BUILDING EXPERT MAPS FOR ERGONOMETRIC, COMPOSITIONAL AND COLORS SCHEME EVALUATION OF MACHINE CONTROL PANELS

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ABSTRACT

In the present study, an in-depth literature analysis was made regarding the theoretical problems of signs and sign-information systems as means of visual communication, about the essence of graphic design and its possibilities for creating a sign-information system as a means of communication in the "man-machine" system. , of the means of presentation of information and control (SPI) and the control bodies (OU) and the ergonomic requirements (standards) on panels of machines during their design. Based on this analysis, a system of design and evaluation criteria was developed regarding:

- the arrangement (arrangement) of the elements of the sign-information system;
- graphic design – composition and color, graphic shapes and signs;

The following methods were employed during the research: theoretical analysis of the problems related to the sign-information systems for visual communication as well as the ergonomic requirements and the graphic design requirements for composition, colors, use of graphic forms and signs; analysis of the variants of sign-information systems, applied on panels (control and indicating equipment), conducted through a system of criteria in order to establish the advantages and the disadvantages of their design; graphical presentation of the analysis results employing frequency tables and graphical images – bar diagrams and others.

Key words: visual communication, ergonomic research, means, design, system.

INTRODUCTION

Developments in the recent years primarily focus on the ergonomic requirements concerning the design features of the various types of control and indicating equipment (indicators, controls and tell-tales) as well as the psychological features of perception – the process of decoding information (William, 2006). There is less research conducted on the problems of the element arrangement (layout) in a sign-information system and especially on the issues related to the compositional and colors solution schemes of control and indicating equipment. These ensure the artistic and the aesthetic characteristics of a given sign-information system and are to be accomplished in parallel with the functional and ergonomic requirements (Angelova, 2009).

In order to achieve optimal results, for example with machine control panels (and other sign-information systems in industrial production), it is necessary to develop certain pre-set conditions based on the most important principles and the relevant parameters and criteria. This requires application of the ergonomic requirements for panel layout (and other sign-information systems as an integral part of the control and indicating equipment) as well as application of the graphic design requirements for composition, colors, graphic forms and signs. Thus the quality of the designed sign-information systems will be optimized.

The quality of sign-information systems means compliance with the ergonomic layout and graphic design criteria (Angelova, 2008).

Sign systems are here regarded as an integral component of information. The research focuses on the most commonly used sign classifications. The psychological activities "perception" and "understanding of the information transmitted by the sign-information system" are considered part of the communicative process. Sign is regarded as a unit of information that affects the user of that information, by taking over the informativity of an object or representing its properties and relationships. The most popular classification of signs is the one built around the criterion "manner of production (origin)". It includes natural and artificial (conventional) signs.

The signs which are subject of the present study belong to the second group – artificial signs. The following system of signs is considered according to the degree of their representativeness of the object they stand for as well as the degree of presence or absence of conventionality (fig.1):

icon – image, associative image, the object is represented through similarity.

pictogram – an image associated with the directly observed real objects; according to the type of relation with the object, there are associative, associative-conventional and conventional images;

ideogram – idea, notion – represents the properties and the characteristic features of the object under investigation which remain hidden for the immediate perception;

conventional symbol – a conditional sign associated with the object only by prior agreement. Sometimes certain characteristics of the object are present.

signal – a conditional sign, instant transmission of information about the current state of the object – technical systems.

Figure 1: Required characters

The present study uses as a reference the international standard for equipment signs (ISO 7000, 2004, Angelova, 2018).

On the12 December 2001, the Council of the European Union agreed on a unified definition of design: “The appearance of the whole or a part of a product resulting from the features of, in particular, the lines, contours, colors, shape, texture and/or materials of the product itself and/or its ornamentation”(https://euipo.europa.eu/ohimportal/bg/design-definition).

Figure 2: Designation of the requirements of the safety rules with signs

Figure 3: Warning signs

THEORETICAL PROBLEMS FOR SIGN – INFORMATION SYSTEMS AS A MEANS OF VISUAL COMMUNICATION

In the course of its practical application, graphic design focuses on the colour and compositional layout of a sign-information system, as well as on the control and indicating equipment of machines in compliance with the international standards (Charlotte and Phil, 2009).

Scientists have found that the patterns and the regularities in the graphic image construction are predetermined by the individual characteristics of a human psyche such as the tendency to geometrization, bordered figures, the use of limited number of elements, strongly defined forms and susceptibility to visual illusions (fig. 2., fig. 3.). Graphic design as a technology of creating graphic images is associated with the search for adequate methods and tools, among which composition ranks first. Some of the basic characteristic features of composition can be considered the following: structure, unity (integrity), harmonic structure, boundaries (frame).

The above mentioned characteristics are seen as visible manifestations of the basic principles of composition: expediency of structure, dominance and emphasis (presence of a main or leading object), hierarchy and subordination of the parts in a whole, integrity of the work, dynamism and movement, balance of the parts in a whole. In order to achieve the above mentioned properties and characteristics and to fulfil the principles of composition, certain compositional tools are applied. These are: symmetry and asymmetry, proportions, scale, contrast, nuance, metricity, rhythm, and colour. The main features of composition are: structure, unity (integrity), harmonious order, boundaries (frame).

The basic principles of composition are: expediency of the structure, dominance and emphasis (presence of a main or leading object), hierarchy and subordination of the parts in a whole, integrity of the work, dynamism and movement, balance of the parts in a whole. These are also defined as properties and characteristic features of a highly organized form.

The application of these compositional tools must become mandatory in the assessment of the characteristics of the sign-information systems of control and indicating equipment. This will significantly contribute to solving the main graphic design task, i.e. to translate and recode in a visual language scientific and technical information. In order to obtain optimal graphic solutions in terms of layout, composition and colour, as for example in machine control panels (and other sign-information systems in industrial production), it is necessary to explore their main characteristics, elements, classifications, purpose and methods of presenting information.

This allows for the investigation of the role and the main characteristics of control and indicating equipment under the conditions of human-machine interface. It is also important to recognize the concrete indicators and controls employed in the case of the given object under investigation taking into

consideration the existing standards. The elements of the ergonomic system "human-machine-environment" related to the researched problem are: the types of control and indicating equipment as elements of the sign-information system (BDS EN ISO 7010:2020/A3:2022); arrangement (layout) of the elements of the sign- information system; ergonomic requirements (standards, norms, rules), which are observed when creating the sign-information system. The control and indicating equipment are those components of the system through which the closest connection and coordination of human and machine activities take place (Angelova, 2010).

The control and indicating equipment which represents intermediate units for transmitting, conducting and presenting information, are known as indicators. These are the devices which provide the operator with messages and data on the measured and control parameters, which characterize the condition of a machine and the course of the technological processes, necessary for the continuous analysis and the decision-making process. During the control and indicating equipment analysis, of primary importance are the arrangement (layout) of the elements, the appearance, shape, size, color, etc., which must all meet the ergonomic and graphic design requirements. A monitor with modern machines is considered the most important control and indicating equipment unit.

A monitor display with automated systems is a universal control and indicating equipment unit and an interface. The controls are intended to act as a connecting unit between the operator and the machinery. They are part of the human-machine interface system and their function is to actuate the controlled object (the machinery) elements. The controlling process is performed by programming through a keyboard towards a display.

The control and indicating equipment classifications have been constantly evolving and have been enriched, but the basic principles of their creation remain unchanged. Basically, the control and indicating equipment is divided into associative and abstract, which are structurally determining within the system. This first hierarchical level is determined on the basis of the following attribute: "whether the control and indicating equipment data received by the operator is associated with the actual controlled object or are abstract".

The problem related to transmitting data from a machine to a human operator is primarily related to the creation of adequate data models. The data model is that element in the human-machine interface system, through which feedback concerning the current state and the functioning of the controlled object is obtained. This data is organized in accordance with a certain system of rules. On a material level, the data model is realized through control and indicating equipment (Angelova, 2004).

Among the elements of the control and indicating equipment, the role of a "language" between the operator and the controlled object is also performed by sign systems.

Therefore, in addition to the term "information system", the terms "sign system" and "sign-information models and systems " are also used both in the scientific theory and the (BDS EN ISO 9241-920 rev:2022). In the process of creating sign-information systems, the efforts of two separate sciences are united. Their subject of study is in the field of natural sciences and design whose subject is basically aesthetic, artistic.

This determines those goals of the two sciences, which are focused on the activities of designing and creating sign-information systems as an artistic product.

INDICATORS AND CRITERIA FOR OPTIMIZING THE INFORMATION MODEL CONCLUSION

Theory and practice in creating data models have indicated the need to comply with the following six criteria:

- *Significance of the information included.*
- *Visualness of the data model regarding the spatial arrangement of the objects and their geometric shape.*
- *Structure optimality of the data model.*
- *Systematic perception of situations.*
- *Controlled object data coding.*
- *Optimal amount of data.*

Each of the above criteria involves optimizing the data model, and hence the operator activity. The activity of the automated control machine operator boils down to operating with the elements of the sign-information system, i.e. control and indicating equipment signals and symbols (associative and abstract), conditional images, numbers and letters. The monitor and the display are the most important control and indicating equipment units and interface in an automated system.

In the process of designing and creating a sign-information model and more precisely in coding the data, the peculiarities of the cognitive activity in psychological aspect must be taken into account.

The individual features of a person are in the basis of establishing the ergonomic factors for assessing the ergonomic quality of a product. Their nomenclature includes:

- *anthropometric indicators* – compliance with the shape and size of a human body; biomechanical indicators which refer to the laws related to human motor activity – for example, speed and force of movement of the operator's hands; psychophysiological indicators – determine the relevance and the conformity of the technical object to the visual and auditory analyzer of a person; psychological indicators – refer to a person's ability to perceive information.

The ergonomic requirements can be grouped as follows [Table 1]:

the first group – ergonomic requirements regarding the design features of the type of control and indicating equipment (indicators, signs, etc.)

the second group – ergonomic requirements regarding the information received from the control and indicating equipment – accurate and timely, in optimal quantities according to the real capabilities of the human operator to process it and make decisions.

the third group – ergonomic requirements regarding the type, structure and arrangement (layout) of the control and indicating equipment.

Table 1: Indicators and criteria for analysis and evaluation

INDICATORS	CRITERIA
1. Ergonomic-Layout	**Principles of layout** **1.1. First group** *1.1.1. Of a functional organization;* *1.1.2. Significance;* *1.1.3. Available in view of the design features of the control panel;* *1.1.4. Available in accordance with the logic of the activity;* *1.1.5. The frequency of use of the elements;* **1.2. Second group** *1.2.1. Autonomy;* *1.2.2. Generalization and unification;* *1.2.3. Structure;* *1.2.4. Conciseness;* *1.2.5. Spatial ratio of the elements of the means of presenting information (SIA) and the managing authorities (GMS);* *1.2.6. Emphasis on the components of the PMF;* *1.2.7. Emphasis on the components of the GTC;* *1.2.8 Use of primary associations and stereotypes;* *1.2.9. Use of semantic / analog / symbols that are associated with an object or phenomenon;* *1.2.10. Use of abstract symbols;*
2. Graphic design- Composition	**2.1. Principles of composition creation** *2.1.1. Integrity;* *2.1.2. Structure;* *2.1.3. Domination of the main, the leading;* *2.1.4. Dynamism;* *2.1.5.Equilibrium in the composition;* **2.2. Compositional means;** *2.2.1. Proportion;* *2.2.2. Scale;* *2.2.3. Symmetry;* *2.2.4. Asymmetry;* *2.2.5. Metricity;* *2.2.6. Rhythm;* *2.2.7. Contrast;* *2.2.8. Nuance;*
3. Graphic signs	**3.1. Predestination from the peculiarities of the human psyche** **Tendency to:** *3.1.1. Closed form;* *3.1.2. Geometrization;* *3.1.3. Limited number of elements;* *3.1.4. Susceptibility to visual illusions;* **3.2. Compliance with international standards for graphic signs;** *3.2.1. Corresponds to;* *3.2.2. Partially compliant;* *3.2.3. Does not respond;*

The ergonomic requirements regarding the control and indicating equipment are regulated by the standards established by the Bulgarian Institute for Standardization. Regarding the sign systems, the present work takes into account the international standards for graphical symbols for use on equipment ISO 7000-2004.

Of particular interest is the *third group* of ergonomic requirements "on the type, structure and arrangement (layout) of the control and indicating equipment.

The term "layout" is interpreted as a process (activity) and the subsequent result of it. In the process of the layout configuration, the functional and ergonomic substantiation of

the control and indicating equipment is guaranteed, and as a result of it the optimal location of the elements can be ensured.

The layout plays a primary role in the design of the control and indicating equipment and most frequently it precedes the design without taking into account the aesthetic characteristics of the product.

In order to ensure the presence of the aesthetic characteristics, it is necessary the artistic compositional tools to be applied.

The essence of the comprehensive compositional solution can be found in the unity of two stages: the layout configuration and the artistic-compositional solution.

Two groups of principles are defined in the selection of layout solutions [Table 1]:

the first group – the principles of grouping including the principle of functional organization, principle of significance, principle of arrangement with regard of the design features, principle of arrangement in accordance with the sequence and logic of the operator's actions, principle of the frequency of the elements used.

the second group – the principles of the layout of the control and indicating equipment: conciseness of the control and indicating equipment, generalization and unification of the control and indicating equipment, emphasis on the control elements, autonomy of the parts of the control and indicating equipment, structure, spatial relationship of the control elements, providing coherence and ensuring the use of primary associations and stereotypes.

The ergonomic requirements for signs, numbers, letters and inscriptions are regulated by (BDS, 1979).

The parameters that characterize the above control and indicating equipment are shape, size, brightness, light, contrast and colour indication. If the layout (arrangement) of the control and indicating equipment and its design and data characteristics are consistent with the human characteristics and capabilities, the operator's actions will be better coordinated and as a result the efficiency of the human-machine system will be higher.

Based on the theoretical analysis conducted simultaneously in the scientific fields of semiotics, ergonomics and graphic design, concerning the sign-information systems in the control and indicating equipment, there have been developed principles and criteria for analysis and evaluation of control and indicating equipment, at the preliminary level of planning as well as after the product has been accomplished. These are divided into three subcategories – ergonomic (concerning the layout), graphic (concerning the composition) and graphic. Each subcategory has 2 groups of criteria.

CONCLUSION

Based on the conducted analysis, the following results and conclusions have been reached:

The most essential groups of principles have been established – ergonomic, design and graphic.

The most essential principles and criteria have been formulated in the groups – layout, composition and graphic signs.

A model for design and evaluation of sign-information systems on control and indicating equipment has been created.

The defined principles and criteria can be applied as technical guidelines both at the preliminary project level as well as for evaluating the already implemented sign-information systems on the control and indicating equipment.

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