The In-Depth Analysis of Contemporary Information Control Systems

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ABSTRACT: *The traditional or contemporary information control systems have different components which are being modified now. To understand the contemporary information control systems, we have used technical issues such as economical, technical and psychological and initiated discussions. We have analysed the human factor for the formation of information control system and how they impact this system. The reliability indicators such as error rate, precision and timeliness to estimate the accuracy of the human issues in the control systems.*

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1. Introduction

At the present development stage of the scientific – technological progress, the task of research and development of a theory of human factor (HF) reliability and efficiency within the control systems and systems "man – machine" is put forward. Working out a solution of such a problem is possible provided that a sophisticated system – informational analysis is carried out both in technical point of view and physiological, psychological, and engineering – genetic problems of the human factor.

The formalization, modelling and analysis of the man in the sophisticated information and control systems in that regard turns out to be *important interdisciplinary scientific problem*, requiring the use of theory and methods in many branches of science: the Cybernetics, Physiology, Ergonomics, Mathematics (fuzzy sets, mathematical linguistics, semimarkov processes, etc.), system analysis, biomechanics, computer sciences etc. When analysing the function of such sophisticated systems, it becomes increasingly evident, that reliable results cannot be obtained without taking into account the human factor, because a person is an active part in them, who defines to a large extent the achievement of its objectives in its operation and development. The man, as an element of the control, participates in every stage of its formation – perception, recognition, prediction, adoption of a decision and implementation [1].

The present work focuses on the existing possibilities for transferring of theory reliability of technical objects in the development of technologies for reporting the reliability of operators in complex hierarchical systems.

The purpose from position of the system approach is to analyze the quality of modern energy systems functioning as well as the requirement for high reliability of the human being as a unit in them. The factors influencing the reliability of the human operator (HO) and their quantification are analyzed.

The problem is particularly relevant in connection with the fact that a number of operations are characterized by extreme conditions that can not only reduce reliability but also cause harmful and dangerous human impacts.

2. Systematic Aspects of Information Systems Functioning

In the technical cybernetics the "big artificial system" is called the aggregate of a big number of hierarchically dependent complex sub-systems, composed of collectives of people and machines with a certain level of organization and independency, united on the base of an active hierarchy of goals and means of the organization, commonly with energetic, substantial and informational connections for the insurance of the purposeful functioning of the entire system as "a whole".

The means of organization include knots for management, where the process of decision making takes place, and executive organs, realizing the information of the made decision in action, directed to achieving the set goals from the management. Commonly, in the big system, the knots of management and the executive organs represent complex human-mechanic complexes. For the purposes of quantity analysis of the big system, it is necessary for all its defined components to be formalized. Presently, the least studied of them, particularly quantity-wise, are the organization, the hierarchy of goals, the information and the independency, as well as the relations between man and machine, composing the knot of management. In relation to the goals of functionality, the big artificial system must ensure the completion of assigned substantial-energetic processes. But its functionality, development and existence as a whole are determined by the processes of transfer, refinement and transformation of information. Therefore, in the big artificial systems it is productive to separate three aspects: substantial energetic, economical and informational. With the informational approach and the observation of informational management systems, each studied system is represented by three levels: field, management, informational – meaning, in an abstract type, it is represented through a hierarchical structure on the lower level, where the technological process sections are located, and on the higher levels, the management knots, connected with the objects of managements and with each other, through channels of the network communication, shift places.

The information, circulating in the system, may manifest itself in three forms: informative – directed with priority from the objects of management to the relevant management knots; managerial – in reverse direction; transformational – defining the regularities of behavior of the management knot and the algorithm of functioning of its individual elements [2].

The management knots transform the informative data into managerial with the help of the transformational information, contained in the algorithms and the structure of the management knot. The different sections of the technological process are considered as generators of primal informative information. As it moves up the hierarchy, the information gradually gets synthesized, transformed in the different management knots and arrives in the main management knot on the top of the hierarchy. Using the acquired informative information, this knot generates managerial information, which gets more detailed as it moves down to the lower knots. The smaller the volume of the necessary higher knot information to form managerial information in the "*i*" knot, the more autonomous this knot is.

To achieve the goals of management, it is of great importance that only the necessary (valuable) information reaches the respective knots. That is why in the informational managerial systems, the semantic and value statistics of the information are displayed with priority. The management of complex technological processes (such as energy) always occurs in an environment of information deficiency. This is mainly caused by the fact that in the management knots in these systems, representing a unification of people and machines, these systems are only partially observable, partially manageable and partially knowable.

The energy system is an example of such large artificial systems. They, with their variety in equipment, huge amount of subsystems and complex connections between them, are a natural subject for the application of a multileveled hierarchic approach in the building of their organization and management, including a wide spectrum of organizational activities, planning, management, building, infiltration, exploitation, support and development of information systems and technologies. With the contemporary organization of the production of electricity and its distribution and allocation through systems for access and transportation, organized by various wholesale companies, some exceptionally elaborate energetic complexes emerge, uniting systems in narrow correlation. Due to the high requirements for reliability and safety of functioning, their management is unthinkable without quick and timely decisions, since possible failures in the energetic system may have serious economical and social ramifications. This requires development and upgrade of new approaches towards organization and control of such huge energy systems.

Hierarchy of management in the contemporary electro energetic complex can be represented with a series of prominent levels: European, regional, national, local; through a wholesale object – electrical station, sub-station, network region. Each of these levels is composed of its own internal hierarchy [3].

The low level of management, particularly if an electric station is being considered as a subject of management, has the most strongly emphasized internal hierarchy: dispatcher management (commands for commutation switching, correction and control of the work of group and autonomous management systems); common (secondary) automatic management of stations in normal and alert modes (distribution of active and reactive power, regulation of frequency, management of commutation operations, function of anti-alert automatics, adaptation of settings of regulators); group complex regulation, "zero" autonomic regulation, ensuring the assigned carrying out of the technological process of preparation of the energetic system and etc. [4].

Typical for the energetic system is the existence of a complex information structure; hierarchic dependency between the knots of management and in them; colossal in volume streams of information over the communication channels, between the knots of management; correlation between information and processes of its transformation relative to the goals, (which defines the semantic and pragmatic properties of the information); big variety of different information properties, transformers of information (different in their purpose regulators, controllers and etc.; people from different fields of expertise in the knots of management).

A classical example of a multileveled hierarchic system is the problem with dispatching of active power in the energetic system (Figure 1)

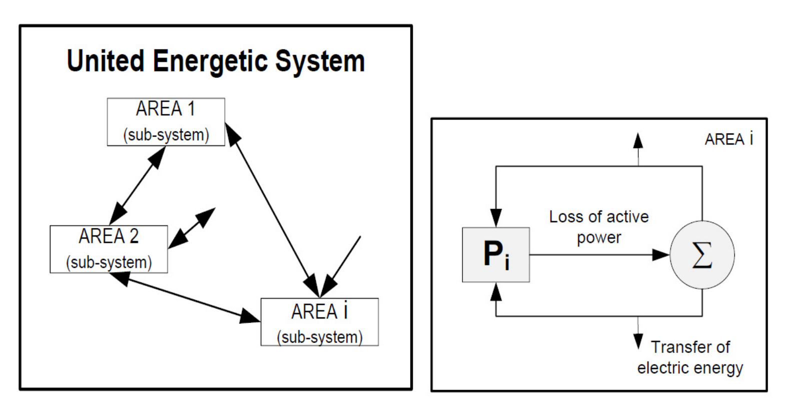

Figure 1. Hierarchical power system

The system is divided in *n* correlated sub-systems. Usually, the boundaries of the respective areas are chosen in a way that each one of them represents a separate association or company [5].

Each area has a series of generator stations and a big variety of consumers, but as long as the transfer of electrical energy between the areas is a major interest, it can be assumed, that each area is characterized only by the following parameters:

C_i – load up (full) in area *i*; X_i – active power, generated by the elements in area *i*; Y_i – loss of active power in area *i*; U_i – transfer of powers through the energetic lines, connecting area *i* with the other areas.

With a set load, the loss in the *i* area depend on the power, generated in the area itself, as well as on the transfer of powers, meaning Y_i is a function of X_i and U_i.

$$Y_i = P_i\,(X_i, U_i) \tag{1}$$

The equation, defining the balance of powers can be written in the following way:

$$P_i = (X_i, U_i) + P_i - U_i + X_i = 0 \tag{2}$$

There can be an *n* amount of equations of this kind. Also, the transfer of powers between the individual areas must be balanced:

$$U_1 + U_2 + ... + U_n = 0 \tag{3}$$

Equation (2) describes the sub-processes, and equation (3) – their relation.

Based on this, it can be assumed that the problem of dispatching of active power in a unified energetic system lies in the need to be able to define, on all lines, the power X_i and the volume of transfers U_i where the value of the produced electric energy would be minimal. For that purpose, the function $F_i(X_i)$ is introduced, called function of value of generation in each of the areas with power X_i. Then the overall value of the generated power will be:

$$F(X_1,.....,X_n) = F_1(X_1) + ... + F_n(X_n) \tag{4}$$

The problem with optimal dispatching is reduced to a minimization of example (4), provided that the variables $X = (X_1,....X_n)$ and $U = (U_1,....U_n)$ satisfy the equations of balance (2) and (3). It can be noted that after equation (3) the number of the independent values U_i is $n-1$. The task and goal of each hierarchic organization is connected with the solving of the problem with minimization. In relation to this raises the question how is this task supposed to be distributed between the computers of the different areas and the central computer. The multileveled management is preferred in comparison to the centralized approach, due to a number of reasons of technical, economical and exploitational nature.

3. Use of System-information Methods for Human Factor Evaluation

It is known that tasks definition of the operator in such a case of automated control systems is reduced practically to the following: timely detection the automated system inability in order to deal with the violations occurring during the process, determination of cause of the fault and making up for the consequences [6].

Human activity is structured and organized as a set of unit operations and is based on concepts: valuables, sense, objectives, actions, and operations. Regulatory activities are associated with the rules, standards and regulations. Elementary activities presented as elemental activity unit have spatial – temporal characteristics, [6]. The information activity model is described through a *Standard Operating Procedure* (*SOP*). It is structured on the basis of (in relation to the information search time) decision – making time, time for action (inaction), and time to obtain this result in accordance with the plan of action.

Operator's reliability can be defined as the probability of accurately and adequately performing the tasks in accordance with the instructions. Accuracy means implementation in accordance with the standard limitations in time and space. Proper operation a1 is performed within a standard operating procedure in moments of time t_1, t_2, …, t_i with reserve excess $\pm\Delta t$. Proper or normal operation is performed in case of timely detection either a signal or a set of signals by the operator which is/are necessary for action. Next, what follows is correspondence identification of signals according to standard configurations, making a decision, the action itself, obtaining and evaluation of the outcome. The concept of time reserve excess is associated with relevance or importance of the procedure, [7].

$$C(\bar{t}_r) = e^{-\lambda \bar{t}_r} \tag{5}$$

where $C(\bar{t}_r)$ means importance in terms of content and time constraints whereas $e^{-\lambda \bar{t}_r}$ denotes a continuous stream of events.

Proper operation a1 within the standard procedure *ps* is performed at a time *t*1 with reserve excess ±Δt. Proper performance of actions is possible in case of early detection of a signal or a set of signals by the operator need for action. What follows is signal identification for conformity to the Standard Operating Procedures, decision-making, action itself and outcome identification, which is determined in the same order. The procedure time *Tp* = *Ta* + *Tr* increases with the reaction time *Tr* (*Ta* – the time of action).

Accuracy could be determined as a degree of approximation of the actual process parameter value to its nominal value, i.e. as result compliance. The accuracy of operator actions depends on the systematic and random causes. They are determined with confidence $\beta = 0, 95$.

$$\delta_s = M + 2\sigma_s \tag{6}$$

where $M = m_1 + m_2 + ... + m_k$ is the systematic error of the system whereas

$$\delta_s = \sqrt{\sigma_1^2 + \sigma_2^2 + ... + \sigma_k^2} \tag{7}$$

is the random error standard deviation of the system elements, [8].

As a category, contrary to the accuracy the term imprecision is adopted. Absolute accuracy of the actions is practically unattainable, therefore a total acceptable imprecision and accuracy reserve are determined:

$$\delta_G = D_j - \delta_{\min} \tag{8}$$

where D_j is tolerance limits of the parameter *j* through D_j whereas δ_{min} is minimum total error by parameter *j* consisting of imprecision of the device during parameter measurement and parameter estimation imprecision made by the operator and his actions. Accuracy reserve excess is determined by the largest admissible imprecision.

A good example of this is the unmanned systems where safety is of paramount importance and is directly connected to selection, assessment and reliability of operators [9].

Due to the widespread implementation of computerized control systems, the operator's field perception narrows to the monitor screen(s) (change numeric values, colors and shapes ripple image) in practice as well as audio messages and violations. Operator's control forces are carried out through a choice of set elements displayed on the screen or keyboard keys and functional devices buttons (joystick, trackball, tablets, etc.), thus depriving the operator's motorial action from a significant motive component. Taking into account the man-operator's specific activity, related to a complex dynamics of observing monotonous parameters and logic elements, it could be said that intellectual tasks predominate before perceptual and motor ones.

Researches on the human brain activity are focusing on the fact that a reasonable person copes with unfamiliar situations and makes rational decisions because he can extract new knowledge from existing experience and can consider the consequences of those decisions. People analyze not only accurate, predefined data, but also incomplete information which often has not a numeric expression. This means that a person meets challenges of unstructured type with nonalgorithmic solution on daily basis; the quantities he operates with cannot be set in numerical form; their solution requires processing of information which is ambiguous and changes dynamically; purposes of the mathematical problem cannot be expressed by exact objective function. The human intellect is complex biological phenomenon and it is not limited only to problem solving, structured or unstructured. But in the present level of knowledge and instruments not all types of human reasoning are well studied and therefore it is impossible to be modelled (for instance like creativity, intuition, imagination).

4. Conclusion

As we noted so far, the operator's activity differs from the other type of activity with this that he resolves issues on control, management, transmission or transformation of information, interacting with the external environment or technical devises not directly, but by the assistance of various means to display the information and by the relevant control authorities. General characteristics of the activity of all operators is the collection, evaluation and processing of information for technical equipment, technological and other processes, dynamic objects; taking the relevant operator's decisions based on the evaluation of information; actions on their implementation; monitoring of the effectiveness.

In this paper is made an analysis in the system information plan of the HF as an element of complex information-control systems. The proposed structure of the hierarchical system is the basis for further fundamental research and development of the activity of dispatchers and operators with intensive professions. The expected results are related to the creation of activity models to allow monitoring of the operator's work.

Reliability and efficiency of the man – machine systems have to do with the particular important features. Not only is the Man – Operator reliability within the human-machine systems determined by psycho – physiological endurance regarding harsh loads but the human intellectual properties to make up for a variety of distorted informational processes during interaction with technology is also important. The development of these systems require more research to be carried out on the processes of information perception, processing, and storage by human as well as decision making mechanisms in different cases, psycho – physiological factor impact on reliability and effectiveness of such systems.

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