FACTA UNIVERSITATIS
Series: **Working and Living Environmental Protection** Vol. 2, N° 2, 2002, pp. 101 - 113

INTERACTION BETWEEN HUMAN FACTORS AND THE AUTOMATIZATION

UDC 331.103.255

Miroljub Grozdanović, Žarko Janković

University of Niš, Faculty of Occupational Safety, Čarnojevića 10 a, 18000 Niš, Serbia
E-mail: zarko@znrfak.znrfak.ni.ac.yu

Abstract. *New structure of human work activity in automated system demands more comprehensive examinations and research, because even slight errors lead to failures, even to complete system destruction with catastrophical consequences. While designing and constructing automated system criteria in choosing the ergonomic solutions haven't been precisely defined, functional and ergonomic demands haven't been taken care of, so that a more complete research of interaction between human work activity and automated systems becomes a necessity.*

The advanced technologies have more influence to various forms of the human activity. That is why, in this article, various levels of the automation are defined as well as theirs impact to the human activities in a different technological processes. The investigation results are presented on the characteristics of the automation in the real-world systems. They point out the existence of many problems concerned with the interaction between men and automation, with potentially serious consequences to the system security. Tree main elements of the human interaction in the automated systems are described: a confidence in automation, an awareness situation in controlling and monitoring and a creation of mental models in the operation of the real-would systems.

Key words: *human – machine interaction, automation, confidence in automation*

1. INTRODUCTION

Theoretical basis of allocation of functions between human operator and machine is a human-factors approach to automation. We proposed that for the different classes to technique's complexity three main approaches must be applied: Machine-centered (MCA), Human-centered (HCA) and Equivalent (EA).

Received November 28, 2002
The contens of this paper is a part of the results of the project; EVB: ETP.6.01.0248.A "Research and development of equipment and software used for reengineering of monitoring, diagnostics, management and industrial safety in underground coal mines", which is finased by the Ministry of science, tehnology and development of Serbia.

The methodology of MCA (as technological approach to automation when human operator must supplement automates and designers strive to maximum automation degree in control) is reflected by such principles of allocation of functions as Principle of Comparability of Man and Machine and its modifications.

In Russian engineering and work psychology from the HCA position (when human operator must be considered as a subject of work and technical systems are determined as a instrument of work) it's developed the special principle of allocation of functions – the Principle of Active Operator. This principle defines necessity of continuous active human operator participation in control for reliable reservation of automation when its failures or emergency and unlikely, unexpected situations oeuvre. Therefore it is needed priority of semiautomatic control regimes over automatic ones, [1].

In American and European human factors to HCA it may be attributed such principles of allocation of functions as the Principle of Comparability of Man and Machine, Dynamic Allocation, and Adaptive Allocation of Functions, [2]. Principles of Dynamic Allocation and Adaptive Allocation of Functions are defined changing of control automation degree in accordance of operator's performance conditions and his mood state. The main conceited of their estimation is workload of different kinds.

For realization of EA (when both designers and human operator must alternately carry out the predominant role in control, mast bear equal responsibility in control reliability ensuring) we developed the new principle of allocation of functions Principle of Mutual Reservation (PMR) of Man and Machine [3]. The PMR defines the strategy of flexible change of automation degree in control processes and consists in the following: human operator reserve automation (when unmemorable by automation failures or unexpected control situations arise) by decreasing of automation degree; automation reserves human (when serious subject complexity occurs in operator's performance) by compulsory increasing of automation degree.

The different cases of automation are developed according to the models of technologies. It is also true that, in some domains, automation is driven by the availability of technology: the thinking is, "the automated tools are developed, so they should be used". Developments in sensor technology and artificial intelligence have enabled computers to become better sensors and pattern recognizers, as well as better decision makers, optimizers, and problem solvers. The extent to which computer skills reach or exceed human capabilities in these endeavors is subject to debate and is certainly quite dependent on context. However, we reject the position that the availability of computer technology should be a reason for automation in and of itself. Is should be considered only if such technology has the capability of supporting legitimate system or human operator needs.

Automation has the capability both to compensate for human vulnerabilities and to support and exploit human strengths. We noted controller vulnerabilities (typical of the vulnerabilities of skilled operators in other systems) in the following areas:

- Monitoring for and detection of unexpected low-frequency events,
- Expectancy-driven perceptual processing, and
- Use of working memory to either carry out the complex cognitive problem solving or to retain information temporarily.

In contrast to these vulnerabilities, when controllers are provided with accurate and enduring (i.e. visual rather then auditory) information, they can be very effective at solving problem. If such problem solving demands creativity or access to knowledge from more distantlyelated domains, their problem-solving ability can clearly exceed that of automation. Furthermore, to the extent that accurate and enduring information is shared among multiple operators, their collaborative skills in problem solving and negotiation represent important human strengths to be preserved. In many respects, the automated capabilities of data storage, presentation, and communications can facilitate these strengths. But we argue that development should be driven by the philosophy of human-centered automation, which we characterize as follows.

The choice of the automation object should be guided by the need to compensate for human vulnerabilities and to exploit human strengths. The development of the automated tools should proceed with the active involvement of both users and trained human factors practitioners. The evaluation of such tools should be carried out with human-in the loop simulation and careful experimental design. The introduction of these tools into the workplace should precede gradually, with adequate attention given to user training, to facility differences, end to user requirements. The operational experience from initial introduction should be very carefully monitored, with mechanisms in place to respond rapidly to the lessons learned from the experiences.

Increasing application of new technology and industry, overgrowing into automated production base, resulted in nature and condition of work which is reflected in numerous fields of human activity through the change of traditional views of life and ethnic values of industrial society. These effect in the transition between two centuries are still of insignificant or initial intensity for the development of human personality, its behavior, creativity, life habits, customs and structure of social relations on the whole [4].

Because of all that, instead of multidisciplinary scientific-research approach and team solution of newly appeared humane-production problems at the industry reorientation into automated production, in a great number of our and foreign publications are met simply derived conclusions form a science of profession with incompletely given professional explanation of very complex life reality.

Electronic offensive in contemporary industrial production and other human activities so far has enabled to the man-operator of information-management systems in automated production – to increase only quantity of own knowledge but it has not provided to him also corresponding wisdom at critical judgment, which is result of many-sided development of human personality, then of his esthetic-ethic balance and scientific-professional multidisciplinary harmonization with requirements and needs. Therefore, if these requirements could not be completely provided – there is justified wary that in the next country will enter alienated and dehumanized human which personality will be decreasingly able to adopt itself to the changes and requirements imposed by the postindustrial society.

2. THE LEVEL OF AUTOMATION

The automation is possible by merit of the modern technologies existence. Very often the automation was stipulated and dictate by a capacity of the new technologies. The present thinking is "the automated tools are developed and they should be used". However, an attitude that an availability of the modern technologies is a reason for the automation it self, should be rejected. The automation is justified only when the modern technologies support the legitimate systems needs and the human factors. In other words, a compensation need of the human abilities should be predetermined element that determines the level of automation.

The term "automation" is defined in many ways in technical literature. Some people like to think of it as any implemantation of a computer technology, particularly if it did not exist before. Other definitions are limited to computer systems that have a certain degree of automation. In the field of an ergonomic design of the centers for control and monitoring of the automated systems [5] the most acceptable definition is: "the appliances or systems which realize (partially or completely) a function that was not performed before (partially or completely) by the human being".

Independently of the application field, several authors suggested a scale from 1 to 10 levels, beginning with low level and ending with high level of automation.

By supporting a presentation of this level of automation, we suggest a partitioning scheme, such as:

- The automation of collecting and integrating information,
- The automation of making decision process and the choices making of the actions, and
- The automation of implementing actions.

A reason for partitioning the levels of automation we find in a current human and machine system where a process of collecting information is separated from a process of making choices of actions, such as:

- The sensors which may vary in their sophistication and adaptability,
- The effectors, which react by doing precise mechanical operation, determined adequately.

The eyes, radars and the information networks are the examples of the sensors. The hands and numerically controllable industrial robots are the effectors.

Although, the collecting of information and choices of actions interacts through the feedback loops in the human and machine systems, it is more convenient to analyze them separately a system men-machine.

The automation of collecting information by using a computer can be applied on any of relatively independent characteristics, mentioned below:

1. Filtration, which is a selection of certain information presented to an operator (for instance, a lightening of certain items and, at the same time, a darkening of irrelevant items [6].
2. Information distribution, where higher levels of the automation may flexibly provide more relevant information for specific customer, by filtrating or surprising the use of information delivery, which are estimated as irrelevant.
3. Transformations, where higher levels of automation transform and integrate raw information into a form that is compatible eight the consumer needs [7,8].
4. Reliability estimates, where the automated systems may empress graduated levels of security or insecurity in a sense of information quality proven (for example, reliability in resolution and reliability of radar position estimates).
5. Completeness checking, where connecting and comparing different serious sources make a review of the sensor reliability.
6. Customer requirements responses include an understanding of the specific customer requirements by presenting information by the automation.

A decision making automation and an automation of the action choices at higher levels provide progressively less degree of freedom to the people in a selection of wider spectrum of actions.

Control actions can be performed in the circumstances that have, more or less, uncertainty or risks because of more or less uncertainty in an environment. For example, the consequences of the automated decisions that a plane flight control is given to an other flight controller can be easily predicted and they are of an automatically transferred permission to a pilot of a plane are less certain because he might not be capable to satisfy the instructions or he may follow them incorrectly.

3. THE HUMAN – MACHINE INTERFACE

There have been many different attempts to [9, 10] produce a model of man as an information processor. Many of these have attempted to describe him mathematically as an information processor in complex systems. It is typical of these mathematically models that they can only handle a small part of man's behavior and an as such their practical use is very limited.

They may be of some value in describing a particular form of behavior in very critical and important situations, for example an instrument monitoring. They are often based on simulator studies that always deviate to some extend from the real-late situation.

The classic view of the interface has neon to understand the operator as a passive and limited capacity processor of information, Figure 1. In this view, the operator and "machine" are in closed loop (although comprising an open system), connected by displays and controls. Machine information" is converted into "operator information" via displays, and controls act as transducers to allow the operator to change a system state. Feedback to the operator comes via the displays and via interaction with the controls (tactile feedback for instance).

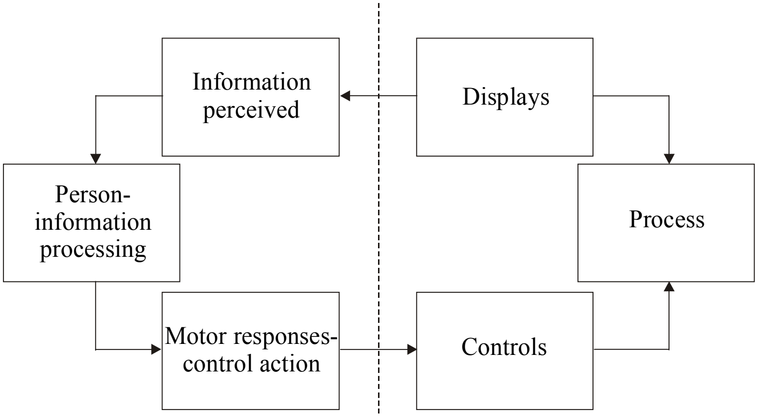

Fig. 1. Views of the human-machine interface as simple closed loop

In more complex situations, with increased development and use of computer generated information systems, the operator is seen as needing jigger level cognitive skills in both normal and abnormal conditions. Skill requirements in perceptual judgment, decision-making, problem solving and diagnosis generally have led too more sophisticated models of on operator.

The way people interact with systems is modeled as including attributes of the operator such as their mental model, experience, etc. and includes representation of their interaction through formal and in formal procedures, Figure 2.

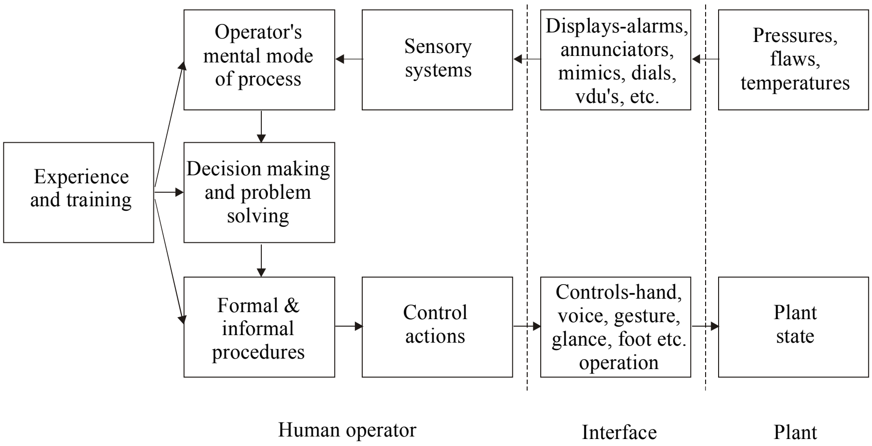

Fig. 2. Model of human operator in process control

Finally, the nature of work in complex systems now is such that basic model is frequently conceived of as the "human as supervisory controller", [11]. In this view, computer systems mediate between the operators plus their displays and controls on the one hand and the task or process and its sensors and actuators on the other. If we look at Sheridan's ten causeefect loops in supervisory control, Figure 3, and understand that he defines possible supervisory roles for the operator as planning, teaching, monitoring, intervening and learning, the we can see the need for a structure comprehensive approach to the design of display – control interfaces.

1. Task is observed directly by human operator's own senses.
2. Task is observed indirectly through artificial sensors, computers and displays. This TIS feedback interacts with that from within HIS and is filtered or modified.
3. Task is controlled within TIS automatic mode.
4. The process of being sensed affects task.
5. Task affects actuators and in turn is affected.
6. Human operator directly affects task by manipulation.
7. Human operator affects task indirectly through a controls interface, HIS/TIS computers, and actuators. This control interacts with that from within TIS and is filtered or modify.
8. Human operator gets feedback from within his in editing a program, running a planning model, etc.
9. Human operator orients him-or herself relative to control or adjusts control parameters.
10. Human operator orients him-or herself relative to display or adjusts display parameters.

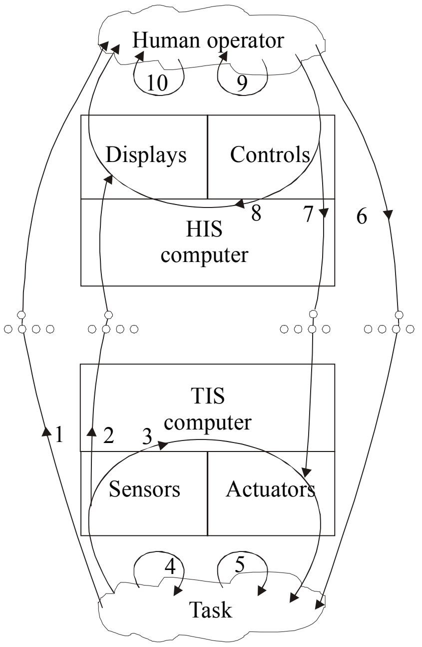

Fig. 3. Model of human operator as supervisory controller

4. HUMAN FACTOR AND AUTOMATION

Various investigations about the automation characteristics in real-world systems identified a series of problems in relation with an interaction between the human factor and the automation. Potentially, very serious consequences were stated against the systems security. These observations were based on a research, which included laboratory experiments, simulation testing and conceptual analysis, [12,13,14]. Many of them, but not all, found that the relationship between the human responses and the faults of the automation systems itself, but also in the faults of an environment in which that system operates. The automation problems do not occur only ads a result of special failures of the automation; but also they take place as a consequence of much complex influence of the automation on a behavior of the system "men-machine" [15]. Here we shall discuss various forms of the men and automation a confidence, situation awareness and a mental model.

A confidence is an important factor in use of the automation systems by the men [16, 17]. Although, the term "confidence" has a wide range of meaning we shall use it here in the context of the human character. For instance, the automation is significant but not absolutely reliable element for the human confidence. If we pay to it much belief and we do not control it constantly, some possible faults will not be identified. A degree of a compatibility between real and observed reliability may be changed every moment, a program in new systems is very complex, not tested completely and because of that the faults may occur as well as degradation. A loss of confidents may cause a throwing out use of automation and too much confidence can make a satisfaction, which may cause an inspector to pay less attention, i.e. a monitoring presentation is weaker. Further on, that caused a weaker monitoring situation of an inspector.

If an automatic operates correctly in a longer period a man is rarely busy. We may compare this procedure with a task of controlling and monitoring very rare events. A lot of explorations show that the human watching organs relax when the events rare. That leads toward a detection of many non- realized events or the events are realized late that a detection of the exact and complete system faults is weaker when the automation performed a task in a comparison with a task, which is made manually. This effect is the biggest when the inspector is busy with different kind of tasks and when he is less loaded with a concrete task, which he has to perform.

Many automated devices have the programs with a self-monitoring system, which detects the system fault. This is a way to reveal a fault, even if they are not easily observed. That may be described, for example, by a loss of the indicators precision, which became slower or less correct because of the hidden failures in them.

Evidence is aware that men are less aware of a state change when this happens, influenced by other sources and not by themselves. Such conclusions were derived from the basic investigations [18], applied laboratory simulators [19], and from the interpretations of the plane crashes [20, 21].

The accident analysis of the air transportation revealed the cases in which a high level of automation led to a loss of awareness on the real-world situations and to pilot failures. A recent investigation [22] detected a casual relation between the automatic (automation updating of a flight) and a situation awareness loss because of a lack of radar. Then, [23] proved, by testing the executives' faults of the satiric systems a relation between these faults and the awareness loss of the real-world situations.

It is important to point out that it is not necessary to present how an automatic operates, but it is sufficient to maintain an adequate level of awareness situation, which can provide a corresponding knowledge about the system status. They also depend upon a mental model an operator has about the functioning of an automated system.

Mental model is an imagined presentation of the functional relations in the automated systems. A model reflects an operator's understanding of a system, which is based on the previous experience [24]. This is such a thoughtful model on which basis an operator predicts and expects the behavior of a system in the future. When the real-world system is an automatic, the experience shows that in many case the failures happen because an operator does not understand a system operation (his mental models are defective or incomplete). Because of a security they continue with the activities, which they practiced during an operation with a real-world system. However, it may cause problems, because an operator does not understand a new system. He continues his work in an old manner and he allows the events to run in their way and he brings the functioning of the system into a danger state.

Possible solution of these problems should be searched in a better training of an operator. Especially, the improvement of his learning level of understanding the algorithms and the logical links of the automated systems. This is better than the influence of the improvement only of his skill's level. The engagement of the operator in installing and testing of the new automated systems is as important as the selection of an adequate training for controlling and monitoring systems.

5. COMPUTERIZATION IN PROCESS INDUSTRIES

There is no difficulty in producing a model which reflects in a general way how man/machine interaction is usually affected by computerization as it is normally carried out in process industries. Moreover, the model would not be particularly complicated at a general level.

The usual reason for working with such a grossly simplified view of the man/machine interaction is that the goals are too limited at the planning stage – being directed mainly towards economic profitability with no correct understanding of man's role and contribution to efficiency in such systems [25].

The model shown in Figure 4 is often used as a basic for discussion of man/machine systems it shows, in a simplified way, how man interacts with a process via a display (information device) and a control device.

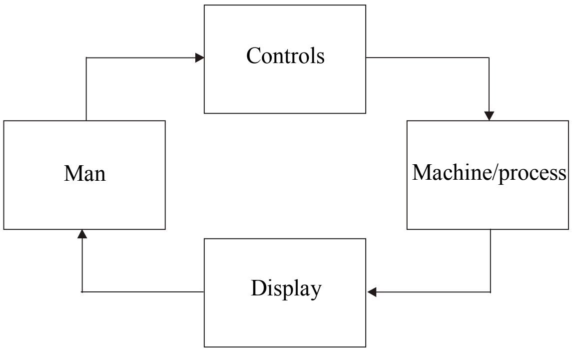

Fig. 4. A simplified model of man's role in control systems

Automation programs as more and more regulators are brought into service, as shown in Figure 5. The operator's task then becomes one of setting up the set values on the regulators, and monitoring the processes, which are being controlled automatically. In addition, of course, the non – automated functions still need to be controlled.

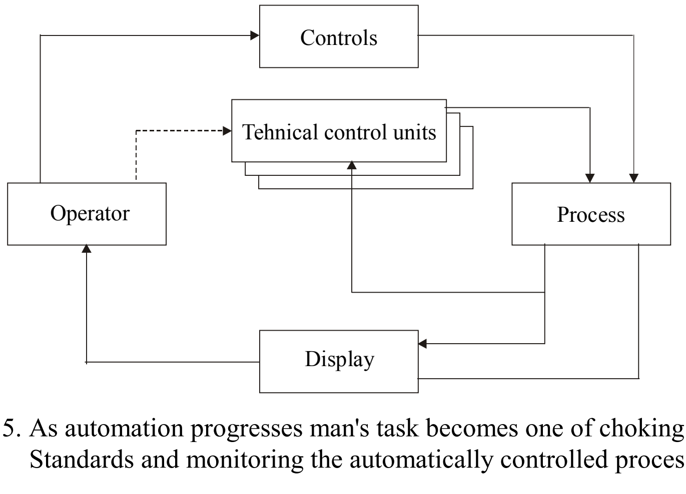

Fig. 5. As automation progresses man's task becomes one of choking Standards and monitoring the automatically controlled process

The first stage in computerization is to start to change the analogue control system to electronic microcomputers. The Honeywell TDC 2000 is a typical example where the analogue regulators are replaced by a large number of microcomputers, which can then be connected together into a common system (using VDUs) for monitoring and for insertion of the set values via a keyboard. Sometimes it is the microcomputer which makes more advanced control and co – ordination of the various control loops possible, for example sequence regulation and control according to certain programs. Figure 6 shows the case where a number of control functions have been transferred to computer.

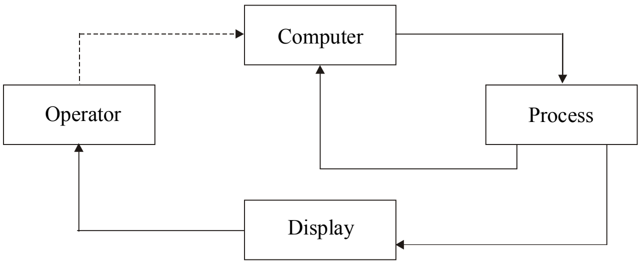

Fig. 6. Computer control

This common method of computerization often results in reducing the worker's active role in the system to such a degree that his best characteristics (flexibility, experience, long – term memory and job skills) are no longer required and the disadvantages of man as an operator are accentuated (for example, his inability to maintain long – term attention in is called vigilance situations). Thus the worker's role and positions within the system are not suited to his intrinsic abilities.

There is however alternative means of computerization, which have hardly been used within the process industries, do date. Man could be allowed to remain in the main control circuit, but provided with improved information, which can be produced by the computer (Figure 7).

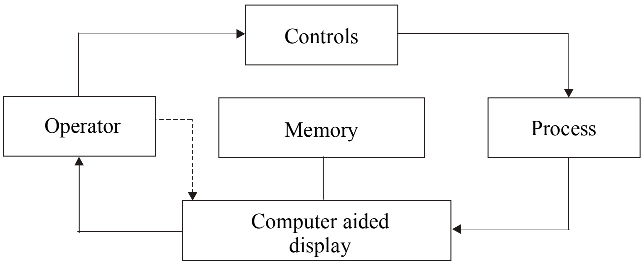

Fig. 7. Computer aided display

The computers could, for example, be used to take the various readings and to make calculations on the basis of these. One valuable aid may for example be to have some form of automatic model of how the process functions. Based on this process mode and the different measured values, the computer can calculate (predict) the changes which will occur in the process if there are no further possible control actions as "trials", as shown by the dashed line in Figure 7.

6. CONCLUSION NOTE

We live and go through a period of the deep changes, radical and social transformation that characterize a transition from an industrial toward postindustrial era.

The most significant changes are of scientific and technological nature. A development and an expansion of the new technologies dramatically transform the economies of various countries.

The advanced societies are the bearers of the new technologies, robotics, biotechnology, new material technology, power technology, etc. General solutions are important as they integrate all related systems. Also, they tie up these, which seem not to be interrelated.

These changes are followed with a decreasing percentage of the employees in the industrial sector and an increasing number of the employees in a tertiary sector (education, science, health, culture and other services). The human factor and the skills become very important: a manufacturing of the tangible product is replaced more and more with a knowledge, information, management, organization "manufacturing". The human activities such as a creation, an innovation, an organization design, a management, a programming, and utilization became of the dominant significance.

In transition between these two centuries may be distinguished some new technologies, which are presenting starting base in reorientation of industrial production systems. These contemporary technologies represent materialization of scientific knowledge and correspond to the high scientific level of development-of automatized industrial production, which as such present extraordinary significant scientific-technical force which is promising to perform in super automat zed production even better and more complex changes than so far. In addition, this scientific-technologic production synthesis of higher order is substantially different from previous revolutions for it encourages the quick transformation of scientific results in new technologies and their transition into automatized industrial production. Then, it enables wider introduction of information-based flexible production technologies in industrial systems, discovers new materials, provides use of new sources of energy, acts on biotechnology development towards production of ogre-synthetic chemicals, establishes ecological-technologic balance, and all other what directly acts on improvement of the production work organization, rationalization and humanization.

Systemic ergonomic is aimed to interactive and synergetic observation of activates of people and also their activities after working obligations, because it is longed for to achieve satisfaction at work and also after work. That is dimension of customization and complete work humanization based on the scientifically collected and verified data and knowledge.

This requires theoretic and methodological approach, which represents mutual coupling of series of old and new scientific disciplines, as well as interpermeatation of knowledge acquired during research. Such an interdisciplinary methodological approach evolves entire series of related scientific, fields and areas, in a range from basic sciences (mathematics, physics, chemistry, biology and sociology) to the help of computer sciences (cybernetics, theory of systems, theory of information, theory of communications), by the help of computer sciences, with a note that none of disciplines, in that complex, may have main role in accomplishing human reengineering of work, since those are in a systemic-ergonomic methodological process of information, coupling and outgrowing into specialized disciplines [26].

In order to approach to this aim it is necessary to know and apply procedures of the knowledge gathering, processing and presenting, what is classified in a new concept of cognitive science, what in essence represents theoretical bases of artificial intelligence.

These sciences are related to the ergonomics for those introduce a principle "how the works" instead of the principle "how to imitate the man". We must more and more to know the man as versatile, conscious and intelligent person which is to realize modern intellectualized solutions, because of majority of solutions of artificial intelligence the man has to use as tool (numerous expert systems, intelligent teams, etc.).

Since form automatization through computerization, it is reached to the form of harmonization, i. e., intellectualization, it is question of elements of human work and machine symbiosis by hybrid intellect, while in evaluation and decision making systems more and more are used expert systems. In such solutions is processed knowledge, and lately thanks to the theory of fuzzy (foggy, uncertain) gatherings, has been established a bridge between database and knowledge.

REFERENCES

1. Golikov, Yu.Ya.: The Evolution of Approaches to Man and Machine during Scientific and Technical Progress, Psychological Journal, vol. 13(4), pp. (68-74), 1992.
2. Kantowitz, B.H. and R.D. Sorkin: Allocation of Functions, In Handbook of Human Factors by, G. Savendy (editor) Wiley, N.Y., pp. (355-368), 1987.
3. Kostin, A.N.: Change of Principles for Allocation of Functions between Man and Machine under Increase Complexity of Technical Systems, Psychological Journal, vol. 13 (5), pp. (57-63), 1992.
4. Grozdanovic, M.: Methodology for research of Human Factors in Control and Managing Centers of Automated Systems, "Facta Universitatis", series: Working and Living Environmental Protection, vol. 1. (5), pp. (9-22), 2000.
5. Grozdanovic, M., Dimitrijevic, M.: Human Factors and Automation, III Medjunarodni simpozijum "Industrijsko inzenjerstvo 2001", Beograd, 2001.
6. Wickets, C.D. and M. Yeh: Attention filtering and Dee uttering techniques in battlefield map interpretation, pp 2-55/2 in Proceedings of Army Research Laboratory Advanced Displays and Interactive Displays Federated Laboratory, Firs Annual Symposium, Delphi, MD U.S. Army research Laboratory, 1996.
7. Vicente, K. and J. Rasmussen: Ecological interface design, Theoretical foundations, IEEE Transactions on Systems, Man and Cybernetics (22), pp. (589-606), 1992.
8. Wickets, C.D., and C.D. Creswell: The proximity compatibility principle, its psychological foundation and relevance to display design, Human Factors (37), pp. (473-494), and 1995
9. Jankovic, M. Z., Jovanovic, B.: Risk of injury analysis in the "operator-means of work" system, Facta Universitatis, series: Working and Living Environmental Protection, vol. 2. (1), pp (9-18), 2001.
10. Grozdanovic, M., Marjanovic, D.: Concept for Human Design of Control and Management Centers, The 6th Pan- Pacific Conference on Occupational Ergonomics, Beijing, China, 2001.
11. Sheridan, T.B.: Supervisory control, In Handbook of Human Factors, by G. Salvendy (editor), Wiley, N. Y., pp. (1243-1268), 1987.
12. Paraguay, R. and A. Riley: Humans and automation, Use misuse, disuse, abase, Human factors (39), pp. (230-2530, 1997.
13. Sartre, N.B. and D.D. Woods: Pilot interaction with cockpit automation II, An experimental study of pilots model and awareness of the flight management system, International Journal of Aviation Psychology, vol. 4 (1), pp. (1-28), 1994.
14. Wickets, C.D.: Designing for situation awareness and trust in automation, in Proceedings of the IFAC Conference on Integrated Systems Engineering, Luxemburg, Austria, International Federation of Automatic Control, 1994.

15. Woods, D.D.: Decomposing automation, apparent simplicity, real complexity in automation and humane performance, Theory and Applications, Erbium, 1996.
16. Lee, J.D. and N. Moray: Trust, control strategies, and allocation of function in human-machine systems, Ergonomics, (35), pp. 1243-1270), 1992.
17. Muir, B.M.: Trust between humans and machines, and the design of decision aids, Pp (71-83) in Cognitive Engineering in Complex Dynamic Worlds, Hollandale, E. Mancini, G., and Woods, D.D., ends London, Academic, 1988.
18. Salamanca, N.J. and P. Graf: The generation effect, Delineation of a phenomenon, Journal of Experimental psychology, Human learning and Memory (4), pp. (592-604), 1978.
19. Ensley, M. and E.O. Kris: The out-of-the loop performance problem and level of control in automation, Human factors (370, pp. 9381-394), 1995.
20. Dornheim, M.A.: Dramatic incidents highlight mode problems in cockpits, Aviation Week and Space Technology, (January 30) pp. (57-59), 1995
21. Starch, B.: Automation and decision making: Lessons from the Cal accident, pp. (195-199) in Proceedings of the 41st Annual Meeting of the Human Factors and Ergonomics Society, Santa Monica, CA: Human factors and Ergonomics Society, 1997.
22. Isaac, A.R.: Situational awareness in air traffic control: Human cognition and advanced technology: In Engineering Psychology and Cognitive Engineering, D. Harris, ed. London Ash gate, 1997.
23. Ensley, M.R., Rodgers, M.D.: Attention distribution and situation awareness in air traffic control, Pp. (82-85), in Proceedings of the 40th Annual Meeting of the Human Factors and Ergonomics Society, Santa Monica, CA: Human Factors and Ergonomics Society, 1996.
24. Moray, N.: Mental models in theory and practice, In Attention and Performance XVII, D. Gopher, and A. Koriat, eds. England: Oxford University Press, 1997.
25. Ivergard, T.: "Handbook of Control Room Design and Ergonomics, Taylor and Francis, 1989.
26. Grozdanovic, M.: Ergonomics and Human Reengineering of Work, 14th Triennial Congress of the International Ergonomics Association, San Diego, USA, 2000.

INTERAKTIVNI ODNOS IZMEĐU LJUDSKIH FAKTORA I AUTOMATIZACIJE

Miroljub Grozdanović, Žarko Janković

Nova struktura radne delatnosti čoveka u automazovanim sistemima zahteva obuhvatnija proučavanja i istraživanja, jer nastajanje i malih grešaka može dovesti do havarija, raspada pa i uništenja čitavog sistema sa katastrofalnim posledicama. Pri projektovanju i konstrukciji večine automatizovanih sistema, nisu bili jasno definisani kriterijumi prilikom izbora ergonomskih rešenja, te se nije mnogo pažnje poklanjalo funkcionalnim i ergonomskim zahtevima, tako da obuhvatnija istraživanja usklađenosti između delatnosti ljudi i automatizovanih sistema postaju neophodnost.

Napredne tehnologije sve više utiču na različite oblike ljudskih aktivnosti. Zbog toga su u ovom članku definisani različiti nivoi automatizacije kao i njihovi uticaji na ljudske aktivnosti u različitim tehnološkim procesima. Rezultati istraživanja su izneti na osnovu karakteristika automatizacije u stvarnim sistemima. Oni ukazuju na postojanje mnogih problema koji se tiću interakcije između čoveka i automatizacije, sa potencijalno ozbiljnim posledicama na bezbednost sistema. Opisana su tri osnovna elementa ljudske interakcije u automatizovanim sistemima, i to: poverenje u automatizaciju, svesnost situacije u kontrolisanju i upravljanju i kreiranje mentalnih modela u operaciji stvarnih sistema.

Ključne reči: *interaktivni odnos "čovek-mašina", automatizacija, poverenje u automatizaciju.*