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Main Tasks of Metrological Support of Modern Moisture Measurement and Estimation of Uncertainty of Materials Humidity Measurement Results

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ABSTRACT: The article deals with scientific, technical and regulatory issues of metrological support of materials humidity measurement. The work is based on issues that are devoted to improving the efficiency of metrological support of humidity measurement. Recommendations and scientific basis for improvement of metrological support of humidity measurement have been developed. Metrological, technical and operational characteristics of modern measuring instruments designed to measure humidity of various agricultural and food products have been analyzed. Uncertainties of moisture meters and results obtained by experimental results were estimated by calculation. The main sources of uncertainty of measurement of moisture content of materials have been determined and methods of improving accuracy and reliability of measurement results have been developed. Indirect methods of measuring the humidity of materials have been analyzed and scientific recommendations for calibration and calibration of the humidity meter have been given.

KEYWORDS: Metrological support, moisture, humidity measurements, measurement uncertainty, scientific basis, technical basis, organizational basis, normative basis, measurement accuracy, measuring instruments for humidity measurement, metrological characteristic of instruments, normalized metrological characteristic, actual metrological characteristic, material humidity, absolute humidity

I. INTRODUCTION

Modern measurement processes of agricultural materials and food products require control and measurement devices that control humidity with high accuracy. One of the important tasks of metrological support of technical progress is creation and introduction of devices of materials humidity control, improvement of metrological support of materials humidity control primarily because the moisture index affects physical, mechanical and chemical properties of the material.

II.LITERATURESURVEY

Scientific publications [1-8] analyzed and investigated certain moments of metrological support of material moisture measurement. The literary review shows that metrological support of measurement of moisture content of materials depending on the kind, variety and other specifics of the material has its own features. In this area, the improvement of scientific, technical and regulatory issues of metrological support plays an important role.One of the main criteria of product quality is humidity of used materials, affecting technological, consumer, operational and other properties of materials, products and structures. The range of materials used in industrial materials and food products is extremely diverse, including composite, bulk, fibrous and other types of materials. Related to this circumstance is one of the problems of development, production and metrological support of working equipment for measuring moisture content of materials. The problem is, on the one hand, the economic impracticability of producing a family of the same type of moisture meters of private application, for example, one for raw cotton, the other for grain, the third for food, etc. The alternative is to produce a universal (in the broad sense of the word) moisture meter, which solves all practical problems of moisture measurement without exception. It seems that a reasonable compromise is needed to solve this

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problem, for example, a basic model of the moisture meter of materials, complete, depending on the needs of the consumer, with different sensors, different sets of calibration dependencies and different measurement methods.

III. SYSTEMATIZING BASIC REQUIREMENTS AND CHALLENGES

Metrological support means the establishment and application of scientific and organizational bases, technical means, rules and norms necessary to achieve uniformity of measurements (measurement results should be expressed in legalized units of values) and the required accuracy of measurements. Fig.1 shows the basis of metrological support at measurement of materials humidity.

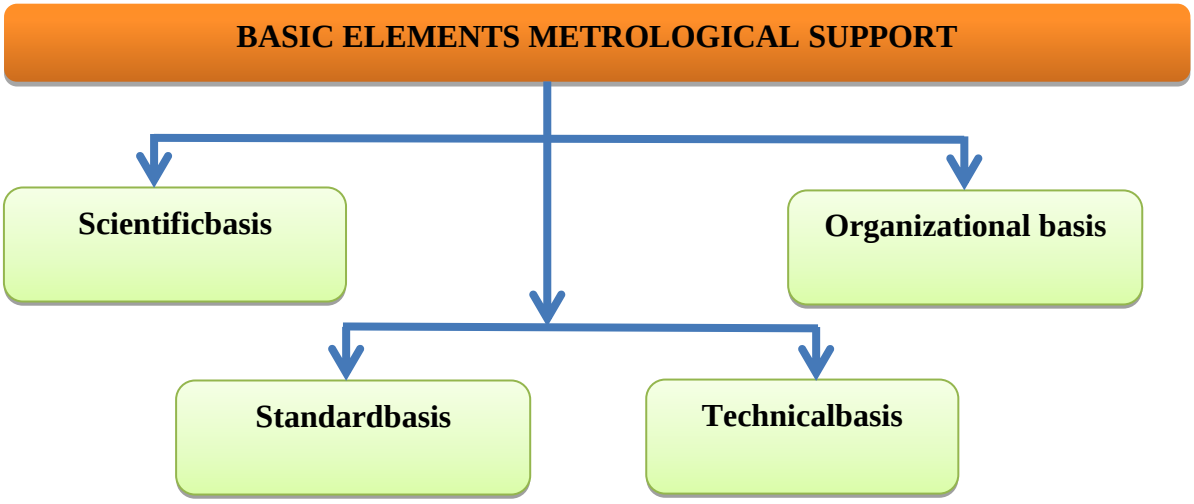

Fig. 1. Metrological support structure for materials humidity measurement

The scientific basis of metrological support is metrology, i.e. measurement science. The regulatory basis of metrology is the State System for Ensuring Uniformity of Measurements. The technical basis of metrological support is a complex of state metrological systems. For example, a sample humidity meter or operating moisture meter. The organizational basis of metrological support is the network of state and departmental metrological services. The purpose of metrological support at measurement of materials humidity is aimed at ensuring accuracy and uniformity of measurements.

The modern development of moisture measurement is characterized primarily by high accuracy of measurements and continuous search for new technical solutions, which allow to take into account in the measurement process all the acting factors and ensure simplicity of the used means along with high speed of operation. The physical essence of the moisture determination process remains unchanged: the analyzed material containing moisture is compared with some model value (for example, dehydrated analyzed material) and an unknown parameter is determined from the comparison results.Devices for monitoring the parameters of agricultural materials are usually a multi-channel system where the number of measuring channels can reach several hundred. Thus, a modern device is a multi-channel system with a large number of measuring channels. The measuring part includes a primary transducer, normalizing transducers, a measurement signal processing unit, an analog-to-digital transducer, etc. All elements of the information and measuring system have certain instrumental uncertainties, and have a direct impact on the total error of the measurement result.

The process of obtaining primary measurement information on humidity is represented by function $W = f(x, y, z)$. The accuracy and informatively of material parameters are influenced by destabilizing factors.It should be noted that the measurement process is characterized by the presence of a significant number of influencing factors on the accuracy of measurement results: a large number of internal links between factors and their complex mutual influence on the process; Besides the useful signal (W), influence the process quite a lot of

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uncontrolled ($Z_1, Z_2, Z_3 \dots Z_m$) and unmanaged factors ($X_1\ X_2\ X_3 \dots X_k$) that play an important role in the reading of the wet measuring device (Y) (fig.2.).

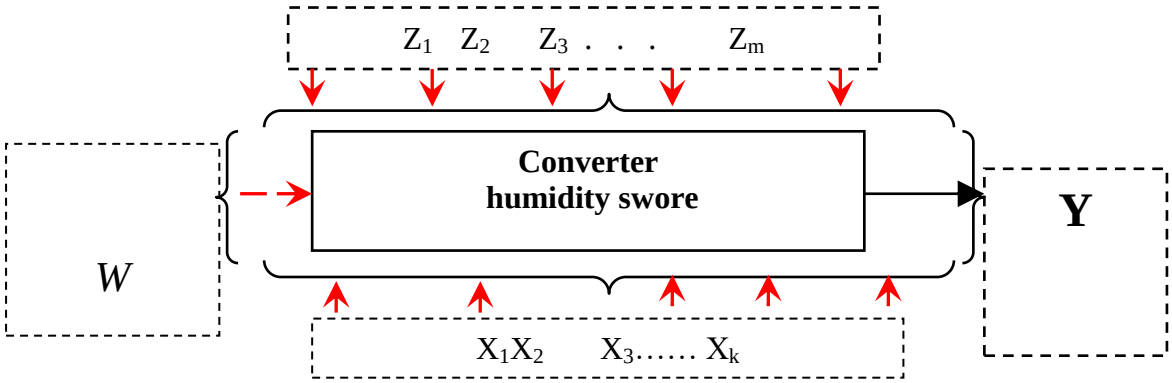

Fig. 2. Process of material humidity measurement information generation

IV.RESULTSANDDISCUSSION

When measuring humidity grain according to the established procedure. The measurement results are shown below. Metrological and technical characteristics of the moisture meter "Grain humidity meter -100" model has the following main characteristics:humidity measurement range (0-25)%;maximum absolute error of the device - 1%; additional temperature error factor - 0.1;Discreteness (uncertainty quantization) 0.05%.

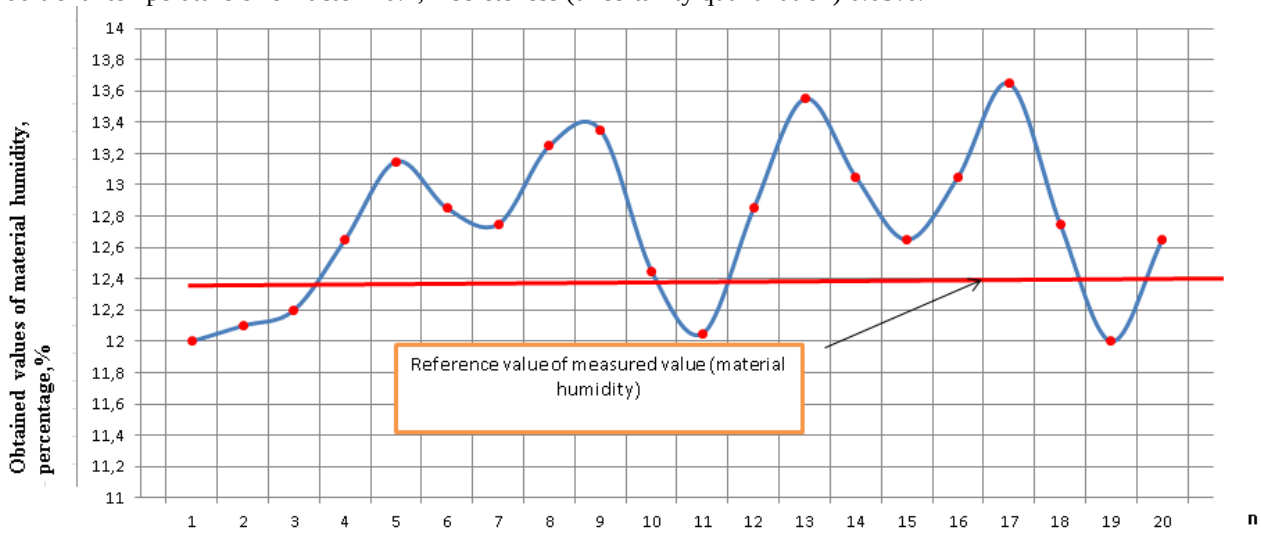

Fig. 2. Dissipation of the obtained results during measurement of material humidity

We estimate the extended uncertainty of the experiment when measuring the moisture content of the grain.

1 stage.We define uncertainty by type A specially developed software that works in Uzbek (Fig. 3)

$$u(x) = \sqrt{\frac{\sum_{i=1}^{n}\left(x_i - \bar{x}\right)}{n \cdot (n-1)}} = 0{,}1133\ \% \qquad (1)$$

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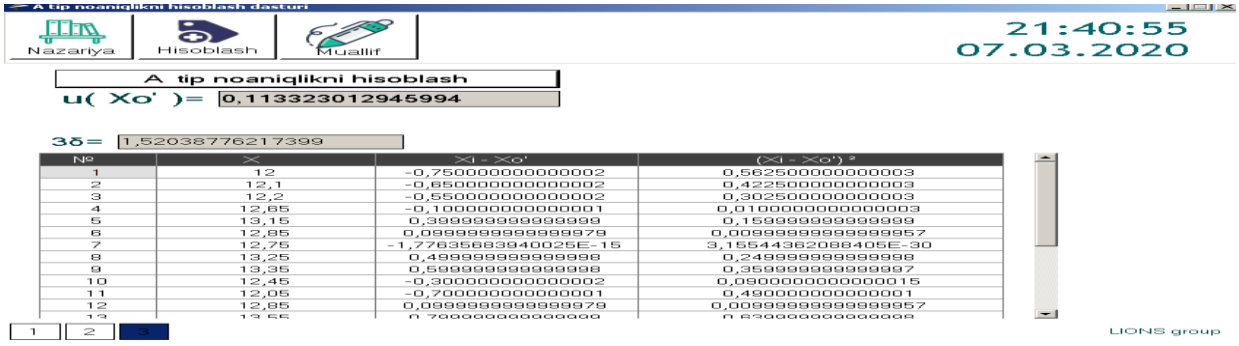

Fig. 3. Software for calculation of uncertainty by type A during measurement of material moisture by multiple means (n = 20 - number of measurements)

2stage. Find the maximum value of the basic absolute error:

$$\Delta_{max} = \pm\frac{K \cdot D}{100} = \frac{1\% \cdot 25\%}{100\%} = 0{,}25\% \tag{2}$$

Uncertainty caused by temperature deviation from normal temperature (T_1=20 ^oC) - additional absolute error at temperature T_2=38 ^oC. The value of this parameter is calculated by formula (2).

$$\gamma_1 = \pm 0{,}1 \cdot \left(38\,^oC - 20\,^oC\right) = \pm 1{,}8 \tag{3}$$

$$\Delta_t = \pm\frac{\gamma_1 \cdot D}{100} = \pm\frac{1{,}8 \cdot 25}{100} = \pm 0{,}45\% \tag{4}$$

Find standard uncertainty (for basic error):

$$u_1 = \frac{0{,}25}{\sqrt{3}} = 0{,}1443 \tag{5}$$

Find standard uncertainty for additional absolute temperature error:

$$u_3 = \frac{0{,}45}{\sqrt{3}} = 0{,}2598\ \% \tag{6}$$

We find standard uncertainty quantization of the measuring device:

$$u_2 = \frac{0{,}05}{\sqrt{3}} = 0{,}0288\ \% \tag{7}$$

Correlation: None of the input values are considered correlated with others to any significant extent. Calculate the total uncertainty of the output value

$$u_s = \sqrt{u_a^2 + u_1^2 + u_2^2 + u_3^2} = \sqrt{(0{,}1133)^2 + (0{,}1443)^2 + (0{,}2598)^2 + (0{,}0288)^2} = 0{,}32\ \% \tag{8}$$

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We will draw up a budget for the uncertainty of measurements.

Inputvalue	Assessment of entrance size	Standard uncertainty	Freedom degree number	Probability distributions of input value	Sensitivity index	Uncertainty contribution
Humidity of material	12,4 %	0,1133 %	19	Normal law of distribution	1	0,1133 %
Main absolute error	-	0,1443	∞	Uniform law of distribution	1	0,1443
Additional error of temperature	-	0,2598	∞	Uniform law of distribution	1	0,2598
Quantization error	-	0,0288	∞	Uniform law of distribution	1	0,0288
Output size	Assessment of output size	Standardtotaluncertainty	Effective number of degrees of freedom	Levelofcredibility	Coverage coefficient	Expanded uncertainty
W	12,4 %	0,32	19	P=0,95		

Estimate the extended uncertainty for the 0.95 confidence level.

Define the extended uncertainty of the measurement result as for trust loss 0.95:

$$U = k \cdot u_c(f) \tag{9}$$

Where k - is the coverage coefficient defined by the Velch-Sattersweet formula as the Styudent coefficient with the effective number of degree of freedom v_{eff}.

$$v_{eff} = (n-1) \cdot \left(\frac{u_s}{u_A}\right)^4 = 19\left(\frac{0,32}{0,1133}\right)^4 = 1200,8 \tag{10}$$

Let's calculate that k=1.96. Extended measurement uncertainty is:

$$U = k \cdot u_c(f) = 1,96 \cdot 0,32 = 0,62 \tag{11}$$

At present, in the field of metrological support of moisture measurements of agricultural materials there are a number of important issues related to theoretical research, development of methodological and regulatory technical documents, development of modern humidity control devices and their technical bases. Taking into account the actual position of moisture measurements of agricultural materials having important economic values of humidity control, it is necessary to note the priority tasks of moisture measurement:

- Develop a single method and a model installation for measuring the moisture content of a specific product of the agro-industrial complex to ensure verification and calibration of working moisture meters with an error of about 0.5%;
- Develop conditions for sample preparation and methods for the transfer of moisture units from the sample plant to the working moisture gauges with minimal loss of accuracy.

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V.CONCLUSION

Inconclusion, one of the main metrological requirements for model measures is that the uncertainty of the moisture meter with its certified characteristic should be 3-5 times less than the uncertainty of the calibrated measure. The level of metrological support of humidity measuring instruments for agricultural materials under conditions of their production and operation is significantly lower than the level of development of modern humidity control devices. Therefore, the creation of scientific, technical, regulatory and organizational bases for metrological provision of agricultural materials corresponding to the current level of moisture measurement in this area is an urgent task, on the solution of which the unity and reliability of humidity measurements, which is one of the rated indicators of quality of products of the agro-industrial complex, depends to a large extent.

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