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Improving the mechanical strength and thermal stability of glassware on the basis of system analysis

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Abstract: *In terms of system analysis any property of glass is a system of correlated factors. In order to establish the factors that influence the mechanical strength and thermal stability of glass the author considers that three main blocks of factors have to be assigned: 1. Characteristics of glass and glassware, 2. Raw materials for glass production and 3. Glass interaction with environment. Every block consists of several groups and sub-groups of factors. The next stage reveals the influence of each factor on the strength of glass and its thermal stability. Then the arrangement of the factors is carried out, according to the degree of their importance. So the integral idea of the factors that influence the mechanical strength and thermal stability of glass can be obtained with the help of system analysis. Such an approach allows optimization of production of glassware with high mechanical strength and thermal stability.*

Rezumat: *Orice proprietate a sticlei de pe poziția analizei de sistem prezintă un sistem de factori cu influență reciprocă. Pentru stabilirea factorilor, care influențează asupra rezistenței mecanice și a stabilității termice autorul evidențiază trei blocuri: 1. Caracteristica sticlei și a produselor din sticlă, 2. Materii prime pentru producerea sticlei și 3. Interacțiunea sticlei cu mediul înconjurător. Fiecare bloc conține câteva grupe și subgrupe de factori. În etapa următoare se explică influența fiecărui factor asupra rezistenței mecanice și a stabilității termice a sticlei. Apoi se efectuează aranjarea factorilor după gradul lor de importanță. Astfel, cu ajutorul analizei de sistem este posibilă obținerea unei imagini integrale a factorilor, care influențează asupra rezistenței mecanice și a stabilității termice a sticlei. Abordare dată permite optimizarea procesului de fabricare a produselor din sticlă cu rezistență mecanică și stabilitate termică a sticlei înaltă.*

Keywords: *glassware, mechanical strength, thermal stability, system analysis, factor, characteristics of glass*

1. Introduction

Industrial glassware is characterized by low mechanical strength and bad thermal stability and as a result losses of production on the stage of manufacturing, transportation and exploitation reach 5 %. Various types of coating, ion exchange, etching in hydrofluoric acid, tempering and dealkalization by acid gases are used in order to increase the mechanical properties and thermal resistance of glassware [1, 2]. But such kind of approach is not always effective for mass production of glassware.

To our mind, system analysis is necessary to reveal reserves, to improve the mechanical strength and thermal stability of industrial glassware. In scientific research and engineering the system analysis is used since the second half of the last century. Nowadays the system analysis is used in different spheres of human activity: industry, construction, education, engineering, economics, medicine, war industry, etc. [3-9].

The aim of the undertaken work was reached on the basis of system analysis, which helped us to reveal the factors that influence the mechanical strength and thermal stability of glassware.

2. Analytical part

The notion of system analysis has a multipronged character.

There is no commonly accepted definition of the term “system analysis“. We believe system analysis can be defined as: “System analysis is a thorough investigation of an object in order to get an integral idea of it and to determine its relations with the other objects”. According to [6], „the main and most valuable result of system analysis is an increased degree of understanding the problem and different ways to solve it.”

The most important principles of system analysis are the following:

1) before taking decisions one must determine and clearly formulate the ultimate aims, and the criteria to assess the expected result;

2) the problem is regarded as a whole, that is as a system.

The basis of system analysis is the system approach, according to which any object is regarded as a system. Zaitsev O. S. determines the system as follows: “a system is a multitude of elements, which are in such relations and connections with each other that they contribute to its integrity and uniformity” [10]. Objects, substances, properties, notions, laws, any material or spiritual objects, etc. can act as elements of a system. Thus, it follows that the element of the system is a part of this object, performing a definite function.

The most difficult and responsible procedure in the system analysis is the construction of a generalized model that displays all the factors and their interaction, which may influence the decision making process. Up till now there is no unified approach to making a common model of factors for material objects.

In terms of system analysis any property of glass is a system of correlated factors. For the first time it is proposed to systematize factors that influence the mechanical strength and thermal resistance of glassware. The author considers that three main blocks of factors have to be assigned, which are shown in figure 1:

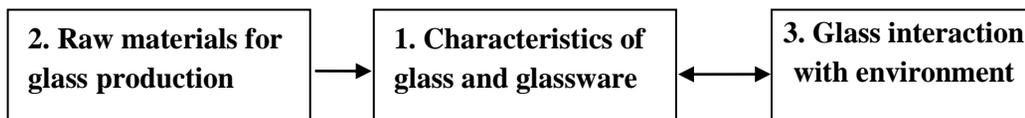


Figure1. Blocks of factors that influence glass properties

The first block includes characteristics of glass and glassware that is the properties that characterize any material object: composition, structure, homogeneity, surface properties, etc. The second block contains factors that influence the glassware production (raw materials and their transformation in glassware). The third block characterizes glassware interaction with the environment, otherwise said with other objects. Conditions of glassware operation, the environmental influence on glassware properties are referred to this block.

In its turn, each block includes several groups and subgroups of factors. The first block deciphering for mechanical strength “1.Characteristics of glass and glassware” is shown in figure 2.

Block “1.Characteristics of glass and glassware” includes 4 groups and 14 subgroups, which contain several tens of factors that the mechanical strength of glassware depends on. It is seen in figure 2 that special strengthening methods are referred to the factor subgroup “1.3.3. Structure of the surface layers”.

Figure 2 also demonstrates that special glass strengthening will become effective, when the incomplete stages in the whole technological process are eliminated. To demonstrate this we shall take an example. We have established that the mechanical strength of industrial glassware much depends on the glass melt heterogeneity index. Consequently, additional treatment of glassware cannot be effective to harden them, if the glass melt is of bad quality.

The influence of the factors subgroups 1.1.2 “Type of structure” and 1.1.3 “Structural and physical parameters” on the mechanical strength of glass is little studied.

The second block of factors “Raw materials for glass production” (raw materials, batch, glass melt and its heat treatment, glassware molding, etc.) and the third block of factors “Glass interaction with environment” (air, water, solid bodies, and others) are analyzed by analogy. There is a connection between the factors of one subgroup (group), as well as between the factors of different subgroups. For example, the glass surface depends on the thermal and chemical homogeneity of glass melt.

In the next stage we ascertain the influence of each factor on the mechanical strength of glass. For example, the way the quality of annealing influences the strength of glassware. Consequently, it is established on which factors the quality of annealing depends.

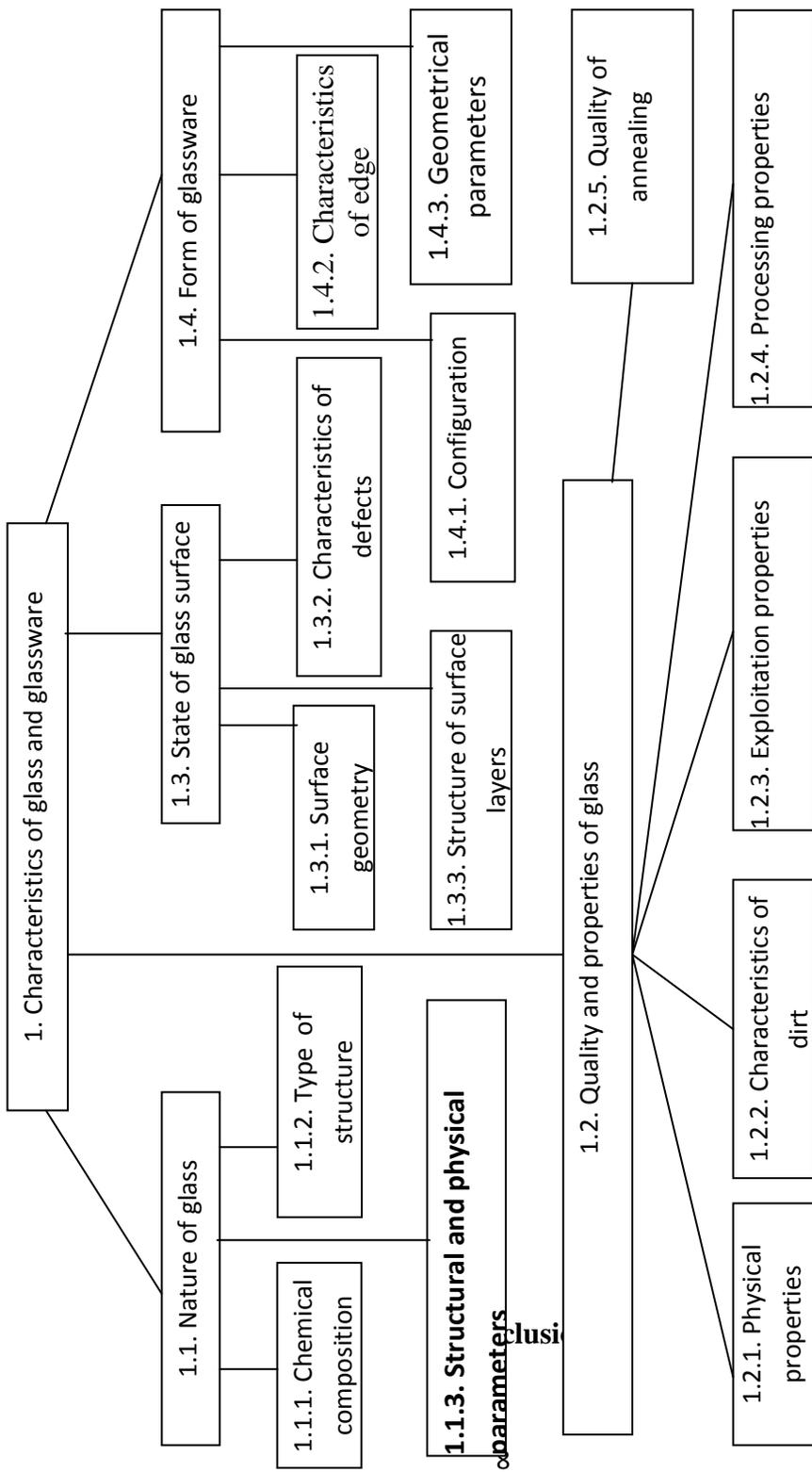


Figure 2. Groups and subgroups of factors of block “1.Characteristics of glass and glassware” that influence the mechanical strength of industrial glassware

Then, the most difficult and responsible stage comes: arranging the factors according to the degree of their importance. For this task, the quantity link between each factor and mechanical strength of glassware is established. In cases when there is no quantitative criterion, we take into account the qualitative influence of this factor on the strength of glass. It must be mentioned that there is not much information concerning the influence of many factors on the strength of industrial glassware.

Similarly, factors that influence the thermal stability of industrial glassware were determined.

The final stage is the design and execution of the taken measures to meet all the requirements at the given stage of the technological process of glassware production.

Thus, with the help of system analysis we can get **an integral representation of factors** that influence the mechanical strength and thermal stability of industrial glassware (or any other glass properties), of their mutual correlation, and one can arrange the factors according to the degree of their importance. Such an approach enables us to avoid miscalculations while manufacturing industrial glassware with required mechanical strength, and in case of necessity it is possible to correct in due time the process of glassware manufacturing.

For the first time, it is proposed to reveal the factors that influence the mechanical strength and thermal stability of industrial glassware with the help of system analysis.

Blocks of groups and subgroups of factors, which influence the mechanical strength and thermal stability of industrial glassware, are made up.

The system analysis helps us to get an integral representation of the factors that influence the mechanical strength and thermal stability of industrial glassware.

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