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CONTRIBUTIONS TO EXPANDING THE FIELDS OF VALUE ENGINEERING APPLICATION

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În acest articol dorim să facem cunoscute rezultatele cercetărilor noastre cu privire la extinderea ariei de aplicabilitate a Ingineriei Valorii (IV) şi la alte domenii decât acelea al produselor şi serviciilor. Cercetările întreprinse de noi în acest scop au început înainte de 1989 şi sau finalizat cu publicarea lucrării Ingineria Valorii în anul 2000 la Editura Economică. Rezultatele au fost concretizate în două metodologii specifice aplicării IV la proiectarea - reproiectarea proceselor tehnologice de fabricaţie şi la proiectarea - reproiectarea obiectivelor de investiţii. Adăugând aceste metodologii la cea existentă - care se aplică în prezent la proiectarea produselor, am creat un sistem integrat de aplicare a IV la produse, procese tehnologice şi la proiectarea structuri de producţie prin proiecte de investiţii, care asigură optimizarea folosirii IV pe întregul lanţ al obţinerii bunurilor. Vom prezenta în acest articol pe prima dintre cele două metodologii specifice.

In this article we propose to impart the findings of our research as regards the expansion of the area of applicability of the Value Engineering (VE) to other fields than those of the products and services. The research conducted by us for this purpose was started before 1989 and was completed through publishing the work "Value Engineering" at the Publishing Editura Economică, Bucarest, in 2000. The results materialized in two methodologies specific to the application of the VE to planning-replanning the manufacturing technological processes and to planning-replanning the investment goals. By adding these methodologies to the existing one – which is currently applied to planning the products -, we have achieved an integrated system for applying the VE to the products, to the technological processes and to creating the production structure through investment projects which ensure the optimization of the use of VE over the whole chain of goods achievement. We will present here the first of the two specific methodologies.

Keyword: function, technological process, technological operation, cost, creativity, rationalization.

1. Introduction

VE has been known in Romania since 1969, but its application to the state-owned economy was performed under the pressure of the political bodies, in the absence of a real motivation of the economic agents for introducing technical and managerial progress. Nevertheless, this method experienced an expansion in the

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Romanian economy of the 1970s as a consequence of its official recognition through a Government Decree of 1971, which stipulated the obligatory application of the VE on the scale of the whole economy. Unfortunately, like so many other correct initiatives intended to assimilate technical and economic progress, this decree melted away into the environment specific to state-owned economy, where stimulating factors such as personal interest, competition and competitiveness did not exist. Unlike the practice in economy, in the university milieu VE enjoyed a particular interest that was materialized in popularizing the method and in numerous studies for redesigning some inefficient products whose findings demonstrated the feasibility and the potential of the method for generating radically positive changes in the designers' conception, resulting in highly competitive products.

On the basis of this experience, the Romanian scientific research developed a general methodology of applying the VE to planning and replanning products and two Standards (STAS 11272/1-79 "Value Analysis. General Concepts" and STAS 11272/2-79 "Value Analysis. Applying the Method to Products," which were updated in 2002 [2].

After 1989, together with the expansion of the privatization process, premises were created for motivating the private economic agents to assimilate the technical and managerial progress by triggering the domestic competition, generated both by the setting up of a large number of companies of the same profile and by the penetration of the Romanian market by foreign products, on the one hand, and by the re-orientation of the foreign trade to the Western countries (at present, 73% of our foreign trade is done with the countries in the European Union) on the other hand. Knowing the potential of the VE for achieving competitive products, the campaign for popularizing and applying this method has been relaunched with a view to ensuring a high level of competitiveness meant to allow the Romanian economic agents to cope with the harsh competitiveness imposed by the unique European market.

At the same time, research was conducted with a view to expanding the area of applicability to other fields of activity as well. The findings materialized in developing specific methodologies for applying the VE to planning the technological processes and investment goals.

Further on we will present the methodology proposed by us for planning-replanning the technological processes through the agency of the VE concepts.

2. The Technological Process and its Significance in the Development of Economy

Technology was and continues to be the fundamental factor of the development of human society, exerting a decisive influence on economy through the contribution it brings to diminishing the consumption of labor per product unit and costs. Besides, the economic discrepancies between similar organizations and even between nations are particularly generated by the technological discrepancies. The role of technologies increases with the continual decrease in the natural resources of production, and also with the increase in the demand for goods and services as well as in the restrictions imposed by the durable development with its ecological component. As a consequence thereof, the competitiveness of the organizations – and, to some of them, even the survival – is determined by their capacity to assimilate competitive technologies and improve the existing ones.

A decisive part in assimilating the competitive technologies is played by the management of the organization. Among the management methods that can be used with remarkable results in improving the technological processes, stands out the value engineering, whose results in this field are superior to those obtained by applying this method to products, because a wide range of products can be manufactured through a technological process. At the same time, obtaining the expected results through the study of VE with products is conditioned by the use of the same conception also in planning the technologies by means of which the products will be manufactured.

The goal of the VE in this field is *setting up an optimum relationship between the quality of the products obtained and the costs involved by the technological process.*

3. Elements Specific to the Methodology of Planning the Technological. Processes through Value Engineering

In the VE study, the technological process must be approached from the angle of several sciences, because it is only in this way that results can be obtained and may lead to the improvement of all components. The global optimization calls for tackling the technological process from multiple perspectives, by integrating the requirements formulated by the technical sciences with those of economy and psycho-sociology. The *technical sciences* thus approach the technological process starting from the technical components, the technical level of the production equipment and plants, the type of raw materials used, etc. The *management of the industrial production approaches* the technological process from the angle of

blending the labor and labor means, as well as the organization method. The *management of human resources* approaches the technological process from the perspective of the division of labour existing therein, of the labour rhythm, of the organization of workplaces, etc. *Industrial psycho-sociology* pursues the observance of the psycho-social requirements of labour with a view to efficiently integrating the human factor into the technological process. The *company management* tackles the technological process from the angle of optimizing the decisions to choose the most efficient technology, of developing creativity with a view to modernizing the technological process.

Consequently, the VE studies applied to the technological process must integrate principles, rules, instruments, methods and techniques formulated by the sciences that study the technological process, with a view to achieving its functions with optimal technical and economic performances.

4. The Methodology of Applying the Value Engineering to Planning the Technological Processes

The methodology we propose for applying the VE to technological processes (VE-T) includes the stages and phases presented in diagram no.1, as well as the techniques and instruments used for improving the technological process in the vision of the concepts specific to VE-T. In the international literature there have been few attempts at developing a unitary methodology to be applied to technological processes. Most attempts have been oriented towards applying the VE-T in approaches similar to the methodology used with products. For instance, Therry Hengren, in his work "L'analyse de la valeur outil de gestion," Les Editions d'Organisation, Paris, 1975, makes such methodological reflections as place the VE-T along the same lines as the application of the method to the product. Of course, there are analogies between the two fields, but, on applying the VE-T, we find that numerous peculiarities appear, particularly when defining the functions of the process, when setting costs per functions, when determining economically oversized functions, etc. The techniques and instruments used in developing the study are also relatively different. An illustrating example is offered by the way in which costs of the functions are set. Unlike the methodology applied to products, the VE-T study requires the use of the techniques of the method tax-hour-machine (THM), as well as of some methods, techniques and instruments characteristic of production and labour organization, such as the rational placement of workplaces, the methods of

production scientific organization, the chart man-machine, the chart of hand motion, etc. – methods that are generally not used when applying VE to products.

Since our intentions in this article are specifically directed to highlighting these peculiarities, we will further on make a synthetic presentation of the stages and phases that make up the VE-T methodology study, the technological process is selected that is going to be analyzed and the goals pursued are set.

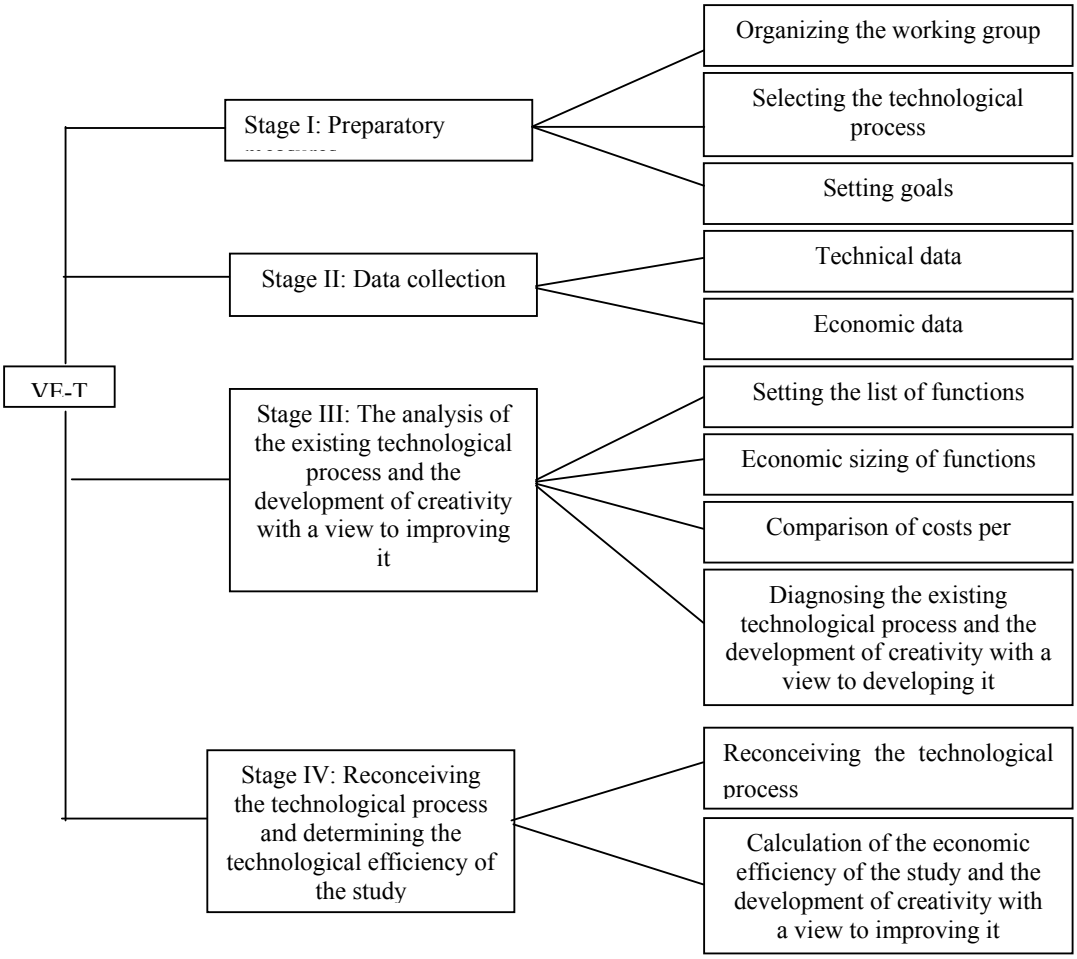

Diagram no.1: The technical plan for applying the VE-T.

- *Preparatory measures*

Within the framework of this stage the team is built that is going to develop the selection of the process is done on the basis of some criteria that are relatively different from the ones used with products, such as: the level of the costs involved by the manufacture of products, the degree of obsolescence and pollution, the qualities given to the product, etc.

- *Data collection*

The necessary data are only the ones of technical and economic nature. The technical and technological data pertaining to the analyzed process refer to: the machines used and their technical level, the degree of mechanization of operations, the raw materials and semi-finished goods used with a view to obtaining the products, the operations to be performed per each workplace and their sequence, etc. The phase ends with a diagram of the analyzed technological process.

For the economic information, data are collected as regards the economic performances of the technological process, such as: the level of the consumption norms for the raw materials and the materials used with the products obtained through the analyzed technological process; the standard time per operations and products; the time spans of the production cycle; the cost of products, of which the material expenses; the quality of products; the number of directly productive and auxiliary workers involved in the technological process; the value of the rejects and of the merchandise refused by customers and the reasons thereof; the overall level of the costs involved in the technological process, etc.

The economic performances of the technological process are considerably influenced by the level of production and labor organization. That is why data shall also be collected as regards the placement of workplaces within the workshop, the production organization form, the labor organization within each workplace, the observance of the ergonomic requirements of labour organization, etc.

- *The critical analysis of the existing technological process and the development of creativity with a view to replanning it*

The functions of a technological process must be viewed in close relationship to the necessities it covers and to the dissatisfaction generated by the products both at the level of the organization that produces them and at the level of the end users. The technological process approached as a system develops four types of functions: the main function; elementary functions; secondary functions; useless functions.

The *main function* derives from the social necessity that the technological process responds to. By analogy to the product, we may consider that the main

function is the general use value of the technological process. Consequently, any technological process has a single main function, namely that of obtaining a product or a series of products manufactured with the same technology. So far there seem to be no differences in content in relationship to the similar phase from the methodology of applying the VE to products. Nevertheless the question may arise in this context why we did not use, instead of the syntagm "main function," the syntagm "use value," as with the products. The differentiation is based on the criterion of the connections with the social necessity. While the technological process is a go-between in relationship to the social necessity, the products respond directly to a social necessity, therefore they constitute an immediate use value in the sense provided by us when defining this economic category. Further on, the differences between the two methodologies appear as obvious.

The technological process represents the sequence of the operations through which the raw materials, the materials and the semi-finished goods pass from the moment of their launching in production up to obtaining the finished products. Consequently, the components of the technological process are the raw materials, the materials and the semi-finished goods that are processed, the machines and equipment used in the course of processing and the operations through which the labour objects pass with a view to obtaining the finished product, as well as the manpower that acts upon the labour objects through the means of production.

The principle of systemic analysis requires that within the framework of the practical study the technological process should be divided into homogeneous subsystems, made up, as we have already shown, of the aggregate of machines or manual workplaces that perform the same technological operation and the assessment of each element and of the interdependence between them. Each subsystem achieves a part of the main function, namely parts of the general use value of the process. We will call the functions developed by the component subsystems "elementary functions". They are elementary in relationship to the main function achieved by the technological process as a whole, but they are primary for each of the subsystems formed.

The *secondary functions* are subordinate to the main function and add utility to the technological process by eliminating the dissatisfaction that may be generated by the limits of the conception on the basis of which the process was planned. For instance, a technological process may ensure the manufacture of the product for which it has been conceived, but it generates low quality products, involves high material costs, poses danger to the labour power, does not ensure continuous circulation of the labour objects between the workplaces, it is polluting, etc. It is obvious that these deficiencies of the technological process generate dissatisfaction both among the end users of the products and within the manufacturing organization. Therefore, the technological process must develop a

series of functions meant to eliminate such dissatisfactions. *Adequate quality of products, raw material processing, labour protection, continuity of the production process* constitute examples of secondary functions. The particular importance of the secondary functions consequently results from their ensuring the economic and social efficiency in the technological process. The use of the adjective "secondary" in defining these functions has no connection with the etymology of the word. They are called "secondary" only in relationship to the main function. Since the secondary functions, as parts of the main function, are as important as the latter, we believe that the main function together with the secondary functions constitute basic functions of the technological process.

The *useless functions* are the ones that do not respond to requirements and do not remove dissatisfaction. These functions must obviously be eliminated, thus reducing the costs involved by the economic process as a whole. In order not to increase the number of functions, we will note that any technological process must also respond to ecological requirements. The technologies that do not range within the admissible pollution limits will be rejected.

In a list of functions that are generally true of an industrial technological process, the following are to be noted:

the main function "product manufacture," which is exactly the general use value of the process;

ensures the quality of products;

rationalization of the use of the means of production;

minimizing the manufacturing cycle;

eliminating the labour accidents, etc.

The technical sizing of functions in the case of VE-T does not appear as a phase in the methodology, since the technological process is a go-between to the products to be manufactured, the latter being technically sized in the VE study applied to products.

The *economic dimension* of functions is expressed in a differentiated manner, in relationship to the type of function. In this way, for the main function and the elementary functions, the economic dimension will be expressed in terms of the level of the total costs of the processing generated by the overall technological system and by each component subsystem, and for the secondary functions – in terms of various specific indicators which reflect the content of the respective function. For example, for the function *ensures the quality of products* one can use, as characterizing indicators, the average coefficient of the quality of products, the level of some technical-economic parameters that express the performances of products, etc.

In the practice of VE-T application, setting the costs of the main function and of the elementary functions represents one of the most difficult tasks. This is because the methods of calculation, planning, scheduling, recording, control and

analysis of the costs used by most economic agents – the order method, the phase method, the global method, the standardizing method, etc. – do not highlight the costs involved by the various workplaces that participate in achieving the products, since they are methods belonging to the global management at the level of the organization. The economic sizing of the elementary functions that participate in achieving the main and secondary functions requires the use of some methods or systems that place the workplaces at the centre of management. For this purpose one can use methods such as tax-hour-machine (THM) and cost-hour-production running and management system (SCOP/CHPS).

The *THM method* allows the calculation of the operating cost of each workplace or homogeneous groups of workplaces, constituted as production centers. The cost of an hour machine comprises direct and indirect expenses occasioned by the operation of a machine for an hour. The cost of the direct materials used in manufacturing the product is therefore not included in the cost of the operating hour.

The production centers materialize exactly the elementary functions of the technological process and, as a consequence, their respective costs can be established through the THM method – a fundamental requirement for applying the VE-T.

The *Cost-Hour-Production* management system (CHPS) includes several cost-management methods, generating a synergetic effect. The system is made up of an aggregate of methods, techniques and procedures, by means of which one plans and schedules analytically the production costs, one ensures the effective recording of the deviations from all categories of costs, one determines the necessary overall cost for the operation of a workplace or production centre for the length of a standard hour, one stimulates assumption of increased production tasks while concomitantly giving up some labour means that cannot be sufficiently loaded with orders, one determines the personal effort in achieving the production and the actual cost of the unfinished products and monthly production.

The cost of each elementary function equals, as a rule, the one registered in the costs budget of the production centre which develops the respective function. If an elementary function is ensured as a result of the activities carried out by several production centers, then its cost is calculated by adding up the corresponding budgets of the respective centers.

The cost of the main function represents the sum of the costs of the elementary functions that make it up, to which one adds the cost of the raw materials corresponding to the products processed by means of the respective technological process.

- Comparison of costs per functions

The purpose of the preceding phases consisted mainly in identifying the technological process and setting the costs that are necessary for the achievement

of the respective functions. It is natural that we should wonder further on: Are all of the functions necessary? Can the respective functions not be achieved more economically? Can the technical performances of the technological process not be amplified? Therefore, we will have to analyze the utility of the functions of the technological process and its technical and economic performances. Under these circumstances the following question arises: Which functions should the analysis be mainly directed to? Attention should undoubtedly be focused first and foremost on the very expensive functions, because diminishing the costs corresponding to them will have the strongest effect on the economic performances of the technological process. In order to identify the functions that will be subjected to analysis, a comparison of the costs per functions is needed. A useful instrument that allows significant comparisons between the aggregate costs of the functions is the histogram [frequency distribution], by means of which are represented all the functions of the product in the descending order of the costs.

- *Diagnosing and assessing the existing technological process and the development of creativity with a view to improving it*

The reduction in costs and the increase in the technical performances of the technological process require diagnosing the latter with a view to identifying the weak points and finding solutions for improvement. In our view, the VE-T integrates into a unitary whole specific problems regarding the manufacturing technology, the organization of production and the organization of labour which, as a rule, are approached separately. Through this systemic conception there is ensured a synergetic effect, namely an extra effectiveness obtained by identifying and implementing some ideas from various fields.

The analysis, the diagnosis and the creativity should be oriented to the following directions:

diagnosing the technology employed and finding ideas with a view to improving it;

diagnosing the organization of production within the technological process and the development of creativity for the purpose of improvement;

diagnosing the organization of labour within the technological process and its improvement by developing creativity.

Diagnosing the technology employed and finding ideas with a view to improving it

It is common knowledge that a certain product can be obtained by employing various technological processes. For instance, a mark that constitutes a component part of a machine can be manufactured through the process of casting, stamping or through a process of mechanical processing. If one opts for the casting process, the latter can be achieved by using the classical procedure of mould casting, channel casting or the advanced procedures such as casting in easily fusible moulds, chill casting, centrifugal casting, etc.

All variants of technological processes may have the same main function - the manufacture of the product or of the component marks - , but the elementary functions will be different, being generated by the technological conception that lies at the bedrock of each variant. The fundamental requirement of the VE-T provides that of the multitude of technological processes and procedures likely to be used for manufacturing the product and the component marks, one should select the one that ensures the most efficient consumption of live and materialized labour and the highest level of excellence of the product.

In the phases of critical analysis of the existing technological process, a first direction to which research must be oriented is the identification of new procedures for achieving the elementary function and, in particular, the functions whose costs have a high share in the aggregate cost corresponding to the technological process. The analysis must be oriented to three main directions: the analysis of the level of the technique used in the existing technological process; the analysis of the raw materials, of the materials and of the energy employed; the analysis of the aggregate of operations integrated into the technological process studied.

In the analysis of the level of the technique existing within the technological process, there can yield good results the comparisons method, which implies comparing the technique used by top manufacturers at home and abroad for achieving the elementary functions to the technique used by the analyzed manufacturer.

Another important component of the technological process which needs to be analyzed refers to the raw materials, the materials and the energy employed with a view to obtaining the products. Preference will obviously be given to those technological variants that provide the use of the materials existing in sufficient quantities, that ensure the reduction in or replacement of the faulty materials consumption and that allow, at the same time, the obtaining of top quality products. Nevertheless the reduction in the consumption of materials must not affect the functions of the products that are obtained within the analyzed technological process. The application of the VE-T is therefore performed in close relationship to the application of the method in the analysis of the products. In fact, it is the manufacturing technology of the products that is analyzed and that is why the technical changes brought to technology, the changes of the procedures or of the materials used must not affect the functions of the products in a negative way.

The conclusion following from this finding confirms the necessity for the systemic application of the VE, its use in all stages of material production, starting with the products and with the technologies by means of which they are manufactured, continuing with the investment process for planning and executing

the productive goal and ending with the service from the utilization period of the products.

A third component of the technological process that needs to be analyzed is that of the operations integrated into the existing technology. For this purpose, one must analyze whether all technological operations provided are necessary, whether some previous operations could be changed by simplifying the operations downstream, whether performing some operations by cooperation with other organizations is not more economic, etc. If there are several technological variants for manufacturing a product, the selection of the optimal variant is done depending on the economic efficiency which is commonly expressed in terms of the technological cost of the products obtained by means of each of the analyzed technological variants. The expenses that make up the technological cost are the conventionally variable and the conventionally constant ones.

The selection of the optimal variant of technological process is also done under consideration of the volume of production, since the cost per product unit varies with the manufactured quantity of the respective product. The technological cost of a product depending on the annual volume of production can be determined by means of the following equation:

$$Ctu = Cvu + \frac{CFh}{Qh}$$

where:
Ctu – technological cost per product;
Cvu – variable costs per product unit;
CFh – annual value of conventionally constant costs;
Qh – annual value of production.
On the basis of this equation we determine the technological cost for the whole volume of production, according to the equation:

$$Ct = Cvu \cdot Qh + CFh$$

Where:
Ct – the technological cost corresponding to the annual production.
These equations are used to establish the balance point of the various technological variants. The balance point represents that volume of annual production (Qcr) for which two technological variants have the same unitary technological cost, and it can be determined by solving the equation:

$$Ctu_1 = Ctu_2$$

$$Cvu1 + \frac{CFh_1}{Qcr} = Cvu2 + \frac{CFh_2}{Qcr} \text{ ; hence } Qcr = \frac{CFh_2 - CFh_1}{Cvu_1 - Cvu_2}$$

If we have in view the technological cost of the whole production, we can present the level of Qcr graphically as in chart no.1.

It results from the chart that if the volume of production planned for one year is bigger than the volume corresponding to the balance point, the use of the first variant of the technological process becomes more efficient, and if the annual planned production is below the balance point, the use of the second technological variant will be more efficient.

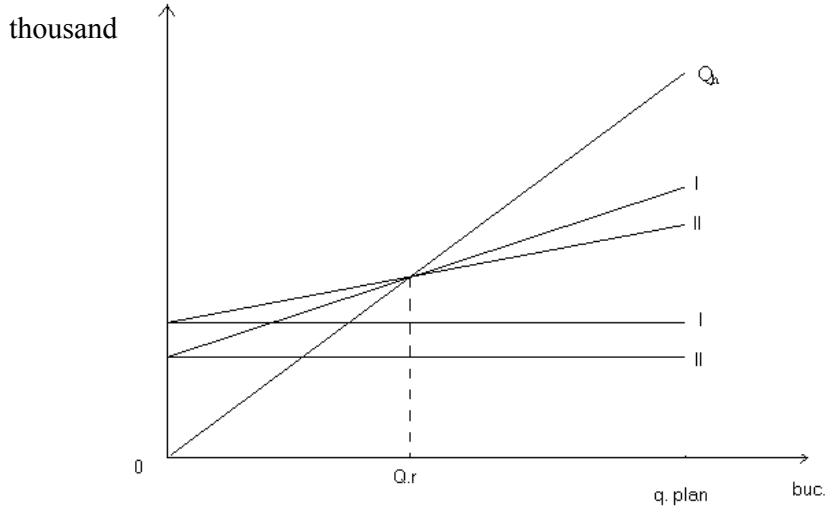

Chart no.1

- *Diagnosing and assessing the organization of production within the technological process*

Another significant direction following the analysis of the manufacturing technology, to which the critical analysis of the existing technological process must be oriented, consists in assessing the organization of production. Special importance should be attached to this matter, because however advanced a technique may be, it can only prove its efficiency under the circumstances of a rational organization of production and labour.

Assessing and diagnosing the level of production organization require the analysis of a complex of problems specific to production organization, such as: placement of the workplaces within the technological process, the production organization form, methods for blending the technological operations over a period of time, organizing the repair works, etc. Although we do not propose to expand on the problems of production organization, we do stress the necessity of integrating some studies of production organization into the methodology of applying the VE-T to the improvement of the technological process.

Highlighting the utility of integrating some studies of production organization into the analysis of the technological process best results from the

problems of placing the workplaces. The rational placement of workplaces requires the use of some methods, such as: the link method, the fictitious range method, the dummy method, etc.

- *Diagnosing the organization of labour and the development of creativity with a view to its improvement*

Another important direction to which the critical analysis of the existing technological process must be oriented consists in evaluating the organization of workplaces, particularly of the workplaces that generate elementary functions with a big share in the production cost. The analysis of the organization of workplaces should enjoy special importance, because they constitute the basic links of any technological process which generate the elementary functions and the costs corresponding to them.

Evaluating the level of workplaces organization requires the analysis of a complex of problems, such as: the work method employed, the activity and working motions of the performer, the work area, the work position, the adaptation of the labour means and labour objects from the equipment of the workplaces to the requirements and possibilities of the performer, etc.

For the study of the various aspects of workplaces organization, an aggregate of instruments are used, such as: the general diagram of the production process, the chart of the performer's activity, the chart performer – machine, the chart of the hand motion, the cyclogram of the hand motion, etc.

Conclusion

The application of the VE-T, conceived in a systemic vision, contributes therefore to an increase in the technical and economic performances of the technological process and, implicitly, to an increase in the efficiency of the activities carried out by the economic organizations. The VE-T methodology comprises significant peculiarities in relationship to the methodology of applying the VE to products and it should be understood and assimilated in order to obtain correct and efficient results.

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