as well as in the intermediate warehouses, which leads to increase of the warehouse costs.

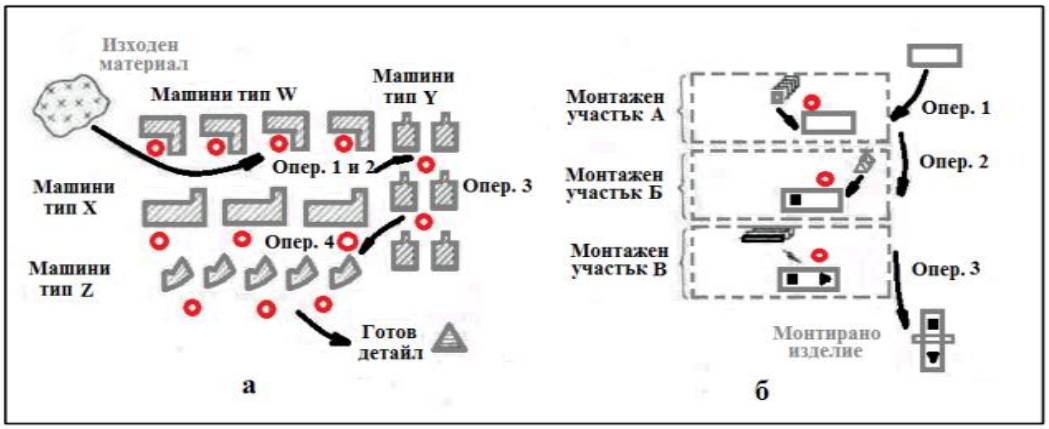

Fig. 1. Grouped form of organization of production

In spite of the listed disadvantages, the grouped form is applied in practice in almost all branches of industry.

3. Subject form of organization of production

The subject form of organization is applied mostly in the medium-sized type of production. The work space is characterized by the construction of production units with technologically diverse machines. The machines are arranged in accordance with the order of operations of one technological process for a group of constructively and technologically similar batches of semi-finished products. The aim is to provide maximum level of completion of the processing of the products in one technological unit. In time in the case of subject form of organization a parallel-sequential combination of technological or transportation operations is applied individually or in batches of the semi-finished products [7].

Characteristics of the subject form of organization of production:

- The machines are located in the section by subject;
- The equipment is mostly universal, which requires high level of qualification of the workers;
- The advancement of the material resources is individual or in batches;
- The products and technological operations are repeated periodically;
- The production process is interrupted, because the duration of the individual technological operations is different.

Advantages of the subject form of organization of production:

- The time for production of the product is relatively short, due to the shortening the product movement route and smaller time expenditure for reconfiguration of the technological equipment;
- Comparatively small volume of the un-finished production;
- The throughput of the equipment is relatively high.

Disadvantages of the subject form of organization of production:

- Necessity of investment of large capitals for purchasing of specialized machinery;
- It is sensitive to changes of the construction of the products, because this necessitates the regrouping of the equipment;
- Lower flexibility is case changes in technology are needed;
- Insufficient load on some technologically specialized machines.

The subject form of organization takes an intermediate place between the grouped and assembly line form of organization (see figure 2).

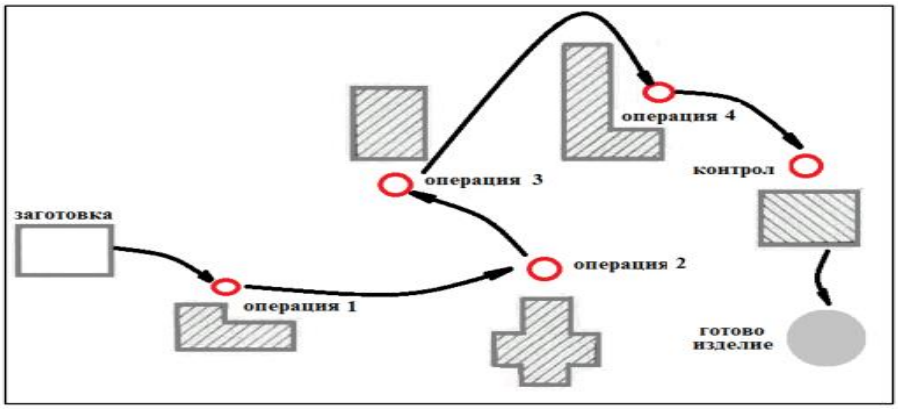

Figure 2. Subject-limited section in subject form of organization of production

A. Subject-limited section

In the subject-limited section a set number of identic or *heterogenous* machines are located at a specific place in accordance with the requirements of the technology, for

the purpose of being able to produce continuously one and the same details, assemblies and products. As a result, there is fuller utilization of the capacities and the work time of the workers.

The sections can be performing processing or assembly activities. An example of subject-limited section is represented in figure 2 [1].

B. Subject-limited line

In subject-limited lines, in contrast with subject-limited sections, the nomenclature is highly limited. Because the sequence of the technological operations is one and the same (or almost identical) for each product, the machines and workplaces are lined up, in accordance with the course of the technological process.

The subject-limited lines do not cover the entire production process of a given product. Usually the subject-limited lines include operations of one phase of the production or assembly. *For example, a subject-limited line is laid out for assembly (of TVs, telephones, radio receivers, etc.).*

The subject lines are similar to the assembly lines, because they follow the principle of linear placement of machines and workplaces, but there is lack synchronization of the technological operations and no uniform rhythm of production.

4. Distinction of assembly form of organization of production

Assembly form of organization is applied in large-scale and mass type of production. In space it is characterize with subject-linear layout of technologically different machines – assembly lines. Due to the small nomenclature and large volumes over long periods of time, specialized machinery and equipment with high degree of automation is used. In time a parallel combination of the operations is applied with advancement of the semi-finished products individually or in batches. The production process is highly differentiated into small and simple to perform operations, which are synchronized with the rhythm of the assembly line. Because of this the production process is uninterrupted and is the shortest compared to the grouped and subject forms of organization [7].

III. CONCLUSIONS

In closing we can summarize that planning and management of a production process requires preliminary determining of the type and form of organization of production. After that, having this basis, one can plan and implement a corresponding system of production management, which would provide rhythmic and uninterrupted flow of the production process for completion of the contracts for volume, nomenclature, quality and terms concluded with users [7].

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CALISTHENICS AND STREET FITNESS: THEIR ROLE FOR ADOLESCENTS AND OPPORTUNITIES FOR DEVELOPMENT IN BULGARIA

КАЛИСТЕНИКА И СТРИЙТ ФИТНЕС: РОЛЯТА ИМ ЗА ПОДРАСТВАЩИТЕ И ВЪЗМОЖНОСТИ ЗА РАЗВИТИЕ В БЪЛГАРИЯ

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Резюме. *Настоящата статия има за цел да разгледа в обзорен аспект набиращите популярност съвременни форми на социализация, физическата активност и спорт, като калистеника и стрийт фитнес. Взаимодеиствието между тези форми на тренировка с ърбан спортс (градски спортове) дава възможност за по-добра социализация, развитие на мотивация и физическа активност сред младите хора в България и Европа. В това отношение този тип активност би могла да бъде адекватно решение във връзка с някой от основните проблеми - намалената двигателна способност, липсата на навици, култура и познания за занимания с физически упражнения и спорт, извеждащи необходимостта от по-специално внимание и грижи за здравословния начин на живот, чрез системни занимания със спорт, физически упражнения и двигателна активност в градска среда. По своята същност калистениката и стрийт фитнесът - стрийт уоркаутът (уличен фитнес), играят важна роля в живота на подрастващите. Те насърчават активен начин на живот и противодействат на нежеланите последици от заседналия начин на живот и изграждат самочувствие и самоусъвършенстване.*

Ключови думи: *ърбан фитнес, стрийт уорк-аут, калистеника, упражнения за укрепване на мускулите, аеробна физическа активност, нов подход към фитнеса*

Abstract. *This article aims to provide an overview of contemporary forms of socialisation, physical activity and sport, such as calisthenics and street fitness, which are gaining popularity. The interplay between these forms of exercise with urban sports (urban activities) allows for better socialization, motivation development and physical activity among young people in Bulgaria and Europe. In this respect, this type of activity could be an adequate solution in regard to some of the main problems - reduced mobility, lack of habits, culture and knowledge of exercise and sport, highlighting the need for special attention and care for a healthy lifestyle, through systematic sports, exercise and physical activity in urban environments. Calisthenics and street fitness - street workout (street fitness) - play an important role in the lives of adolescents. They promote active lifestyles and counteract the undesirable effects of sedentary lifestyles and build self-esteem and self-improvement.*

Key words: *urban fitness, street workout, calisthenics, muscle-strengthening activities, aerobic physical activity, new approach to fitness*

I. ВЪВЕДЕНИЕ

В съвременния свят, където технологиите и интернетът създават нови форми на социализация и забавление, физическата активност и спорта се явяват ключови елементи за здравето на подрастващите. Едни

от най-популярните и достъпни форми на тренировки са калистеника и стрийт фитнес, които стават не само методи за поддържане на добра физическа форма, но и начин на живот. Съчетанието на тези форми на тренировка с ърбан спортс (градски спортове) дава възможност за по-добра социализация, развитие на мотивация и физическа активност сред младите хора. Какво е калистеника? Калистеника, или каристеника, е форма на тренировка, която използва тежестта на собственото тяло за изграждане на сила, гъвкавост и издръжливост. Упражнения като лицеви опори, набирания, клякания, планк и други базови движения се изпълняват с цел укрепване на мускулите и развиване на физическата форма. Калистениката е не само ефективен метод за тренировка, но и достъпен, тъй като не изисква скъпо оборудване или членство в фитнес зала. Това я прави привлекателна за широк кръг хора, включително подрастващите, които търсят начин да се развиват физически, без да имат достъп до специализирани съоръжения.

II. ОСНОВЕН ТЕКСТ

1. Рамкова ориентация на физическа активност и развитие на българското население[1, 2, 3]

Като базов рамков документ даващ ориентация физическа активност и развитие на българското население може да с евзприеме Национална програма БУЛФАР‘ 2021 – 2024.

Според насоките очертани в документа в периода 2021 – 2024 г., трябва спортът за всички да навлезе по-широко в живота на българина, движението да се популяризира в цялата страна, както и да се постигне координация и пълноценно сътрудничество между всички звена в системата на спорта, общините и другите институции в страната, които имат отношение към здравословния начин на живот на всички граждани, без разлика във възраст, пол, здравен и социален статус.

Отбелязва се, че особен проблем в световен мащаб е нарастването на *физическата неактивност*, което е основен фактор за редица заболявания и ранна смъртност в индустриализираните страни и огромни загуби на човешки потенциал и ресурси, така много специалисти да преоценяват ролята на спорта и търсят баланс между невероятното развитие на високото спортно майсторство и спортуването за здраве, за добра форма, за рекреация, за продължителна дееспособност и дълголетие – спорт не само за млади и талантливи хора, но за всички – деца, хора в активна възраст, хора в неравностойно положение и хора от третата възраст.

Някой от основните проблеми в страната ни, които определят необходимостта от специално внимание и грижи за здравословния начин на живот чрез системни занимания със спорт, физически упражнения и двигателна активност са като:

- Изключително високият процент на заболявания и смъртност от болести, за които рисков или благоприятстващ за развитието им фактор при намалената двигателна способност /сърдечно-съдови заболявания, наднормено тегло, ендокринни и обменни болести, болести на опорно-двигателния апарат, стрес, психози и други/.

- Липсата на навици, култура и познания у населението от всички възрасти както за организирани, така и за самостоятелни занимания с физически упражнения и спорт.

- Необходимостта от новата организация на работа и на живот, изискваща изключителна дееспособности постоянно поддържане на добра форма, може да се постигне единствено чрез системни занимания със спорт.

Също в тази насока Законът за физическото възпитание и спорта и редица подзаконови нормативни документи, определиха ясно и точно спорта за всички като приоритет, както и задачите на отделните звена и институции в тази сфера.

Независимо от полаганите усилия до момента, по настоящем в сферата на спорта за всички, стоят много нерешени въпроси.

Интересът към спорта за всички на средствата за масова информация – преса, радио, телевизия, е незначителен, което е съществена пречка за широкото популяризиране на системните занимания със спорт за здраве и добра форма.

2. Калистениката - основа за много от съвременните *"ърбан спортс"*

Калистениката е основата за много от съвременните ърбан спортс, които се практикуват на открито в паркове, улици или на специализирани фитнес уреди, разположени в градски условия. Какво е стрийт фитнес? Стрийт фитнесът е разновидност на калистениката. В този контекст терминът "стрийт фитнес" обикновено обхваща цялостния набор от упражнения, базирани на телесно тегло, които могат да се изпълняват на уреди като лостове, хоризонтални пръти, стендове за набирания и други, разположени в градската среда. Това е типичен пример за ърбан спорт, който има за цел да използва градската среда и инфраструктура, за да се извършват тренировки. Стрийт фитнесът, като част от ърбан спортовете, насърчава хората да тренират на открито и да излязат от традиционните фитнес зали. Привлекателността му за подрастващите е в неговата социална компонента — тренировките се провеждат често в групи и създават усещане за общност и принадлежност. Освен физическите ползи, тези тренировки могат да подобрят и социалните умения на младите хора, като същевременно развиват лидерски и организаторски качества. Ролята на калистениката и стрийт фитнеса за подрастващите Калистениката и стрийт фитнесът играят важна роля в живота на подрастващите, като предоставят редица ползи за тяхното физическо и психологическо развитие. Първо, те насърчават активен начин на живот и противодействат на нежеланите последици от заседналия начин на живот, като например затлъстяването и намалената физическа активност, които стават все по-чести сред младите хора в съвременния свят. Тези тренировки също така изграждат самочувствие и самоусъвършенстване. Чрез постигането на нови фитнес цели (например изпълнение на ново упражнение или увеличаване на броя повторения) подрастващите получават чувство на постижение и увереност в собствените си способности. Стрийт фитнесът и калистениката развиват и социални умения, тъй като тренировките често се извършват в групи, което води до създаване на приятелства и общности. Примери за позитивни инициативи в България В България все повече млади хора се увлекат по калистениката и стрийт фитнеса, а с помощта на общините и инициативи от местни спортни клубове и организации, тези спортове се популяризират и сред подрастващите. В различни градове на България има изградени специализирани площадки за уличен фитнес, на които всеки може да тренира без да плаща за членство във фитнес зала. Тези площадки съдържат уреди, които позволяват да се изпълняват основни упражнения като набирания, лицеви опори, коремни преси и други. Пример за успешен български проект в тази посока е инициативата "Street Workout Bulgaria", която организира състезания, тренировки и събития за младежи, занимаващи се със стрийт фитнес. Това не само предоставя възможност на подрастващите да се включат в активно физическо натоварване, но и създава възможности за социализация и участие в национални и международни състезания. Освен това, редица млади хора в България вече са постигнали впечатляващи успехи в областта на ърбан спортовете, като редовно участват в състезания и печелят награди. Те не само че доказват, че тези спортове могат да водят до постижения на високо ниво, но и се явяват вдъхновение за новото поколение. Заключение Калистениката и стрийт фитнесът са не само ефективни форми на физическа активност, но и играят важна роля в развитието на подрастващите в България и по света. Те предоставят възможност за физическо натоварване, социализация и изграждане на увереност, като същевременно подкрепят здравословния начин на живот. Благодарение на нарастващото присъствие на тези спортове в градската среда и положителните примери на успех в България, подрастващите имат на

разположение достъпни и вдъхновяващи начини да се развиват физически и психологически. [4, 5, 6, 7]

3. Стрийт уоркаутът

Стрийт уоркаутът (уличен фитнес) набира популярност сред младите хора като достъпна, ефективна и социално ангажираща форма на физическа активност. Съществуват редица научни изследвания и публикации, които доказват ползите от този вид спорт за физическото и психическото здраве на подрастващите.

Според редовно актуализирания уебсайт на спортните центрове за калистеника [5, 7] този нов модерен уличен спорт понастоящем се практикува на 1287 места за практикуване на SW във Франция (от 1017 през 2020 г.) и на 15 699 места в света (от 13 193 през 2020 г.). Според тренировките на школата SBL [5], френската школа по SW със седалище в Ница, SW, известен още като калистеника, е дисциплина по средата между гимнастиката и бодибилдинга, съчетаваща сила, гъвкавост, баланс и ловкост в нов стил, основан на въздушния фрийстайл. По-конкретно, тя често се практикува на открито (откъдето идва и името Street Workout) и без аксесоари. Трудно е да се определи произходът на тази техника за изграждане на мускули, базирана на телесното тегло, тъй като тя се е развила по целия свят за много кратко време

Според някои научни изследвания "стрийт уоркаутът" заниманията имат следните позитивни аспекти: [5, 6, 7 ,8, 9]

1. *Подобряване на физическата форма* и сила. Изследване, публикувано в ProQuest, проведено с 48 деца на възраст 10–11 години, показва, че четириседмична програма по стрийт уоркаут води до значително подобрение в силата на горната част на тялото, издръжливостта и гъвкавостта. Участниците са показали средно увеличение от 33.4% при лицевите опори и 24.6% при задържане на вис.

2. *Повишаване на физическата активност* и здравословни навици Изследване от Украйна, публикувано в списанието "Society. Integration. Education", установява, че включването на стрийт уоркаут в училищни програми увеличава броя на учениците, които редовно се занимават с физическа активност, с 20.2%. Също така се наблюдава подобрение в качеството на съня и увеличаване на продължителността му до 7–7.5 часа при повечето ученици.

3. *Достъпност и социална ангажираност* Според публикация в DoveMed, стрийт уоркаутът е нискобюджетен и достъпен за всеки, тъй като не изисква специализирано оборудване. Той насърчава социалното взаимодействие и може да се практикува в група, което допринася за мотивацията и постоянството.

Стрийт уоркаутът е функционална форма на физическа активност, която развива както физическите, така и когнитивните способности.

Изследвания за координация и физическа активност при младежи. [4, 7, 9] При 10-седмична програма за подобряване на координацията и физическата форма (изследване, публикувано в PubMed) оценява ефекта от базирана на игри, върху координационните способности и физическата форма на 12-годишни ученици. След интервенцията, участниците показват значителни подобрения в тестовете за баланс (тест на фламинго), пъргавина (Т-тест за ловкост), спринт на 20 метра и сила на захвата. Това подчертава ефективността на игровите физически дейности за подобряване на координацията и физическата активност при подрастващите.

В друго изследване, публикувано в Frontiers in Psychology е изследван ефекта от въздействието на координационната двигателна програма върху баланса при 5-годишни деца. След 10-седмична интервенция, включваща паркур, игри и последователни станции, децата в експерименталната група показват значителни подобрения в динамичния баланс, измерен чрез Y Balance Test. Това подчертава важността на координационните упражнения в ранна възраст за развитието на двигателните умения.

Стрийт уоркаут и повишаването на физическата активност.

Изследване, публикувано в списанието Society. Integration. Education., анализира въздействието на стрийт уоркаут върху физическата активност на ученици. След

включване на стрийт уоркаут програма, се наблюдава:

- *увеличение* с 20.2% на учениците, които редовно посещават спортни клубове;
- *увеличение* с 12.8% на учениците, които започват да се занимават с физическа активност у дома;
- *увеличение* с 13.5% на учениците, които започват да правят сутрешна гимнастика.

Все пак трябва да се има предид, факта че този вид спортна практика изисква специфични спортно-физически качества. Например когато всеки от практикуващите от дадена общност или група може да се справи със собственото си тегло, Street-Workout може да изглежда достъпен. Въпреки това простото издърпване на собственото тегло може да бъде сложно дори за отдадените на спорта хора. Това е изключително взискателна дисциплина, чиято основна цел е да развие сила, баланс, координация и гъвкавост, а не издръжливост или експлозивност. Това я превръща в нишов спорт, практикуван най-често от млади и много спортни хора, предимно мъже. [4]

Обикновено се смята, че тази практика предпазва младите хора от кварталите или "гетата" от попадане в престъпна среда, поради което понякога се нарича "тренировка в гетата". Всъщност в интервю за уебсайта étudiants.ch [4] *Allan Muller*, докторант по темата за SW, обяснява, че по време на изследванията си често се сблъсква с популярни дискурси, които свързват практиката с градски контекст на непривилегировани групи, "поради което стрийт уоркаутът се нарича “тренировка в гетото". Тази негативна идентификация се защитава от пионери като Ханибал Фор Кинг[7], икона на практиката според уебсайта litobox [9]. Той е публична личност, която е спомогнала за демократизирането на стрийт уоркаутът чрез многобройните си видеоклипове с ефектни изпълнения, публикувани в Instagram, Facebook и други социални мрежи. Публикувани от 2008г. насам, те са довели до стремително нарастване на популярността на спорта.

Днес SW претърпява сериозна трансформация, която се случва далеч от трудните квартали и включва трениращи от всички социални слоеве. Тези нови хора се обръщат към SW за т.нар. « fun » културизъм, където могат да съчетаят естетическите цели с удоволствието, но също така и най-вече за упражнения на открито, които им дават известна свобода да бъдат част от градския пейзаж. Въпросът е до каква степен SW е част от градския спортен дизайн. Виждаме, че тази практика изисква малко ресурси и че като се разполага на стратегически места - места за преминаване и близо до природата - предлага активна постановка на тялото на практикуващите под формата на ефектни гимнастически фигури, които привличат широката публика и организират нови взаимодействия, благоприятстващи един нов стил на живот. [4, 6]

4. Стрийт уоркаут и тенденции в Европа [5, 6, 7, 9]

Нидерландия: Стрийт уоркаутът набира значителна популярност през последното десетилетие. Хора от различни възрастови групи тренират на открито, като в страната се наблюдава високо ниво на физическа активност сред населението. Проучване на Eurobarometer показва, че 56% от холандците се занимават с физическа активност като колоездене, ходене, градинарство или плуване седмично, което е по-високо от средното за Европа (denfit.nl). [7, 9]

Германия: От 2011 г. насам се наблюдава нарастващ интерес към стрийт уоркаут, с изграждане на специализирани паркове в градовете. Броят на тези паркове се е увеличил от 785 през 2018 г. до 1419 през 2021 г. През 2013 г. в Офенбург се проведе първото състезание "Street Workout World Cup Germany" (de.wikipedia.org).

Испания: Стрийт уоркаутът се разпространява от около 2010 г., благодарение на младежки групи и колективи. Те организират събития, работят с общините и провеждат обучения в училища и младежки организации, което допринася за социалната интеграция чрез спорта (es.wikipedia.org).

По-ниска е популярността на стрийт уоркаут в Югоизточна Европа: В страни като България, Румъния, Полша и Кипър се наблюдава по-ниска честота на упражнения за укрепване на мускулите, включително стрийт уоркаут. Проучване показва, че само 0.7% до 7.4% от възрастните в тези страни практикуват такива упражнения два или повече пъти седмично (pubmed.ncbi.nlm.nih.gov)

Общи тенденции в Европа

Скандинавските страни: Исландия, Швеция и Дания показват най-високи нива на участие в упражнения за укрепване на мускулите, с честота между 34.1% и 51.6% (pubmed.ncbi.nlm.nih.gov).

Източна Европа: В страни като Полша, Украйна и Естония има установени общности, практикуващи стрийт уоркаут, често използващи съоръжения, останали от съветската ера. През последните години се изграждат модерни паркове за калистеника, което допринася за нарастващ интерес към този вид тренировки (calisthenics-parks.com).

III. ЗАКЛЮЧЕНИЕ

Стрийт уоркаутът (ърбан спортс (спортове в градска среда)) набира все по-голяма популярност за хората живеещи в градската среда. Това е сособенно значим вид физическа активност, към която все повече млади хора се присъединяват. По този начин се създафат навици на двигателна култура, социализация и дисциплина и в други аспекти на живота на, а и не само, младите хора.

От друга страна трябва да се има предид, факта че този вид спортна практика изисква специфични спортно-физически качества. Които трябва да се поощряват в развитието си в дългосрочен план. Това може да бъде занимание, както с индивидуален характер, така и групово. Привлекателността на тази спортна практика е в нейната особенна социална компонента — тренировките се провеждат често в групи и създават усещане за общност и принадлежност. Освен физическите ползи, тези тренировки могат да подобрят и социалните умения, като същевременно развиват лидерски и организаторски качества.

Възможностите за развитието стрийт уоркаутъта в България са с добър потенциал. Страната се намира в пояс с четири сезона, което позвлява практикуването на спортове открито през по-голямата част от годината. Заедно с това по редица програми за развитие на градска среда в градовете се изграждат все повече съвременни спортни площадки, съоръжения и комплекси на открито, които подпомагат равитието на този вид спортна дейност. По този начин стрийт уоркаутъта може да заеме един не малък дял при развитието и поддържането на физическа и двигателна активност, спортния начин на живот и положителното мотивираща социална среда.

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POLYMINERAL MICROPUZZOLAN ADDITIVE FOR COMPOSITE LOW ENERGY BINDERS

ПОЛИМИНЕРАЛНА МИКРОПУЦОЛАН ДОБАВКА ЗА КОМПОЗИТНИ НИСКОЕНЕРГИЙНИ СВЪРЗВАЩИ ВЕЩЕСТВА

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Abstract: *The article discusses the problem of increasing the water resistance and strength of a composite gypsum binder for concrete. The effect of complex modification of a composite gypsum binder with a micro-reinforcing, polymineral micropuzzolanic additive filler and superplasticizer from Sika was investigated. The use of filler additives in optimal ratios made it possible to obtain a composite gypsum binder with a softening coefficient of 0.9.*

Key words: *concrete, increasing the water resistance and strength of concrete, gypsum binder for concrete, additives for concrete*

Резюме: *Статията разглежда проблема за повишаване на водоустойчивостта и якостта на композитно гипсово свързващо вещество за бетон. Изследван е ефектът от комплексната модификация на композитно гипсово свързващо вещество с микроармиращ, полиминерален микропуцоланов добавъчен пълнител и суперпластификатор от Sika. Използването на добавки за пълнене в оптимални съотношения позволи получаването на композитно гипсово свързващо вещество с коефициент на омекване 0,9.*

Ключови думи: *бетон, повишаване на водоустойчивостта и якостта на бетона, гипсово свързващо вещество за бетон, добавки за бетон*

I. INTRODUCTION

Energy efficiency, resource saving, lower operating costs and increased housing comfort is a priority in construction practice. Development trends of the modern construction industry are focused on increasing competitiveness, developing and introducing new technological solutions that provide resource and energy saving, high technical, economic and consumer indicators of product quality. The optimization of product quality indicators is ensured through the use of durable, sound, high-quality building materials. An important requirement is the environmental friendliness of building products, which can be achieved through the use of appropriate materials and compliance with the closed-cycle technological mode [1].

The materials of this type relates gypsum concrete - concrete based composite gypsum binder [2-4]. Gypsum materials and products are advanced building materials due to the simplicity and low energy consumption of production. For

the production of 1 ton of gypsum binder, 4.5 and 4.9 times less fuel and electricity are used than for the production of 1 ton of Portland cement. The hardening time of a gypsum binder is 20–25 times less than that of Portland cement; a set of design strength for products based on gypsum binder is 30–40 times faster than that based on Portland cement. In addition, materials containing gypsum are high-tech, because already 15-20 minutes after the product is formed, it can be removal of formwork, because of this the mould reusability increases in 8-10 times, and manufacturing techniques are less energy-consuming in contrast to the use of other types binders, including Portland cement.

Ukraine has sufficient reserves of natural gypsum raw materials and a huge amount of gypsum-containing waste. One of the disadvantages of gypsum binders is the low water resistance. One of the modern effective ways to increase water resistance can be a modification of the structure of the binder with polymineral microdispersed filler additives [5-7].

The use of new types of volumetric hydrophobizators will provide a further improvement in quality. The compositions of hydrophobizators are available in the form of concentrates or ready-to-use solutions in aqueous or organic solvents. They create a water-repellent effect, while the vapor permeability of such composites is practically not reduced. The introduction of water repellents does not change the color of the product, hydrophobization significantly increases the frost resistance of any material. These properties allow the use of water repellents for composite gypsum binder.

II. MAIN TEXT

1. Objective

To development of a complex of highly dispersed polymineral additives, a micro-reinforcing filler additive and a superplasticizer for a composite gypsum binder with improved properties.

2. Research Objectives

-selection and justification of the components of a complex polymineral micropuzzolanic additive and micro-reinforcing filler additives for composite gypsum binder;

- selection of the ratio of the finely divided components of the complex polymineral micropuzzolanic additive and the micro-reinforcing filler additive for the composite gypsum binder using experimental statistical modeling methods based on the mathematical theory of experimental design;

- evaluation of the interdependent on water resistance and compressive strength of the composite gypsum binder complex of a polyfunctional modifier, and a volume hydrophobization.

3. Materials and research methods

The following components were used as binder components: building gypsum G5 produced by PJSC Gypsum, cement pozzolanic non-additive produced by OJSC Euro Cement Ukraine PC-I-500D0 according to DSTU B B.2.7-46: 2010.

To obtain a composite gypsum binder, highly active metakaolin TU U 14.2-36363275-001: 2009 manufactured by LLC Meta-D, silica fume produced by Elkem AS EN 13263 – 1 as active pozzolanic additives were used.

Wollastonite TU 5777-006-40705684-2003 of different dispersion produced by Geocom CJSC was used as a micro-reinforcing additive.

Sika ViscoCrete 225 superplasticizer proshka VP SIA 162 (1989) and prEN 934-2, manufactured by Sika trademark, was used as an additive of retarder.

Composite gypsum binders' samples were tested for strength at the age of 28 days according to DSTU B B.2.7-187: 2009, followed by drying to constant weight. The determination of the softening coefficient was carried out according to TU 21-0284757-90.

4. Planning a Six-Factor Experiment

The choice of the experimental plan for solving specific materials science problems is dictated by the specific conditions of these problems and the requirements for the results of their solution. For the purpose of work, a 24-point plan in the form of "triangles on a cube" was applied. The use of MTQ plans is subject to the following provisions. Used to obtain modified composite gypsum binders, additives modifiers and fillers are mixtures with q various substances of different microdispersion.

The composition of such mixtures can be specified by the concentrations of the components in the form of mass, volume or molar fractions (percent) $\underline{v}_i$. Systems whose properties are determined by the group of dependent mixed factors $\mathbf{v} = (v_1 \dots v_q)^T$ and

the group of independent technological factors $\mathbf{x} = (x_1 \ldots x_k)^T$, are called systems "composition, mixture - properties" or "composition - technology - properties" and are designated by the abbreviation MTQ. To describe MTQ systems, an experimental statistical (EU) model is used, which has a general view:

$$\mathbf{Y} = \underbrace{\begin{bmatrix} A_1v_1+A_{12}v_1v_2 \\ A_2v_2+A_{13}v_1v_3 \\ A_3v_3+A_{23}v_2v_3 \end{bmatrix}}_{(a)} + \underbrace{\begin{bmatrix} D_{14}v_1x_4+D_{15}v_1x_5+D_{16}v_1x_6 \\ D_{24}v_2x_4+D_{25}v_2x_5+D_{26}v_2x_6 \\ D_{34}v_3x_4+D_{35}v_3x_5+D_{36}v_3x_6 \end{bmatrix}}_{(b)} + \underbrace{\begin{bmatrix} b_{44}x_4^2+b_{45}x_4x_5 \\ b_{55}x_5^2+b_{46}x_4x_6 \\ b_{66}x_6^2+b_{56}x_5x_6 \end{bmatrix}}_{(c)} \quad (1)$$

Experimental-statistical (ES) models are calculated according to the results of experiments using a standard version of COMPEX, which implements a sequential regression analysis with a generating experimental error. ES models can be used for decision-making only after the algebraic calculation of coefficient estimates is supplemented by statistical analysis of both individual coefficients and the model as a whole. Statistical control makes it possible with a given degree of probability to evaluate the significance of the experimental results and the adequacy of the resulting model to the real process.

Experimental-statistical (ES) models are graphically interpreted as triangles (v_1, v_2, v_3 – variable specific surface or fractional composition) on a cube of three prescription factors, applied to obtain new scientific information about the structure-forming role of mineral fillers and organic additives. The formation and development of space-time structures in open disperse systems is determined by the irreversibility of processes and associated with phase transitions of components when the system reaches some critical parameters [8,9].

The task of analyzing the structure is quite complex, characterized by a set of various structural parameters. This complexity is due to the diversity and inconsistency of the development of elementary physical and chemical processes. The interactions of these processes in the future determine the level of properties of composite materials [10,11]

Open disperse systems, which are characterized by a nonlinear synthesis of hydrate formation, are characterized by the effects of synergistic interactions [12,13]. Experimental-statistical (ES) modeling allows us to assess the degree of interaction between different types of additives used in research.

5. Analysis of experimental results on experimental statistical models

At this stage, the change in water resistance and compressive strength of the composite gypsum binder is described and analyzed.

ES models of the influence on the properties of composite gypsum binder additives of various types and purposes, taking into account the interactions between them, are calculated in the PC COMPEX program [14,15]. The program implements a sequential regression analysis with an experimental error of not more than $S\{R\} = 0{,}04$ at $\alpha = 0{,}02$.

Compressive strength. The full ES model (2), which describes the effect of the studied factors on compressive strength, has the following form:

$$\mathbf{Y}(f_{cm}) = \underbrace{\begin{bmatrix} +13.44v_1+3.43v_1v_2 \\ +11.96v_2\pm0v_1v_3 \\ +13.07v_3\pm0v_2v_3 \end{bmatrix}}_{(a)} + \underbrace{\begin{bmatrix} \pm0v_1x_4-0.71v_1x_5-0.93v_1x_6 \\ -0.79v_2x_4-0.61v_2x_5+0.70v_2x_6 \\ -1.45v_3x_4-0.62v_3x_5-0.87v_3x_6 \end{bmatrix}}_{(b)} + \underbrace{\begin{bmatrix} \pm0x_4^2\pm0x_4x_5 \\ -0.68x_5^2-0.62x_4x_6 \\ -1.09x_6^2\pm0x_5x_6 \end{bmatrix}}_{(c)} \quad (2)$$

The graphical interpretation of the model (2) is presented in Figure 1 in the form of mixed triangles in coordinates (v_1, v_2, v_3) on a quadratic diagram in coordinates (x_4, x_5). The content of additive-superplasticizer by Sika (x_6) was fixed at 0.1%; 0.6%; 1.1% levels.

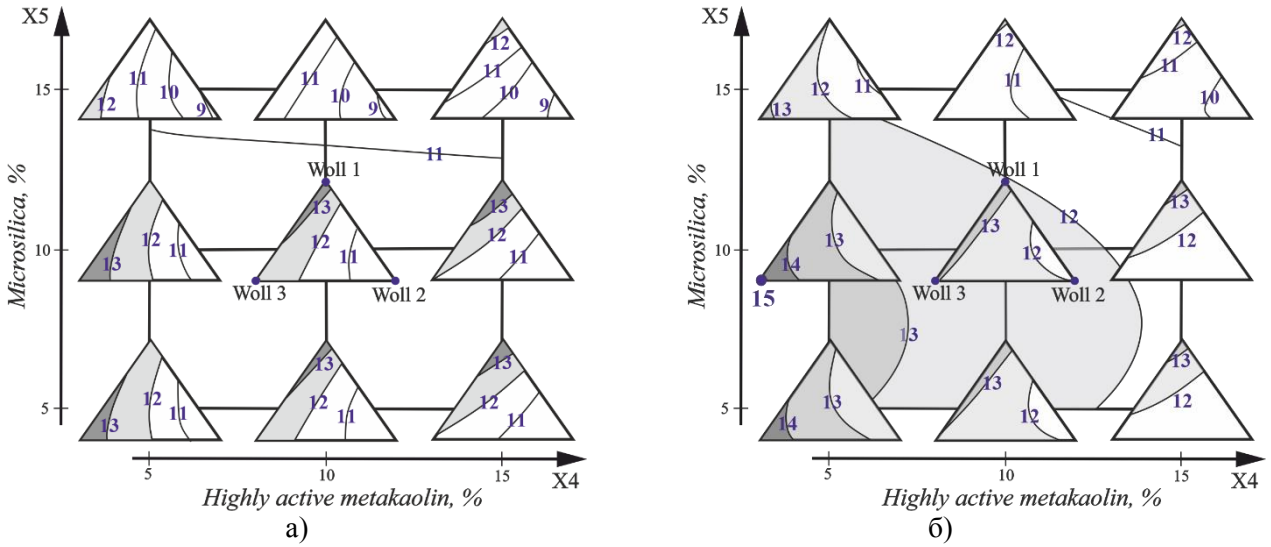


Figure 1. The effect of polymineral micropuzzolanic additives, micro-reinforcing filler additives (wollastonite) on the compressive strength of a composite gypsum binder.

The effect of the three fractions of wollastonite is illustrated on graphical images of ES models in the form of triangular diagrams. The needle-shaped form of wollastonite grain determines the main direction of its use as a micro-reinforcing filler. The physico - chemical affinity of wollastonite with composite building materials containing cement promotes active selective adsorption of binder hydration products, has a significant effect on rheological parameters, structure formation, strength and deformation properties of hardened composites.

Triangular diagrams show the effect on the properties of three dependent factors (v_1, v_2, v_3). These are dependent factors that are interconnected. The total content of all three components (Woll 1, Woll 2, Woll 3) remains constant, i.e. ($v_1 + v_2 + v_3 = 1$). Triangular diagrams located on the square of the analyzed property, in this case R_{cr}, allow you to choose the best fractional composition of wollastonite, the content, the ratio of two or three fractions to each other.

The effect on the properties of micropuzzolanic filler additives is graphically interpreted as isolines on the square of two factors x_4 → (highly active metakaolin), x_5 → (microsilica). The content of highly active metakaolin as well as microsilica varied experimentally in the range of (10 ± 5) %.

Micropuzzolanic filler additives are highly pozzolanic. Microsilica has pozzolanic activity of 350 – 450 mg of bound lime per 1 g of microsilica. Highly active metakaolin, due to the content of active alumina, is able to bind a significantly larger amount of lime than silica fume. Its activity reaches more than 1000 mg of bound lime per 1 g of highly active metakaolin. The introduction of these additives into the composition of the composite gypsum binder should provide early and prolonged strength.

The high-quality superplasticizer on polycarboxylate base by Sika Visco Creit, which consists of specially synthesized chemically pure substances, was introduced to improve workability, reduce water demand and slow down the setting time of the composite gypsum binder.

As follows from the diagram in Figure 1, the maximum value of compressive strength is equal to R_{str}=14.5÷15.0 MPa. The obtained strength value is two to three times higher than the applied gypsum binder grade G-5. Portland cement PC-500-D0, non-additive in the amount of 21% from ∑ (G+PC), was used as the second component of the composite gypsum binder.

The obtained maximum values of f_{cm}^{max} are achieved when the content of Sika plasticizer in the amount of 0.1 – 0.6% (from b.m.), the minimum

content of highly active metakaolin = 5% and the content of microsilica in the amount of 5 – 10% (from b.m.). Woll 3 wollastonite has a positive effect on R_{str}. The appending of wollastonite in the mixture increases R_{str} from 13 – 13.5 to 14.5 – 15.0 MPa, i.e. by 10 – 12.5%. Moreover, an increase in the content of Sika additive more than 1% reduces f_{cm}^{max} by ~ 12% to 12 – 13 MPa.

Water resistance. At the next stage, an analysis of the change in water resistance by the value of the softening coefficient K_p under the influence of micropuzzolanic additives, micro-reinforcing modifier additives and Sika superplasticizer was carried out. The range of variation of all additives is limited by the experimental plan.

The change in water resistance of composite gypsum binder under the influence of the above additives is described by the model (3):

$$\mathbf{Y}(K_p) = \underbrace{\begin{matrix} +0.676v_1+0.209v_1v_2 \\ +0.711v_2+0.432v_1v_3 \\ +0.690v_3-0.437v_2v_3 \end{matrix}}_{(a)} + \underbrace{\begin{matrix} \pm 0v_1x_4-0.033v_1x_5+0.069v_1x_6 \\ +0.071v_2x_4-0.037v_2x_5\pm 0v_2x_6 \\ +0.027v_3x_4-0.071v_3x_5-0.071v_3x_6 \end{matrix}}_{(b)} + \underbrace{\begin{matrix} \pm 0x_4^2-0.057x_4x_5 \\ -0.033x_5^2\pm 0x_4x_6 \\ +0.056x_6^2\pm 0x_5x_6 \end{matrix}}_{(c)} \quad (3)$$

A graphical interpretation of the model in the form of two diagrams (triangles on a square) with a fixed content of additives Sika in the amount of 0.6 and 1.1% is presented in Figure 2.

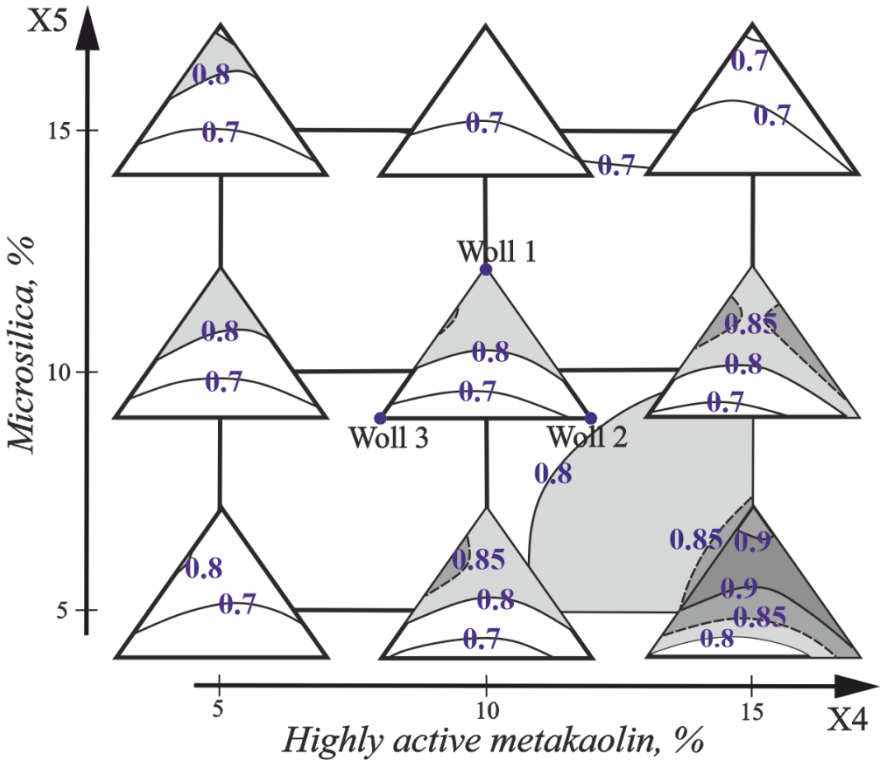


Figure 2. The effect of polymineral micropuzzolanic additives, micro-reinforcing filler additives (wollastonite) on the water resistance of a composite gypsum binder.

The softening coefficient varies in the range from 0.6 to 0.92. Most of the compositions of 24 series of samples are waterproof, because their softening coefficient is 0.8 – 0.92. The required conditions for research problems softening coefficient value obtained at the maximum $K_p \geq 0.85$ content metakaolin high activity in an amount from 10 – 15% m. c. microsilica content 5 – 10% of m.v. and subject to the content in the mixture of wollastonite a certain fraction. The fractional composition of wollastonite for different mixtures is different for different contents of Sika superplasticizer. The compositions, which in the framework of the experiment have the maximum values of water resistance K_p = 0.9 – 0.92, were obtained when 15% of highly active metakaolin and 5% of microsilica were added to the composition of composite gypsum binder. The content of Sika is 0.1 or 1.1% by weight. The choice of the fractional composition of wollastonite remains the task of the technologist and is assigned taking into account the levels of other properties and the conditions of the multicriteria optimization problem [16].

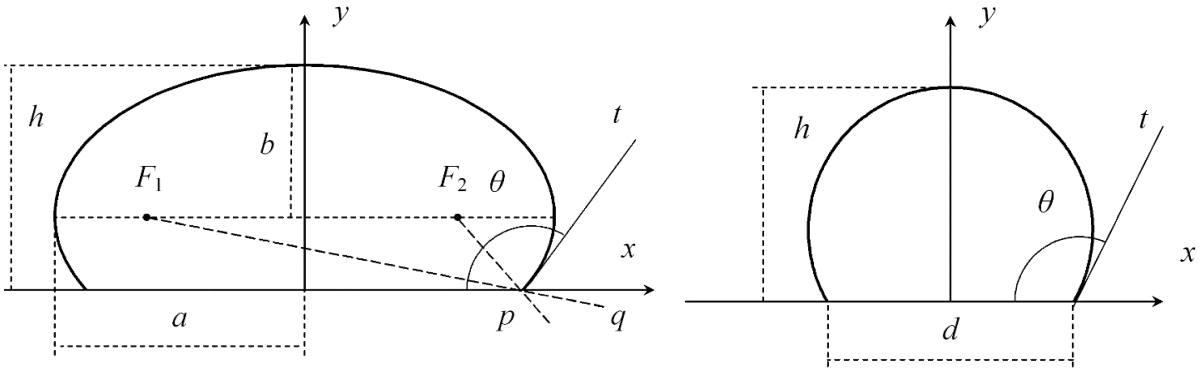
As follows from the analysis of the diagrams (Fig. 1-2), compositions that have a maximum compressive strength of 14.5 – 15.0 MPa are characterized by low water resistance K_p = 0.7 – 0.75. Compounds that have a maximum water resistance of K_p = 0.85 – 0.92 have R_{str} = 9.5 – 12.5 MPa.
In accordance with the purpose of the study, for further analysis of the properties, samples with $K_p \geq 0.85$ were selected. The strength of samples with such values of the softening coefficient is equal to R_{str} = 9.5; 10.5; 10 – 12.5 MPa with the content of Sika superplasticizer in the amount of 0.1%, 0.6% and 1.1%, respectively.

The values of the softening coefficient $K_p \geq 0.9$ have compositions that contain superplasticizer Sika = 1.1%, highly active metakaolin = 15%, microsilica = 5%. That is, the specific surface area of the microreinforcing additive of wollastonite (Woll), acting as a structure modifier, is an effective factor that allows you to adjust the properties of composite mixtures in a wide range and should be assigned taking into account the content of microfillers.

The choice of the wollastonite fraction remains the task of the technologist. It is possible to use monofraction wollastonite (Woll 2 = 1), bifraction wollastonite (Woll 1 + Woll 3 = 1) or (Woll 1 + Woll 2 = 1), or polyfraction wollastonite (Woll 1 + Woll 2 + Woll 3 = 1). The choice of the fraction of wollastonite may be due either to the technological capabilities of the preparation of mixtures, or to indicators of the quality of other properties.

6. Analysis of the effect of water repellents on the water resistance of a composite gypsum binder.

At the next stage of the study, the possibility of a further increase in water resistance due to volume and surface water repellents was analyzed.



a) b)

Figure 3. The shape of the droplets lying on a flat hydrophobic surface:
a) – "heavy" drop; b) – "small" drop;
θ – limiting contact angle, t – tangent to the meridian section of a drop at the point of separation of the three phases.

To evaluate the effect of water-repellent primers on the surface properties of samples from a gypsum binder, we measured the wetting angle by the method of a lying drop (sitting drop method). The shape of a drop resting on a horizontal flat surface in a gravitational field (Fig.3a) is axisymmetric and is described by the Young – Laplace equation (Young–Laplace) [17]:

$$\rho g y + \sigma \cdot \left(K(y) - K(h)\right) = 0, \qquad (4)$$

where ρ is the density of the liquid, g is the acceleration of gravity, σ is the surface tension of the liquid (specific free energy of the liquid-gas interface), $K(y) = \frac{1}{R_1(y)} + \frac{1}{R_2(y)}$, $R_1(y)$ и $R_2(y)$ – principal radii of curvature of the surface of the drop at the ordinate point y,

$K(h) = K(y)\big|_{y=h}$, i.e. on top of a drop.

Equation (4) has no analytical solution; therefore, numerical methods are used to calculate the droplet shape with high accuracy and to find the contact angle.

Small droplets under the action of capillary pressure are able to maintain a spherical shape (see Figure 3b). In this case, the contact angle can be easily found from elementary geometry θ. A drop can be considered small if its weight is much less than capillary pressure; the radius of a small spherical droplet r must satisfy the dependence

$$r << \sqrt{\frac{2\sigma}{g\rho}}$$

(here the gas density is considered negligible compared to the density of the liquid). Estimates show that this approximation is applicable to water droplets ($\sigma \approx 0.072$ N/m) with a radius of about 0.4 mm or less.

For larger droplets of radius

$$r \le \sqrt{\frac{2\sigma}{g\rho}}$$

(up to 3.5 mm) their meridian section can be approximately considered as a segment of a conical section - an ellipse [18]. In this case, measuring the sizes of the semiaxes of the ellipse a and b (see Fig. 3a), it is easy to determine the positions of its characteristic point F_1 and F_2, then find the equations of the focal radii p and q connecting the foci of the ellipse with the point of separation of the three phases. The bisector of the external angle formed by the intersection of these focal radii will be the tangent t to the meridian section of the drop at the interface between the three phases. The angle of its inclination, which is easy to calculate, knowing the equations for p and q, is complementary to the desired angle θ.

In the experiment, the size of the liquid droplets is determined by the inner diameter of the dropper channel. In our case, it was 0.53 mm (with an outer diameter of the needle 0.8 mm). The masses of droplets of distilled water produced by the dropper were measured on an analytical balance. The needle used formed droplets with an average weight of 15.6 mg. The radius of the corresponding spherical drop is approximately equal to 1.55 mm, which, obviously, exceeds the criterion of smallness of the drop. To analyze the shape of such a drop, we decided to use the conical section method.

For photoregistration of the droplet shape on the test surface the CANYON CNR WCAM820 web camera with a resolution of 1600 × 1200 pixels was used. The standard camera lens was replaced with an optical system composed on the principle of a microscope. The field of view of the frame was about 9 mm, the image scale was determined using an object micrometer and was 5.75 μm / pixel. Two LED illuminators with brightness controls made it possible to combine oblique reflected and transmitted lighting to establish the optimal image contrast at the phase boundaries. During working with water-absorbing samples, the camera switched to video mode with a resolution of 800 × 600 pixels and with a frame interval of 100 ms.

The image obtained by the camera was saved on a computer and analyzed using a graphical editor. In the graphical editor an ellipse that satisfactorily coincided with the contour of the drop was selected. After that, the sizes of its semiaxes, the coordinates of the center and the coordinates of the points of separation of the three phases was read, then the contact angle was calculated by the method described above.

Figure 4 shows a drop of distilled water on the surface of a sample that has not been primed. The surface of the sample is hydrophilic, as evidenced by a contact angle of less than 90 °. Water spreads and is absorbed by a gypsum binder: the drop on the figure

shows at various time intervals that have passed since the moment of contact.

a) b) c)

Figure 4. A drop of water on the surface of the untreated sample after the onset of contact: a) – 0.4 c (θ = 83°); b) – 2.0 c (θ = 72°); c) – 5.0 c (θ = 62°)

Water-absorbing surfaces can be characterized, in addition to the contact angle, by the rate of absorption through a single contact surface. The absorption rate can be estimated by the decrease in droplet volume over time, if the evaporation rate can be neglected, which is acceptable at a high absorption rate.

The calculation of the droplet volume was carried out under the assumption that the droplet is a truncated ellipsoid of rotation. It is easy to show that in this case the volume V is determined by the height of the droplet h and the dimensions of the semiaxes of its meridian section:

$$V = \pi a^2 \cdot \left(h - \frac{b}{3} + \frac{(b-h)^3}{3b^2} \right) \quad (5).$$

The experiments showed that the droplet absorption rate into the samples can be considered high, because during the time of complete absorption, the volume of the control drop on the metal surface remained unchanged within the measurement error.

On untreated samples, the contact angle decreases during the first two seconds of contact from 86° to 72°, but the drop volume remains unchanged within the measurement error, therefore, only the drop spreads. The start of absorption is recorded by us from the 3rd second. The maximum absorption rate is 5–6th second and amounts to 0.017 $g \cdot cm^{-2} \cdot s^{-1}$. The total absorption time of the droplet varied in the range of 12-30 s with an average contact area of 0.15 cm^2.

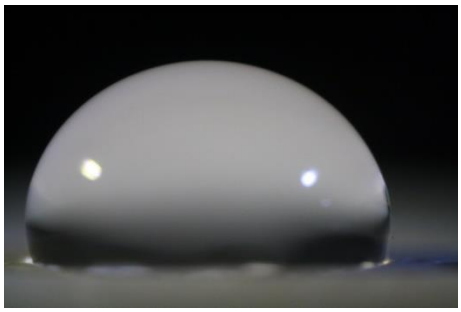
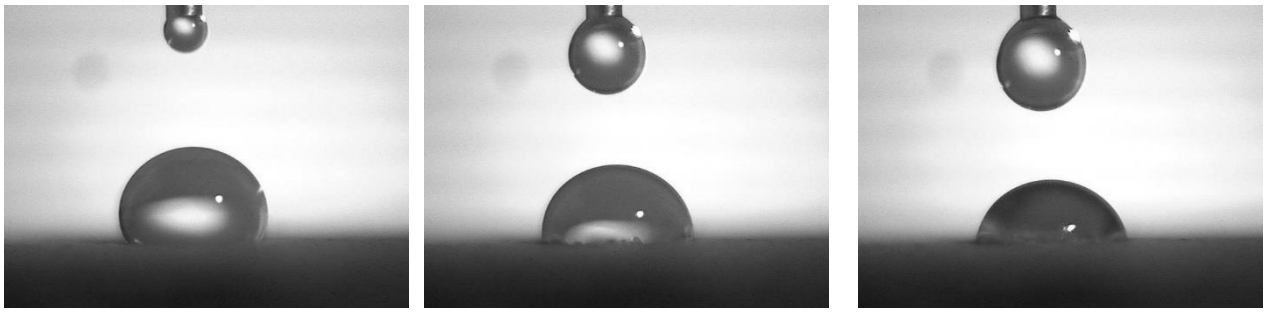


Figure 5. A drop of water on a sample surface treated with a hydrophobic prime

Figure 5 are shown drop of distilled water on the sample surface treated with a hydrophobic primer. The surface of the sample acquired hydrophobic properties: the contact angle for water exceeds 90°. On these surfaces was not observed the spreading and absorption of a drop.

The average contact angle for gypsum surfaces treated with PGK-12S and PGK-24 primers is, respectively 129 ± 7° and 130 ± 5°. Taking into account the specified error, these contact angles of wetting can be considered the same, thus, primers PGK-12S and PGK-24 demonstrate the same efficiency in relation to hydrophobization of the gypsum binder surface. A slightly worse result is given by the WHITE primer, for which the average contact angle was 121 ± 4 °.

The hydrophobizing primer introduction into the volume of a gypsum binder at the mixing stage without subsequent sample surface treatment leads to a different result. Fig. 6 shows the evolution of a distilled water drop on the surface of such a sample.



а) б) в)

Figure 6. A drop of water on the surface of the sample with WHITE primer added to the volume of the binder after the onset of contact: a) – 1.0 c (θ = 122°); b) – 3.9 c (θ = 90°); c) – 7.0 c (θ = 81°)

Immediately after the drop hits the surface and stabilizes its shape, the contact angles of wetting take on values exceeding 90°, which is typical for hydrophobic surfaces. The drop does not spread on the surface, and the area of the contact spot does not increase. However, the drop is absorbed into the sample volume. As the droplet volume decreases while maintaining the area of the contact spot, the contact angle decreases, and after a short time takes on the values characteristic of hydrophilic surfaces.

III. CONCLUSION

An analysis of the results of the study allows us to conclude that the proposed composition of the multifunctional modifier allows to obtain a waterproof modified composite gypsum binder with a softening coefficient Kp≥0.9 on gypsum grade G-5, rather than gypsum grade G-10 used for concrete concrete.

It was shown that the complex modification of a composite gypsum binder on gypsum of the G-5 grade and Portland cement PC500-D0 with micro-micropozzolanic and micro-reinforcing filler additives and Sika superplasticizer in optimal proportions allow to obtain a composite gypsum binder with a softening coefficient of 0.9. That is, the specific surface area of the micro-reinforcing wollastonite additive, acting as a structure modifier, is an effective factor that allows you to adjust the properties of composite mixtures over a wide range and should be assigned taking into account the content of micro-fillers.

Volumetric hydrophobization provides an additional increase in compressive strength and water resistance. Further studies are aimed at obtaining and optimizing multifunctional modifiers with a wide spectrum of action.

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