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MEASURED PROPERTY OF OBJECTS IN ANALYTICAL MEASUREMENTS

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Abstract: *The paper presents analytical measurements for the study of the object under investigation, while the property of the measured objects is considered. Aspects of measurement aimed at defining the physical properties of the physical value, including the purpose and concept of measurement were defined, which includes the study or evaluation of any properties of the object in analytical measurements.* The *results of experiments for valid objects are presented that are determined by infinite number of properties to obtain measurement results that are adequate to the measurement purpose. For that certain properties of objects are regarded as measured values that are essential for the chosen target, i.e., select the model of the object is chosen.*

Keywords: *measurement, measurement object, analytical measurements, objects properties, physical value, qualitative composition, quantitative concentr ation, macroproperties.*

Introduction

The most important part of analytics is the correct determination of the *measured property of the measured object.* It would seem that the right answer to this question should have been a well-known conventional definition of the term "physical quantity", where the "property" would be the main one. However, such an attempt to solve the above issue of how it belongs to physical quantities is unsuccessful, since it was not possible to find a correct definition of the generic concept "property" from metrological viewpoint neither in specific rules nor in special literature. In the course of various discussions about its content, there is no hint about fundamental concept of "property", its essence is not revealed in this aspect, which seems to be wrong.

1. Statement of the problem

The goal of any natural-scientific technique is, ultimately, to comprehend the essence of the nature of a certain matter. This essence is reflected by a set of properties of the object under investigation. We will proceed from the fact that, the reason for the properties of a particular thing, as well as their change, lies in the interaction of the elements that form the thing. From a physical viewpoint, any measurement object property happens to be its inner disposition and appears as a response of the trial object to any predetermined and controlled external influence.

2. Concept of resolving the problem

Information about the substance is based on the equation:

$$\hat{w} = -\hat{x}F , \qquad (1)$$

where $\hat{w}$ – perturbation operator; $\hat{x}$ – operator of a given physical quantity; F – perturbing generalized force acting on the object of investigation.

As $F \rightarrow 0$, the system is described by the Hamiltonian:

$$H = H_o + \hat{w} \quad (2)$$

where H_o is the Hamiltonian of the unperturbed system.

Note: The Hamiltonian (the Hamilton function) is the sum of operators of energy of free fields and the energy of their interaction.

wherein we get:

$$\hat{x} = \frac{\partial H}{\partial F} F^{-1}, \quad (3)$$

The function $\hat{x} = f\ (H,F)$ is called the *generalized susceptibility* . Equation (3) in the most general form represents the corresponding physical property of matter. Through the generalized susceptibility $\hat{x}$ it is characterized by the ratio between the external force *F* and the change of its internal state *H*. Therefore $\hat{x}$ is a source of knowledge about the nature of matter and, depending on the nature of the perturbing force *F*, isolates and reflects the corresponding (interesting) property of matter.

All the variety of properties observed in a substance is usually distinguished by nature of the conditioning that drive these properties of physical fields, i.e. thermal, mechanical, electrical, magnetic and electromagnetic fields. They belong to the category of the main properties, thereby setting a certain hierarchy of the observed properties of matter. Such a notion of property appear to be consistent with universal description of interaction, which includes the observation object more precisely a certain part of its internal energy (represented by a Hamiltonian $H_{o)}$ perturbing field F (a cause) and response - reflection <*x*> (which is a consequence). With this approach, all the observed properties can be derived from the formalism of generalized reproducibility. For example: heat capacity

$$C = \frac{S}{T} = -\frac{\partial H}{\partial T} T^{-1}, \quad (4)$$

elasticity

$$\xi = -\frac{\partial H}{\partial V} V^{-1}, \quad (5)$$

dielectric susceptibility

$$\varepsilon = -\frac{\partial H}{\partial E} E^{-1}, \quad (6)$$

and so on.

In its essence, the generalized susceptibility is a quantitative measure of the interaction of a substance with the corresponding perturbing field. Thus, the property is identified with the physical quantity obtained in the experiment (heat capacity, elasticity, e.t.c.).

3. Implementation of the concept

A property that can be identified as a result of a physical experiment is called a *measurable property*. That is why the essence of any analytical technique of measuring the composition is regarded as a certain power impact on the object of measurement and quantitative and qualitative fixation of its response to this effect (Fig. 1).

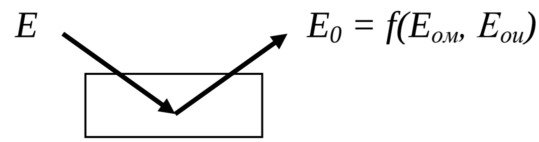

Fig.1. ***General diagram of the analytical method of measurement.***

It is important that the energy of a substance described by its Hamiltonian is the only source and starting point of any knowledge of the properties of matter and its essence. And the deepening of knowledge about the properties of matter is associated with the differentiation of energy.

Proceeding from the foregoing, the whole set of properties of any physical system can be generalized, based on the general Euler equation for internal energy:

$$dU = TdS + PdV + JdL + HdM + FdE + + \boldsymbol{\Sigma\mu_i\, dN_i} + \ldots \quad (7)$$

As for analytic quantities, the problem can be analyzed rigorously using the classical Gibbs equation:

$$dU + PdV - TdS = dH - TdS = dG \equiv = \Sigma\mu_I\, dN_I \equiv \Sigma\,(dG / dN_I)\, dN_I \quad (8)$$

where T is temperature, S is the entropy, P is pressure, V is volume, J is the mechanical stress, L is the deformation, H is the magnetic field strength, M is the total magnetization of the body, F is the electric field strength, E is the electric potential, μ - chemical potential, N - amount of substance of the system or its components.

Generalizing the equation (7) we obtain:

$$dU = \Sigma(Э_B)_i = \Sigma(P_э P_u)_i, \quad (9)$$

In equations (7 and 8), each term expresses a specific kind of internal energy $(E_B)_{i:}$ and therefore characterizes a definite macro-property of the system: TdS thermal, PdV - mechanical, HdM -magnetic, JdL - deformational, FdE – electric properties and so on.

The term μdN reflects the *chemical* property of the system. This can be shown as follows: when dN_i is i^{th} substance, it receives $\mu_i dN_i$ chemical potential energy. Therefore, μ called the *chemical potential of* matter or the *Gibbs molar energy*. In this term, if the monosystem is meant, N is the absolute quantity of the substance, and in the case of the polysystem - the relative amount of the substance of the i^{th} component: $\Sigma n_i = \Sigma C_{nni} = 1$. Since the subject of the analysis are mixtures, we will then discuss the concentration of $C_{nn} = n_i = N_i / N$, where N_i and N are the amount of the substance of the i^{th} component and the system, respectively. Thus, $n_i = C_{nn}$ characterizes the intensity of manifestation of the chemical properties of mono- or poly- system. But that is not all.

Each macro-property is expressed by the product of intensive parameter and the differential of the corresponding extensive one. As is known, the former includes parameters independent of, and to the second dependent on the amount of matter N. This means that C_{nn} affects all macro-properties, and therefore reflects not only its own individual, specific chemical property, like other quantities, but also characterizes quantitatively the *intensity of* manifestation of all properties of the measurement object, and therefore is not only a function, but also an argument of the property.

Proceeding from the above and on the basis of the analysis of equations (7 and 8) we make the following assumptions:

1. Since all the terms of these equations are indisputably physical quantities, it should be assumed that $C_{nn} = n_i$ is also one.

2. In contrast to other (industrial) physical quantities, C_{nn} characterizes not only one specific chemical property (μdN), but it also expresses the intensity of all (or at least the majority) of the measured properties of the system. This manifests its peculiarity, on the one hand, and the insufficiency of the accepted interpretation of the concept of "physical quantity" as properties on the other. And this circumstance cannot be considered a sufficient reason to exclude it from the category of physical quantities.

3. The intensity of the manifestation of a property object of measurements depends not only on the size of n_i, but also on the nature, type of those components, the substances that make up the system, i.e., its qualitative aspect. This means that C_{nn} is three-dimensional physical quantity in contrast to most other physical quantities which are one-dimensional.

Any measured property (conductivity, specific heat, magnetization, etc.) are directly related to the composition of the object under study. In this sense, the analysis process, as a kind of measurement, "serves" other types of measurements. Therefore, the definition of the second component (qualitative) should be included in analytical measurement information, since in all cases it is unambiguously predetermined already in the formulation of the measurement problem. This is inherent only during [to] analytical measurements, this is their second fundamental feature and it must also be reflected in the construction of a system for ensuring the uniformity of measurements.

Therefore, there are two subtasks of analytics: finding the *qualitative* (composition) and *quantitative* (concentration) values of the object of measurement.

This is another fundamental feature of analytical measurement information.

A graphic illustration of this is spectroscopy, as one of the main tools of analytics. Here, the qualitative aspect, i.e., the nature of each detected component of the measurement object is reflected by the position of the energy absorption line on the frequency scale of the spectrum of the electromagnetic irradiation, whereas the quantitative aspect is reflected by intensity of the absorption peaks.

The multidimensionality of the displayed C_{nn} properties is illustrated by well-known equations describing physical and chemical laws. So n = C_{nn} is a characteristic of the thermodynamic property in the equations of the thermodynamic state:

$$(P - nB)(P + \frac{am^2}{V^2}) = nRT \ , \qquad (10)$$

and

$$\frac{PV}{nRT} = \left[1 + \frac{n}{V}B(T) + \left(\frac{n}{V}\right)^2 C(T) + ...\right], \qquad (11)$$

– chemical in equation of chemical affinity

$$\Phi(E)dA = \frac{\sum(\mu_{oi} + RT \ln \gamma_i C_i)dC_i}{RT\sum C_i}, \qquad (12)$$

– magnetic in the Curie law equation

$$M = \frac{nDH}{T}, \qquad (13)$$

– dielectric in the Mossoti equations

$$X = \frac{\varepsilon - 1}{(\varepsilon + 2)N} \qquad (14)$$

and Kirkwood

$$X = \frac{(\varepsilon - 1)(2\varepsilon + 1)}{9N\varepsilon} \qquad (15)$$

and so on.

Conclusions

So, as we have noted above, if one use the concepts of vector algebra for clarity, we can represent the analytical measurement information conditionally as *three-dimensional*, where one coordinate reflects the qualitative, the second – the quantitative aspects of the measured property, and the third aspect, i.e., the system which the analyzed component belongs to. In this regard, qualitative and quantitative analysis represents the two sides of one measurable property. They are not opposed, but complement each other although there may be problems when it is enough to have information only about the quality side. And this circumstance should also be taken into account when one intends to design a system for ensuring the uniformity of measurements of specific physical quantities.

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