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Industrial Process Cybernetization

1. THE ROLE OF INDUSTRIAL CYBERNETICS

The computing electronic systems and the other automation equipment of industrial processes functioning in correlation with the cybernetic-mathematical methods represent one of the most important means of improving the control of both technological and economic processes in the conditions of efficiency growth.

In the Report presented by President Nicolae Ceauşescu to the Twelfth Congress of the Romanian Communist Party, it is pointed out that the main orientation of the Five-Year Plan is the more rapid increase of social productivity by the scientific organization of production and work in all economic fields, by the cybernetized control of technological processes and the use of electronic technique in production scheduling.

The Report points out: "Of great importance for this purpose will be the extension of mechanization and automation, the achievement of entirely automated lines especially in foundries and forge shops, in thermic treatment sections and in other hard work sectors, the use of multifunctional aggregate machines, of industrial robots and of microprocessors. Action will have to be taken for a cybernetized control of technological processes, for the generalization of work on several machines, the rational use of the work time, the use of electronic technique in production scheduling, in computation and registration work and, on this basis, the reduction of the office workers to the strictly necessary number. Workers, training must be raised in all units to the complexity level of modern production, the scientific standardization of work being also ensured" [1].

The ensurance of a still more efficient use of the computing electronic technique in the economy in general and, in industry in particular is acquiring a special importance following the development envisaged for informatics, in the programme-documents of the Twelfth Congress of the Romanian Communist Party.

The theoretical development of cybernetics stimulated by the vast field of applications, and the large variety of problems posed by them has witnessed, during the past two decades, a progress which can hardly be equalled in the field of other exact sciences. Similarly, cybernetics is among the applied sciences most deeply anchored in all socio-economic development fields, interdisciplinary branches such as economic cybernetics, bio-cybernetics, industrial cybernetics and many others being detached from its trunk.

The industrial processes, in their turn, have witnessed a phenomenon of marked cybernetization considering that the impact of cybernetics on technologies has powerfully stimulated their development.

Indeed, a careful analysis of these phenomena allows unequivocally to conclude that the cybernetization of production processes is a condition for economic progress in the contemporary epoch.

In the first place, the application of cybernetic methods in the industrial processe control has allowed for increasing labour productivity and economic efficiency as a result of a wide-scale introduction of automated systems. The technological processes specific of industrial branches, such as the chemical, metallurgical, energetic, pulp and paper, cement and other industries have permitted, from the very beginning, to obtain a high automation, level the number of workers who are running big capacity productive units being very small, at present.

The technological processes which, through their character, involve many, complicated manipulations of the object of work have accumulated due to technical difficulties and to still unsolved theoretical aspects a certain delay in the cybernetization process, passing through an intermediate stage of automated control of the sequencies of the operations of certain phases. The evolution of the cybernetization of technological processes in the machine-building industry is a typical example, the processing of parts being successively achieved, in the course of time, on universal machine tools and aggregate-machines which are carrying out multiple operations, automated machine tools, then automated with programme-aided digital control and lately, the penetration of industrial robots in the fabrication and assembly lines have raised the level of labour productivity to that of industries with an entirely automated continuous flow.

The cybernetization of technological processes means apart from an automatic control, a control, based on a mathematical model, of the technological process and consequently its optimal control by attaching to the control model an objective function which should permit the selection from among the numerous possible solutions, in the control of the process, of those which extremizes the expected results.

The cybernetization of technological processes thus permitted to increase the index of the intensive use of fixed means and, implicitely, labour productivity and economic efficiency. At the same time, by choosing adequate objective functions, the technological processes can be controlled so as to extremize the useful transformation of the materials. By assigning this constraint not to an operation but to a processing tree both at the level, of operations and at the level of distribution between the tree branches, an optimal control of production is achieved by using to the maximum the primary resources in the given conditions of a processing technology.

The cybernetization of industrial processes thus meets an urgent demand of the economic development of society in the conditions of restricted natural resources. But, at the same time, it is a condition for technical progress caused, today, by the application of advanced technologies, by a high technical standard and quality of products.

The advanced technology in the accepted sense of the present standard of the development of human society means, in the first place, to master the top parameters, the high qualitative indices by one size class higher to the fields of obtaining technologies which have already become classical.

It is a common knowledge that the advanced technologies in electronics and microelectronics have passed from using pure chemical or analytical substances to pure electronic substances in which the quantity of impurities is measured in number of atoms contained in the gram of basic substance.

Another example is the technology of high integrated circuits (LSI) or, more recently very high integrated (GSI) in which the engaving of masks for a vacuum sediment on silicon boards is made by using the laser technique at nanometric proportions in comparison with the micrometric measurements obtained in very fine classical processing.

The advanced technologies also imply, at present, a reproducibility of technological processes in the conditions of a high production rate superior to those obtained in direct human activity for supervising and controlling the technological process.

The technology of modern motorvehicle assembly lines in which the conveyor lines of the assemblage line are commanded by programmes and the assemblage operations are robotized or controlled with the aid of electronic computers is one of the most wide-spread examples in support of the affirmation made.

The achieved technological installations must also correspond to high safety indices in exploitation with best performances . It implies, within the advanced technologies, the test of the behaviour of the installations achieved in conditions simulated by extreme functioning. The reliability of installations and the risk in exploitation are becoming measurable parameters and are taken into consideration in designing the new machines and installations. The airspace, nuclear technology, that of sea drilling or of the chemical industry are only a few examples in this respect.

As can be seen, the presence of the command and execution cybernetic devices is a condition for achieving advanced technologies because the obtaining of high performances exceeds man's physical capabilities of execution, intervention and of continuous control.

Estimating the importance of cybernetics in building up the new multilaterally developed socialist society in our country, the Romanian Communist Party has included among the targets of the technical-scientific revolution in full swing also that of creating the technical and material basis necessary for ensuring a rapid and profound process of cybernetizing of industrial processes.

The Guide-lines of the Twelfth Congress of the Romanian Communist Party on Romania's socio-economic development in the 1981—1985 Five-Year Plan and the long-range orientations until the year 1990 show that" in

keeping with its basic target, the 1981—1985 Five-Year Plan will ensure a still higher growth of labour productivity which will represent the decisive ellement in increasing material production and the national income; the steady promotion of modern technique and technologies, of mechanization and automation, the improvement of production and work organization in order to most rapidly place Romania, in the range of economically developed countries" [2].

To this purpose, the electronic industry will grow $2 \cdot 3 \div 2 \cdot 4$ times in 1985 as against 1980, being directed mainly towards the development of the production of automation means and of the computing technique, of microprocessors, of industrial electronic equipment and of electronic components.

The 1981—1990 decade will have to mark a powerful development of science and technology by keeping pace with the general requirements of the material and social progress. Scientific research will have constantly to outrun production pursuing the increase of the national potential of the cnergy and raw material resources and their best turning to account, the eomplex mechanization, automation and cybernetization of production [3].

The Guide-Programme of research and development in the field of energy for the 1981—1990 period and the main guide-lines for the period until the year 2 000 [4] lay stress on the orientation of the cybernetization process, specifying that the modernization and optimizing of the production technologies will take place with a view to raising the power efficiency of all installations and fabrication lines and they will also pursue the speeding up of the assimilation and production of measuring, control and automation apparatus including process computers intended for preventing irrational energy consumption and for the optimal functioning of all installations.

The Guide-Programme of scientific research and technological development and of introducing the technical progress in the 1981—1990 period and the main guide-lines for the period until the year 2000 are, in their turn, directing research in the development and improvement of the informatic systems in the operation of technological processes inclusively with industrial robots and of the mathematical basis of informatics (formal and programming languages, mathematical logic, data structures, the algorithm theory), the operations research and the systems mathematical theory with applications in automatics and in the analysis of other phenomena [3].

2. THE EVOLUTION OF INDUSTRIAL PROCESS CYBERNETIZATION

The automation of the production process control, a prevalent phenomenon of the first half of our century has created the theoretical and technological infrastructure existing at the basis of the present rapid and advanced cybernetizing process.

The automat, as mechanism with a pre-established action had been invented already before our era, having been improved especially in the past century when the mechanical society had attained the maturity of its development.

The automatic control of the production process, therefore the maintaining within the established limits of the evolution of parameters which may otherwise have an accidental evolution is essentially a conquest of the 20th century.

The use, in the first instance, of local controllers and then, after the 30's, of the pneumatic signal and controllers represented the essential praxiological element of development as a fundamental and practical theory of the technological process control.

The rapid development of the chemical industry which followed after World War II has called for the control of technological processes from control rooms proving the advantages of the integrated operation of installations and the raising of labour productivity obtained on the basis of this concept in process automation. During the 60's, the technical concept of the industrial process automation has reached its climax.

In the same period, cybernetics was consolidated as a science, its application becoming the significand element of the ensuring period characteristic of the technological process control.

After 1965, the use of quality flow measuring apparatus and of process computers has permitted the passing to the next stage in industrial automation, namely the cybernetization of technological processes based on advanced control algorithms.

The rapid evolution of the industrial analysers following their improvement and perfection for ensuring their functioning, in the industrial field is also linked with the evolution of the use of process computers, installations which are able to turn to good account, in real time, the complex data obtained with the aid of these analyzers. Lately, taking into account the considerable decreasing of the price of the computing units, most of these flow analyzers contain incorporated process microcomputers permitting their relatively independent use in comparison with the computers intended for process control. For illustration, this evolution is exemplified with a petrochemical plant of Holland, where over 850 instruments of automatic quality analysis were set up at the end of 1979, representing an investment worth over 116 million lei currency, requiring over 23 million lei currency annually for maintenance expenditure [4].

Table 1 presents the typological structure of these analyzers.

Table 1

Concise table of the analyzers set up at the end of 1979 in a petrochemical plant of the SHELL company in HOLLAND

1. pH-metre	132
2. electric conductivity	108
3. oxigen analyzer	113
4. gas chromatographer	103
5. fog/smoke analyzer	51
6. gas analyzer	49
7. H_2S analyzer	28
8. humidity analyzer	33
9. colosimeters	28
10. viscosimeters	24
11. ASTM distiller	22

12. initial boiling point	8
13. final boiling point	7
14. automatic titremeters	21
15. densimeters	21
16. inflammability point	20
17. Cloud point	15
18. turbidity point	5
19. smelting point	6
20. content in sodium ions	14
21. infrared analyzer	13
22. ultraviolet analyzer	9
23. refraction index	6
24. radioactivity analyzer	6
25. thermic conductibility	5
26. content of oils in water	4
27. corrosion measurement	3
28. soaking point	2
29. dielectric constant	2
30. miscellaneaous	13

Total: 870

As for the process computers, they started by being used already since the 60's in the hope of their utilization in direct digital control as the highest stage in computer-aided process control.

Although this stage was not attained even at present due, in the first place, to the risk factor in exploitation since the whole computing power for the entire installation is concentrated into a single high complexity unit and until not long ago, due to the economic factor, because the third generation computers could not vie, from the point of view of the price per the adjustment loop with that of the conventional automation apparatus, the number of process computers has constantly increased in over 20 years at an average annual rate of 67% related to the number of central units implemented industry [5].

The process computers have gradually become common objects in industry, over one million big and small central units having been set up in all industrial branches, at the end of 1979. Most of these computers are used for extensive technological computations and process information systems and, to a smaller extent, for computer-aided process control and optimizations.

The evolution of the level of process computer implementation was directly dependent on the evolution of their constructive technologies.

The first applications belonged to the second generation computers in which the technology of germanium and afterwards of the silicon transistors ensured a satisfactory reliability to the computation equipment necessary for a centralized control of the technological processes. The level of safety in exploitation attained by the equipment and mainly by the programmes — the first being destined for industrial purposes — and of their rigidity imcompatible with the dynamic character of the industrial processes in which not only the quantitative side of parameters but also the qualitative-structural aspect of technology and production are changed as a result of the influence of the rapidly developing external factors linked with the permanent ensurance of energy and raw

materials resources, with the reliability of installations have not permitted their use in the technological process control, in spite of the attempts made and of the repeated failures.

The third generation computers has considerably progressed as regards the reliability of both the equipment and programmes. The concept of specialized computer for the technological process control has led to the design of specialized equipment oriented towards the solution of a relatively reduced number of tasks yet with a high degree of repetitivity, a concept which was finalized in the implementation of the minicomputers whose representative firm, DEC, has succeeded in ensuring already in 1969 an annual market of several thousands of installations [6] mainly in the chemical industry.

The existence of a concentrated computing power even in the conditions of the evolution of the processing and storage capacities up to levels which should ne longer require a constraint in the process control has proved to be at the end a serious handicap due to the risk involved by this concept in the process control.

The first solutions have soon appeared. The solution mainly known and applied, namely that of doubling the equipment by ensuring the capacity reserves proved to be, in case of the computers, an expensive one both as regards the initial investment considering the cost of the equipment and as regards exploitation because the second equipment requires an important consumption from the time budget of the first one, for a permanent updating of the data base, so that control should be taken over, if necessary, without any shocks in the installation.

The wide penetration of the minicomputers in installations dedicated for a specialized control of the equipment, the need of their coordination and of dispersing the computing power for reasons already mentioned here has led to the formation of new applicative concepts known as hierarchized system for industrial units control.

Once initiated, the hierarchization process has taken place in both directions. Downwards, the computing power has undergone a treelike dispersion within a two-level subordinated network. The first decomposition level belongs to the set of specialized equipment whose coordination is no longer in the charge of the central equipment which plays the part of a coordinator of the communications among the subordinated equipment. At a process level, each specialized process computer coordinates the adjustment activity of the process achieved by the conventional automated adjustment loops whose control algorithms are selected and granted by the immediately superior hierarchical level just as the stationary or dynamic reference which has to be achieved.

Upwards, the phenomenon took place inversely but with the same effect: the generation of the control systems hierarchized as a result of the need of coordinating the productive activity of installations and the control of the resources used in common by them. In forming this concept, the chemical industry has played a major part as a result of the creation and global control of the integrated platforms within which the technological processes can be controlled only in keeping with the state of the other installations

on the platform considering their powerful intercorrelation (for example: the correlation between the refineries and petrochemistry, between the chemical products and mineral fertilizers, etc.).

All these evolutions, as regards concept, have found a powerful theoretical support in the development of the cybernetic theories. The theory has been created of sampling automatic systems specific of computer-aided control of technological processes, of the experimental identification of systems necessary for modelling the controlled, objects and of the technological process optimal control.

The theory of linear automatic systems has marked a particular theoretical development having created its own mathematical apparatus with a high level of abstractization.

The increase in the computing power of the equipment has permitted to make new steps in the theoretical research of nonlinear automatic systems. The ever more complex approach of the dynamic systems problems has led to the theoretical formulation of the control of multivariable adaptive and optimal systems.

The theoretical development of industrial cybernetics on such a fertile ground and with so great opportunities has taken place in such a rapid tempo, in the past twenty years, that the application of the whole theoretical arsenal has been lagging behind, practitioners admitting today the existence of a gap between theory and practice, a gap which must be bridged.

In this context, a new information revolution has appeared following the considerable penetration of microelectronics in all sectors of human activity and mostly in that of technological process control.

The microprocessors built in practically unlimited quantities and at a very low cost price have ensured the economic basis for the penetration of digital technique at all hierarchical levels of the technological process control implicitely at the one which was traditionally held so far by the analogical computation technique, namely conventional automation. They have considerably speeded up the digitalization process whose tendency has long been existing due to its inherent advantages as regards reliability, precision and flexibility.

The effects of microelectronics were soon evident in three main directions whose development has become spectacular digital automatics, robotics and testomatics.

The replacement of the analogical signal by the digital one at the level of the automation apparatus has allowed for making them compatible with data processing in the process computers without requiring the existence of specialized signal converting equipment to prepare them for processing.

The use of data processing digital technique at all levels has also allowed by bringing the peripherals of the electronic computers to the control rooms and by replacing the control panels by them. This replacement is entailing a new upsurge in using the process computers because the control panels have long been an obstacle in the way of an advanced control of processes because of the ergonomic incompatibility with the working method at the computation peripherals no matter how specialized.

The process control rooms are entirely reconsidered under the impact of the new technology, the ergonomic studies presenting the new requirements

for the work places in which, instead of big areas with information elements disposed monotonously, redundantly, with an average low information content per surface unit, an element conversational with the operator is found, containing data presented in a diversified way according to their importance, within a conceptual framework superposed on the operator's mental model as regards the technological process and in a form which constantly keeps his attention vigil.

As regards robotics, microelectronics represented the element which was missing for its industrial-scale implementation. The cybernetic studies of the mechanisms of robots, of their movements and commands represented one of the oldest preoccupations of this science, the achievements obtained always stumbling over the complexity of data processing in real time for each separate movement.

The penetration of microprocessors into the control systems of the industrial robots and the automatic execution by them of the operations in the production process under the control of microprocessors represent one of the revolutionary elements in the technological process control technique achieved in the past few years. As a result, a powerful industrial process robotization is in full swing, so that at the end of 1980, there were several hundreds of thousands of robots operating in the world and, moreover for ensuring the outfit, Japan has passed on to the building and putting into operation, this year, of a robot-building robotized line [7].

In the third place, a new technology has been perfected for establishing the quality of products and for a diagnosis of faults by the cybernetic study of the interactions between the testing device and the analysed product, called testomatics.

By studying the dynamic behaviour of the products, testomatics permits the carrying out in a very short time of complete tests on the product, in conditions which should exceed the probable limits of the stress of the applications for which the product was designed thus lending greater reliability in their practical use.

The testomatic methods are currently used today in the electronic technology both in the production of the microcomponents (impossible to test in point of quality by other means) and of the subunits (printed circuit boards) and of the assemblage units. This technology is ever deeper penetrating into other industrial branches, being used mainly in the field of top technologies: nuclear equipment, airspace, sea drilling platform constructions or in the field of special constructions or considered as artistic work.

In a near future, the design of industrial products will probably be considered as complete only after the design of the tester interface and, the product will be launched in fabrication with its test programmes.

The penetration of industrial cybernetics into the design workshops, a trend known today as CAD (computer-aided design) represents the basis of automizing the interface design and of the test programs.

3. THE REVOLUTION OF MICROELECTRONICS AND THE TECHNOLOGICAL PROCESS CYBERNETIZATION

The expansion of automation is one of the main trends of the contemporary technical and scientific revolution aimed at improving and moderni-

zing the technological processes and, often at radically changing them, with profound implications in various sectors of the economic life. Considering the new opportunities appearing with the wide-scale use of electronics and of the computation technique, automation, as the highest expression of technical progress is ensuring today the control of the most complex technological processes, in conditions which are incomparably higher to their manual control (in many cases, the carrying out of these processes would be impossible without automation).

The most visible influence of cybernetization on the technological processes was the constant increase in the capacity of the fabrication lines, respectively the size of the industrial units. The industrial fortresses built in the chemical and metallurgical sectors in our country bear witness to this evolution keeping in mind the size of the workshops with which the development of these branches has started.

The achievement of this growth is, however, conditioned by the process of automation, respectively the cybernetization of industrial processes without which this growth is impossible.

Nobody can imagine the running of industrial processes in giant installations working today in conditions of current tooling with process control and adjustment means, thirty years old, without being scared of the risk implied by the functioning of such an installation not only for those working there but also for the inhabitants of the neighbouring localities.

To maintain an acceptable value of the risk expressed as a product of the probability of the major technical accident with the caused material damages, a growing safety in exploitation is necessary and consequently an increased reliability in the control of installations much higher than that of the size of installations considering that the potential material damages and the danger of the losses of human lives are increasing not only with the growing investments but also with the accumulations of products of different levels of perilousness (inflammable, toxic, explosive, corrosive, etc.) of the installations [6].

The industry of nuclear energetics provides another example of the effects of cybernetization. The high degree of cybernetization of the control of these processes is dictated not so much by the dynamic character of processes which does not exceed the limits of human reaction capacities (the first nuclear reactor built by the atomists in the U.S.A during the second world war was entirely under manual control) than rather by the effects and, consequently, by the existing industrial risk following the possibility of losing this control.

The cybernetization of industrial processes brings about a change in the architecture of the work place, its redesign from the ergonomic point of view in keeping with the constant change in the quality of work performed by the technological process operator.

The diminishing of the share of physical effort and the increase of the mental one, the growing importance of the observation capacity in comparison with that of exercising for a long time some contracted habits, the increase of digital agility in comparison with that of the movements from an orthostatic position are only a few elements calling for profoundly structural

transformations in designing the control rooms and in the descriptive file of the work place.

The new stage attained by the production process cybernetization in a rapid evolution and transformation requires the resumption of the ergonomic studies and the redimensioning of the working conditions, laying this time special stress on the psychological aspects of the work place (intellectual stress, effects of claustrophobia, etc.) including them into the preventive study of professional pathologies and establishing recommendations in connection with the design of the new control stations.

This must be designed by taking into account that it is the meeting place of three inter-acting subsystems: the technological process, the control system and the technological process operator, a place whose cybernetic study of the interactions is extremely complex and on whose optimal solution depends the reliability of the installation in an emergency regime and the quality of installations exploitation in a normal functioning mode.

For exemplification, we shall review the various aspects embraced by the control of chemical installations, in our country, along the time.

The design of chemical installations with a local automation and control apparatus has permitted the control of processes from local control boards located near the apparatus under the operator's direct observation, releasing him from moves on complicated routes, often on different stories for passing from one measurement or control element to another.

By concentrating the instructions in a single place, a periodical control of higher frequency parameters has become possible and, consequently, the reduced possibilities for the process to exceed the limits of the established technological parameters.

The concentration in specially set up control rooms of the data from the entire installation has enabled the operator to coordinate the functioning modes of the installations by correlating the main technological parameters of various installations based on a conceptual model of the installation. The operator is aided by the presence of the mnemonic scheme on the control panel.

The increase in the level of the endowment of installations with automation and control apparatus in parallel with the growing size and complexity of the installations has brought about an increase in the control rooms up to expensive sizes as is the case with the refineries, the petrochemical installations, in spite of the miniaturization and concentration of the measuring. and control apparatus going up to the elimination of the synoptic diagrams.

The utilization of process computers in the technological process control has solved a greater part of the coordination problems posed by the installations.

The lack of a cybernetic study on the working place and the existence of two information channels competitive (and not congruent) for the operator, represented by the information supplied by the control boards and by the computer system had conducted to a reduced efficiency of data and he appearance of a perturbative noise associated with the thus created redundancy.

The design of the control rooms, following the use in installations control exclusively of the peripheral equipment of process control numerical systems achieves a reconcilliation of the conflicting situations caused in the

process operators' decision-making by the presence of data from various information sources simultaneously with the reduction of the control rooms to reasonable dimensions, both technically and economically.

The studies made in this sense by the Computation Centre for the chemical industry are in an advanced stage of finalization leading to the formulation of an outlook based on the peripheral equipment of the computers produced in Romania.

The cybernetization of technological processes requires not only the redesign of the control rooms but also of the location of the technological lines. The robotization of operations sets before designers as a criterion of locating the equipment the technological flow correlated with the activity of robots instead of the criterion of polyservicing by a single operator. At the same time, the reconsideration of the technological operations following the need of their detailed description for programming requires their minute analysis with a direct impact on the improvement of the technological process.

The installations, machine-tools and apparatus are also undergoing profound transformations. Until recently, the technological equipment was optionally and supplementarily delivered together with the computation technique, the latter being evidently grafted on the basic technology.

Thus, they are produced with the inbuilt computation technique, such as for instance the naval power aggregates turned out at the Reșița Iron and Steel Works endowed with digital control equipment, with the inbuilt microprocessor of the ECAROM-800 type produced at the Factory for Automation Elements. The computation technique is part of the basic technology no longer being an option, without supplementary costs or, in many cases, at a lower price having economic advantages in comparison with the traditional relay solutions.

In the cement mills, the main targets of the system are the centralized control of the main technical parameters, the periodical processing of data resulting from the process of dosing the raw materials, the analysis of the raw materials, the periodical calculus of dosing the raw materials for obtaining the desired quantity of the mixture (flour), etc. On this basis, the computer commands directly the reference values of the flow regulators of the raw materials, etc.

To control the natural gas wells, the TELEROM—SG system of the 3 · 5 generation is used with microprocessors, integrated circuits, on a large scale, etc. The functions fulfilled by them are: the collection of data, the preliminary treatment of information, the transmission of data, the supervision of the process variables by telesignaling, telemeasurements, telecommands, teleadjustment, displaying, etc.

The system can also be used in irrigations, energetics, etc. For the control of the crude-oil wells the TELEROM—SP system is used for the remote control and supervision of pumping crude-oil wells (maximum 24 for every research point). The functions performed by the system are those of telesignaling, telemeasurement and telecommand. By telesignaling, the controller can be informed on the condition of the derrick: start-halt, normal-damage state, etc. The telemeasuring of the specific para-

meters permits their vizualization at the supervizor's office, on a display, automatically or upon request, the supervisor's office can operate any derrick by start-halt telecommands.

The revolution brought about by the integrated circuits, mainly by the microprocessors has considerably influenced the architecture of the electronic computers. Microcomputers built around a microprocessor have appeared and more recently, completely on a single silicon pill. Generally, the microcomputers are incorporated into a product (or into a system) which we are using, often ignoring the presence of the minicomputer. By using the computation technique in technological processes, important savings of raw materials, fuel and energy are obtained as well as an important qualitative growth.

As can be noticed, the cybernetization of technological processes entails profound transformations at all technological levels with implications not only on the technological process control but also on the very technological substratum of the installation, as well as ,on the working conditions and of the satisfaction of work of those operating these installations.

THE EFFICIENCY OF THE CYBERNETIZATION PROCESS

The cybernetization process cannot be discussed outside the quantitative valuation of its effects.

Undoubtedly, the cybernetization of industrial processes has positive economic effects of great economic efficiency. The utilization of a computation system in the control of the technological process of producing high pressure polyethylene at the Pitești Petrochemical Plant has allowed, for example, as a result of cooperation within limits closer to the dangerous zone without increasing the risk as compared to the manual operation, the increase of conversion and, on this basis, the growth of the production capacity of the installation by nearly 10%.

The chemical industry and in this frame other big platforms such as those of the Brazi and Borzești Petro-chemical Plants, the Săvinești Plant for synthetic yarns and fibres, the Craiova Plant for chemical fertilizers, the Rîmnicu Vîlcea Industrial Group for Inorganic Products are witnessing a profound process of intensification of cybernetization of their processes inclusively by hierarchical systems of complex control, by microprocessors-process computers-management computers.

The large-scale introduction of programme-aided machines has created in machine-building conditions for the appearance of a contradiction between the possibilities of the automation devices and those of various handling, painting welding and other operations, apparently simple which must be carried out by man (the loading and unloading of machine-tool parts, interoperation transport, welding, painting etc.).

For solving these contradictions, the industrial robots have been created which, since the first robot set up in 1960, have developed along several generations. The latest types of robots are equipped with a great variety of sensors which can sense the light, the difference of pressure, couple, etc. Controlled

by microprocessors, they can recognize spare parts in the course of assemblage work, select tools and carry out, within certain limits, disassembling, fitting and assembling work.

The programming of industrial robots is made by storing the succesive positions initially carried out by the operator, a method called „learning". This way of command requires no specialized language, a fact which is considerably reducing the dimensions of the command equipment.

The industrial robots are carrying out operations exceeding by far the human possibilities (for example, the space ones) also ensuring the rapidity and exactness of the programmed operations. In connection with the production of industrial robots, organized preoccupations regarding the automatic manipulation of parts have appeared in our country already in 1965, at the Bucharest Polytechnic Institute finalized in the design and practical achievement of seizing-releasing devices, of robot programming and command equipment. The Faculty of Electronics of the Bucharest Polytechnic produced in 1969 an automaton for recognizing the alpha-numerical characters with a certain degree of distorsion.

The Central Institute for machine-building has intensified, during the past few years, its preoccupations for designing and implementing automatic manipulators and robots and the Bucharest Research Institute for machine-tools and aggregates has developed its studies on the automatic manipulation for machine-tools services.

The Timişoara Polytechnic Institute has achieved two industrial robots for the Reşiţa Metallurgical Plant (one electric and the other pneumatic). It has also achieved the laboratory experimental model of an industrial robot with a 7 degree of freedom, for the Timişoara Electromotor Enterprise.

The Iaşi Polytechnic Institute has achieved an industrial robot with a 4 degree freedom, hydraulically run. The Central Institute for machine-building has produced the industrial prototype of an industrial robot in Cartesian coordinates, in a complex configuration with a CORAL minicomputer. They are also working on an industrial robot in cylindric coordinates. Experiments were made with industrial robots for under pressure casting, point welding, painting, drilling, etc. One of the hydraulically run robots is used as an operator at several under pressurse casting machines. Another one is specialized in welding car coachwork.

The robots do not get tired, they are not bored, they are working in 2 and 3 shifts. They are very reliable and are used in places with hard working conditions, such as: painting in toxic places, foundry and forge work, welding, sectors of nuclear industry with a danger of radiation as well as in assembling with repetitive, boring and exhausting movements, in certain situations for men, mainly women.

Auditory robots which should "listen to" the human voice are under study for the future; robots for the automatic supply of machine-tools which permits, in principle, at least the doubling of labour productivity by using the present machine-tools, robots for metallization (not yet produced in the world) which will play a great part in materials reconditioning and reusing.

Although we are at the beginning, the gradual introduction of robots in industry is foreshadowed as an imperative demand. Undoubtedly, in a few

years, one of the main indices of the level of development of industry and of labour productivity will be the number of robots used in the economy.

Added to them, there are the applications which practically could have not been solved without solutions based on industrial cybernetics, such as the cybernetization of the national hydro-power grid, the cybernetization of the national power control system, etc., which also brought about a considerable increase of safety in exploitation and of the reliability of the national electric power grid.

We should also like to recall the technical, technological and economic effects brought about by the cybernetization of big iron and steel platforms in the country, such as the Hunedoara Iron and Steel Works, the Galați Iron and Steel Plant, the Tîrgoviște Plant for special steels, etc.

Added to all these aspects is also — not yet estimated quantitatively, but of utmost importance — the contribution to the moulding of the new man.

The release of man from hard physical work and his involving in an elevated decision-making process brings about profound transformations in the very typological constitution of the future worker.

The cybernetization of industrial processes creates the acquiring of the habit of a permanent industrial activity calling for a constant raising of the professional training of the working people, the training of specialists with a high professional skill.

Its interdisciplinary character calls for the formation of a broad technical knowledge based on a solid general culture capable of ensuring the basis for a harmonious intellectual development of the future worker. Cybernetics is thus contributing to the elimination of one of the present social contradictions specific of the present stage in the development of the productive forces, namely the contradiction between the physical and intellectual work.

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