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THE CONSTRUCTION OF THE FUNCTION OF THE ULTIMATE GOAL OF THE TECHNOLOGICAL PROCESS OF NON-AUTOCLAVED FOAM CONCRETE OBTAINING

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Abstract: This paper presents the method of solving the multicriteria problem of obtaining foam concrete with a required set of properties for each subsystem of the technological process. The General decision algorithm based on usage of lexicographic or "specified" method of purposeful search has been constructed.

1 Introduction – Technological process as a system

The process of non-autoclaved foam concrete obtaining is complex and multifactorial and it must be considered as a technological system that has the main features of complex systems [1,2].

1. Decomposition: the system is divided into a finite number of subsystems, and each subsystem, in turn, into a finite number of simpler subsystems, etc. to get the simplest elements of the system.
2. Subsystem interaction ordering: all elements of a complex system interact with each other and with the external environment.
3. The general property of complex systems is defined as an integral combination of properties and interaction patterns of constituent subsystems.
4. Performance of the main function of the system is achieved by the time-ordered performance of functions by its main elements.
5. A complex system is not stationary. As a rule the processes occurring in it depend on the time factor τ.
6. The system is nonlinear. External disturbances can have a significant effect on the result of the system.
7. The system is highly dependent on the initial conditions.

The presence of all these signs is proof of the possibility of representing the process in the form of a complex technological system "Process of obtaining of non-autoclaved foam concrete", which is divided into subsystems according to time, functioning processes, equipment grouping, etc.

A certain sequence of basic operations in the technological process suggests an obvious relationship between the subsystems. Each subsystem performs its specific work – a process, regardless of the work of other subsystems [1,3]. To ensure the compatibility of work and the integrity of the entire technological system, the results of the previous subsystem should serve as the initial conditions for the subsequent [2,4].

Based on these conditions, the system "Process of non-autoclaved foam concrete obtaining" can be represented in the form of interconnected subsystems corresponding to the main technological operations (figure 1): preparation of raw materials, preparation of form concrete mix and moulding. The last subsystem ends with the receipt of the product with the specified properties.

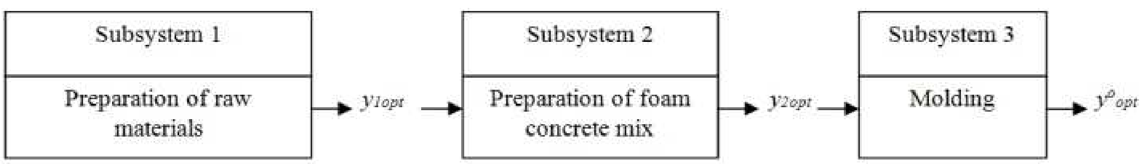

Figure 1 The linear diagram of the relationship in the system "Process of non-autoclaved foam concrete obtaining"

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For the functions y_{1opt}, y_{2opt} we take the necessary intermediate indicators of the subsystems of the technological process to obtain the final result Y^o_{opt}.

2 Method of constructing the function of the final goal of the technological process of foam concrete obtaining

To obtain the functions y_{1opt} of subsystem 1 and y_{2opt} of subsystem 2, it is necessary to formalize the functions of the influence of controlled factors on the indicators of each operation, up to the function y^o_{opt} of the entire system and to solve the multi-factor problem of determining the optimal technology for obtaining the desired building material according to the quality criteria chosen by the customer.

This means that for each subsystem it is necessary [5]:

1. To choose a specific set of k controlled factors x_k that affect the optimality criteria y_n according to customer requirements:

$$x \in [x_1, \dots, x_i]; k \in [1; i] \tag{1}$$

and to build dependencies:

$$\left.\begin{aligned} y_n &= y_n(x_1) \\ &\dots \\ y_n &= y_n(x_k) \end{aligned}\right\} \quad y_n(x_1, x_2, \dots, x_k) = y_n. \tag{2}$$

And this is provided that the factors (x_1, x_2,…, x_k) do not depend on each other.

If such a relationship exists, for example, between x_1 and x_2, then:

$$x_1 = y_0(x_2). \tag{3}$$

Then in (2) there will be not $y_n = y_n(x_1)$, but:

$$y_n = y_n[y_0(x_2)]. \tag{4}$$

As criteria of optimality y_n it is possible to distinguish intermediate quality indicators of subsystems – the components of the functions y_{1opt}, y_{2opt}, or the final indicators as a part of y^o_{opt} – the quality characteristics of foam concrete. These can be average density (ρ), compressive strength (R_b), tensile strength in bending (R_{bt}), thermal conductivity (λ), frost resistance (F), vapour permeability (μ), etc. The totality of the above characteristics makes up the vector of quality indicators of the finished product Y^o – a generalized optimality criterion by which the only acceptable solution y^o_{opt} should be chosen.

$$\overrightarrow{Y^0} = \{\rho, R_b, R_{bt}, \lambda, F, \mu\}. \tag{5}$$

2. To select a system of normalization of units of measurement of factors in order to lead to a single measurement for all (these are usually dimensionless numbers from 0 to 1) [6,7].

3. To construct functional dependencies for the control factors [8,9]:

$$y_n(x_k) = y_n\left(y_j(x_k)\right); n \in [1; q]; j \in [1; q]; n \neq j. \tag{6}$$

4. To formalize or accept the boundary conditions for the factors $a_k \geq x_k \geq b_k, k \in [1; i]$ and for the range of acceptable solutions to the customer's problem $c_n \geq y_n \geq d_n, n \in [1; q]$.

5. To assign targets – to construct objective functions with a formalization of their dependence on the selected controlled factors [10]:

$$\begin{aligned} &F_l \to max, l \in [1; q] \\ &F_r \to min, r \in [1; q] \\ &l \neq r \end{aligned} \tag{7}$$

In practice, the degree of importance of the criteria is established by agreement with the customer.

There are several variables (x_1, x_2, …, x_k) for evaluating the quality of foam concrete. They can be assigned or be given a range of valid values for each individually. Binary dependencies can be built from experiments by processing the response data by a statistical method:

$$\left.\begin{aligned} &y_1 = f_1(x_1) = f_2(x_2) = \dots = f_n(x_i) \\ &\dots \\ &y_n = f_n(x_1) = f_{n+1}(x_2) = \dots = f_{n+i}(x_i) \end{aligned}\right\} \tag{8}$$

Any criterion y_n, $n \in [1; q]$ can be taken as the objective function, and a number of its extremums can be found from the conditions of x_k: $y_n' = 0, n \neq k$. For each criterion y_n it is possible to find the zone of admissible values, knowing the values of extremums from (8).

For each y_n, it is easy to determine the most influential parameter of all x_k, $n \neq k$. Let it be x_g.

And, if this x_g is the most influential, then the rank of x_g is the highest, i.e.:

$$x_g \succ \text{ the rest.} \tag{9}$$

Similarly, to continue the series (9), the second, more important of the remaining criteria, is found similarly, the third is found and so on to the last. But the customer can name and create a number of priorities. Then, for (9), the parameters to the left of the ordered one do not play a role and can become restriction conditions. The maximum or minimum of x_g is known from (8), and the values for the remaining y_n, $n \neq g$ at the extremum can be also determined from (8) and compared with the other customer requirements.

If they are in the zone of permissible values, then the problem is solved, if they do not there, then a compromise is required: a concession on x_g.

A compromise between the optimality criteria implies that the one is permissible to lose, but the other is acceptable to add.

With the compromise, the problem becomes definable and it is a mathematical model of the system:

$$\left.\begin{array}{l} \alpha_1 y_1 + \alpha_2 y_2 + \cdots + \alpha_q y_q = Y^o \\ \sum_{q=1}^{N} \alpha_q = 1; \alpha_q \geq 0. \end{array}\right\} \quad (10)$$

Y^o is a generalized optimality criterion that the units are normalized in such a way that all y_n at $n \in [1, q]$ tend simultaneously to either the maximum or the minimum. The generalized criterion can be obtained in the record as a function of any one variable using binary dependencies (8):

$$Y^o = f(x_i) = \alpha_1 y_{1q}(x_i) + \alpha_2 y_{2q}(x_i) + \cdots + \\ +\alpha_i y_{qq}(x_i). \quad (11)$$

The ratio (11) needs to be supplemented:

$$\left.\begin{array}{l} Y^o = f(x_1) = \cdots \\ Y^o = f(x_2) = \cdots \\ \ldots \\ Y^o = f(x_k) = \cdots \end{array}\right\} \quad (12)$$

For each line we are looking for *extr* $f(x_k)$, i.e. Y^o. The acceptability of the solution is checked by a real experiment, the results of which clarify the compromise between the optimality criteria, i.e. values of α_q. When Y^o is accepted as the only, albeit generalized criterion for evaluating the quality of a material, it is itself a complex function $Y^o = f(x_k)$. The compromise estimates the degree of influence of each x_k on Y^o.

In other words, although at Y^o the task is single-criterion and makes it possible to find Y^o_{opt}, it leads to a new problem: to find the domain of all y_n under the condition $Y^o_{opt} = const$. Then we define sets of values for each y_n. This set of values will determine the scope of acceptable solutions:

$$\left.\begin{array}{l} y \in \{y_n\} \\ Y^o_{opt} = const \end{array}\right\} \quad (13)$$

The correct set of y_n satisfies the equality $\sum_{q=1}^{N} \alpha_q = 1$. Thus, the calculation experiment significantly narrows the scope of the search for acceptable solutions to the customer. The importance of choosing the essence and the number of controlled factors and optimality criteria for each subsystem of the technological process becomes apparent.

3 Conclusions

Thus, the technological process of non-autoclaved foam concrete obtaining has been constructed according to the formulas (1)-(13), which we will consider as stages of the technological process. According to (13), each stage is easily programmed and its values are obtained by changing the parameters. Therefore, the technological process can also be programmed as a whole. And this will already be a program of the calculation experiment. The calculation experiment is based on the principle of determining the rates of influence of parameters on the output properties of foam concrete.

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