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TO A QUESTION ON A RELIABILITY OF CONTROL DURING A CONCRETE MANUFACTURING

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ABSTRACT

In this article is estimated a reliability of an observance of the technology of manufacturing of products from concrete with taking into account errors of measurement devices. It is established, that even if all measured values of parameters lay inside allowable limits, actual values of parameters of a quality of a production can be outside of allowed limits.

KEYWORDS: Reliability of Control, Error of Measuring Device, Probability, Concrete Products

INTRODUCTION

For buildings' and constructions' safety, parameters of quality of building materials and products should correspond to an established norms (admissions), for example:

$$x \geq x_{\min};$$

$$x \leq x_{\max}; \tag{1}$$

$$x_{\min} \leq x \leq x_{\max}$$

Any output for borders of the admission is considered transgression**.** It is known, that any process of manufacturing is connected to variations of its parameters caused by a plenty of factors influencing it. Many various factors can influence volatility of results of measurements, including:

- An operator;
- Used equipment;
- A calibration of an equipment;
- Parameters of an environment (temperature, humidity, air pollution, etc.);
- Time intervals between measurements.

For an estimation of an observance of a technology, a control service carries out entrance, operational and acceptance quality control. Meanwhile, there is an uncertainty of a judgment on a measured value. Measurement devices fix values of factors and of course there can be devices' errors. That is why an actual value of factors can be out of a necessary range.

At an estimation of a reliability of the control of a frame technology is offered using entropy as a quantitative measure [1]. It is shown, that the ratio between a range of change of a factor and a range of an error of a device allows to receive a measure of an uncertainty of judgment about observance of requirements of the frame technology. Let's take as an example a manufacture of concrete products (concrete wall stones). Let's consider an influence of an error of devices of measurement on probability of reception of a qualitative product. Let's consider only a part of a monitoring system - an acceptance control of finished goods. Let $y_i (i = 1,2...n)$ parameters of quality, n - a number of parameters $u_i^{НД}$, $u_i^{ВД}$ - minimal and maximal allowable values which are set in normative documents [2,3,4]. The technology is considered performed if actual values of sizes at the bilateral admission satisfy to restrictions

$$u_i^{НД} \le u_i \le u_i^{ВД} \quad i = 1,2..n \tag{2}$$

A number of parameters of a quality can include different sizes regulating the technology. All of them are registered by devices which have errors of a measurement, therefore on an output of a device measuring a factor u_i, there is a size τ_i - a measured value u_i

$$\tau_i = u_i \pm \varepsilon(u_i) \tag{3}$$

where $\varepsilon(u_i)$ - an error of a measurement.

It is received with the account (2) and (3)

$$u_i^{НД} \le \tau_i \pm \varepsilon(u_i) \le u_i^{ВД} \quad i = 1,2..n \tag{4}$$

or

$$u_i^{НД} \pm \varepsilon(u_i) \le \tau_i \le u_i^{ВД} \pm \varepsilon(u_i) \quad i = 1,2..n \tag{5}$$

Normalized parameters of the quality wall concrete stones include a mark of stones, sizes, a humidity, a frost resistance, deviations from straightforwardness of edges, a number of beaten off and dulled edges and corners on one product, etc. This is according to GOST 6133-84 “Wall concrete stones. Technical conditions”. Let's calculate probability of the observance of the technology at the account only some parameters of the acceptance control, namely, durabilities, sizes, humidity. The numerical values of controllable parameters and the errors of measurement of the devices, recording these parameters, are resulted in the table.

Table 1

The Parameters of Quality	**The Borders of the Admission**		**The Devices and the Equipment For Measurement**	**The Error of Measurement**	**The Conditional Probability**
	Bottom $u_i^{НД}$	**Top** $u_i^{ВД}$			
Durability, kg/square sm	200	250	The hydraulic press GOST 28840	±2%	0,996
The length, mm	386	394	The steel ruler GOST 427	1mm	0,968
The width, mm	187	193	The steel ruler GOST 427	1mm	0,957
The height, mm	184	192	The steel ruler GOST 427	1mm	0,9684
The humidity, %	0	12	The balance GOST 24104	±0,1%	0,9952
The General Probability					**0,8924**

Let's consider, that a change of parameters of quality of concrete stones submits to the normal law of distribution, and an error of a device - to the uniform law of distribution. Let's designate through $P(u_i)$ - density of probability of distribution of values of parameters of quality; $P(\varepsilon)$ - density of probability of distribution of an error; $P(u_i/\tau_i)$ - density of distribution of conditional probability of hit of a measured size in an allowable limit. The conditional probability is the probability of a hit of a random variable u_i in the set interval provided that its measured value τ_i gets in the set interval. The conditional probability $P(u/\tau)$ was calculated via the formula

$$P(u_i/\tau_i) = \frac{1}{\Delta u_i} \int_{u^{НД}}^{u^{ВД}} P(u_i \in [u_i^{НД} ; u_i^{ВД}] / \tau_i \in [u_i^{НД}; u_i^{ВД}]) P(u_i) du_i \quad (6)$$

It was supposed during the calculation of the probability of the observance of the technology, that the parameters are independent from each other. The probability of system of independent sizes was calculated as product of probabilities of these sizes:

$$P(u/\tau) = P(u_1/\tau_1) P(u_2/\tau_2) ... P(u_n/\tau_n) \quad (7)$$

At the normal law of distribution the probability of a presence of size u_i in an interval $u_i^{НД} \le u_i \le u_i^{ВД}$ was defined in view of the Laplas function [5,6,7] via the formula

$$P(u_i) = \Phi(\lambda_2) - \Phi(\lambda_1) \quad (8)$$

We recognized that an output for the top limit of the admission it is not considered spoilage at an estimation of probability of hit of a parameter of durability in an allowable interval. If a measured value τ_i gets in an interval from $u_i^{НД} + \varepsilon$ to $u_i^{ВД} - \varepsilon$ than the value of probability of this event is equal $P(u_i/\tau_i)$ =1. If value τ_i gets on an end of an interval $u_i^{НД}$ or $u_i^{ВД}$ the probability of this event is equal $P(u_i/\tau_i)$ = 0,5.

The value of the probability $P(u_i/\tau_i)$ on the end of the interval $u_i^{ВД} + \varepsilon$ and $u_i^{НД} - \varepsilon$ is equal $P(u_i/\tau_i)$ = 0. On the site from $u_i^{НД} - \varepsilon$ to $u_i^{НД} + \varepsilon$ probability $P(u_i/\tau_i)$ will grow from 0 to 1, and on the site from $u_i^{ВД} - \varepsilon$ to $u_i^{ВД} + \varepsilon$ - to decrease from 1 to 0. The graphic interpretation is shown on the Figure 1.

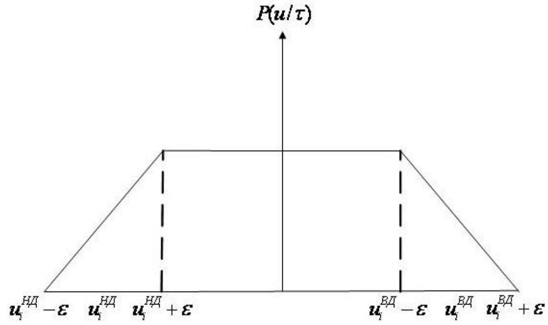

Figure 1: The Conditional Probability of the Hit of the Measured Value of a Random Size in the Allowable Interval

The results of calculation, performed according to above mentioned formulas, show that reliability of observance of the technology of manufacturing of wall concrete stones, evaluated with the account only for 5 parameters of quality, is 0.8924 (the table). The last means, that if all measured values of parameters lay inside allowable limits actual values for 10.76 % of products could appear out of the allowed limits. With the account of other parameters, evaluated during the entrance operational control, reliability of observance of technology will be much less. This implies a conclusion about a necessity of an increase in accuracy of measurement devices and increase of reliability of the control.

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