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CONTRIBUTIONS CONCERNING THE DESIGN ASSISTED BY THE COMPUTER OF THE ECONOMIC ANALYSIS OF THE MACHINE TOOLS

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Abstract: *The evaluation of the ergonomic organization of the activities contains many aspects, among for the ideas enounced in this paper are important the ergonomic evaluation of the working place, the ergonomic evaluation of the machine-tool and the ergonomic attestation of the working place security. In the present paper it is proposed an evaluation method of the security of the working place at the machine-tools and a computer program able to elaborate all the types of the global ergonomic indexes (of the working place, of the working place security and of product machine-tool).*

Key words: *ergonomy, ergonomic certificate for the product, for the security of the working place, ergonomic certificate of the working place.*

1. INTRODUCTION

The science of the ergonomy appeard and developped as a science from the necessity of the improvment of the humanactivity'effieciency, in the conditions of the economic and social development of the humanity.

The ergonomy is a multi disciplinary science by the used methods, but it is unitary by is objectives. The evident purpose of the ergonomy is the increase of the work productivity with rational human energy consumption, and it is based on the optimisation of the relation man-work-environment. Behind this optimisation it results the increase of the work capacity of the human operators end is avoided any kind of over stress, and the decreasing the tiredness and the professional illness that generate big social coasts.

The modern ergonomy is practiced in the conception phase, but also after the obtention of the final product, in order to correct the signalled deficiencies of a product.

The ergonomy of the product intends that it have ergonomic qualities, respectively that the product requests the human actions into the limits of his normal possibilities, satisfying totally the needs of the beneficiary.

The specification of the ergonomic level of the product is made using an ergonomic certificate accompanying the product and named *ergonomic certificate of the product*.

A larger study of the complex man - machine-tool permits the elaboration of some conclusions concerning the development of the production process.

Such study that permit to specify the ergonomic level of the working place can be made by the elaboration of an *ergonomic certificate of the working place*, certificate that represents a certificate that analyses the working place.

The level of the security of the working place represents also a problem attached by this ergonomic analysis and defines the measure in which are or can be prevent work accidents produced by the fatigue, tiredness or ban manipulations.

The problem of the work protection is extremely important, and, by consequence, we have a well marked tendency in all the world to define an ergonomic certificate for the security of the working place from the point of view of the protection at accidents, clarifying the problems with the choice of a machine-tool and introducing a usefully criteria for the customer.

Further we propose to define such *ergonomic certificate for the safety of the working place*.

This kind of certificate is centred on the security of the working place, suiting aspects of the work protection from the point of view of the machine-tool designer, and not from the point of view of the worker's instruction.

The specialty literature presents same methods (more or few elaborated) to obtain the product certificates for the machine-tools or for the working places (Ergomun, Lest, Saviem, Check-List, RNUR). We precise that there are a lot of other methods, but based on the same principles.

They are missing the methods able to compare from an ergonomic point of view many machines of the same type or to give a view of the ergonomic properties of a machine-tool compared to a reference value (unfortunately a such value is not yet précised).

For to realize such activity is necessary to assign numerical quantificators or of other nature, précised, computable (and not only estimable).

Our studies concluded that between the ergonomic certificate of the working place (ergonomicity and safety) and the ergonomic certificate of the product common areas good enough extended exist, the main analyzed problems being the same.

Else, there are some differences given only by the purpose of the three kinds of certificates (the certificate of the working place is mode for the evaluation of the product with all its consequences, and the product certificate is dedicated inclusively to the marketing activities.

2. THE ERGONOMIC CERTIFICATION OF THE PRODUCT

As a consequence of the different kind of certifying activities, there are ellaborated final documents called *product ergonomic certificate* that certify the main ergonomic characteristics of the working place or of the tested machine-tool or installation.

At the level of the execution design, the ergonomic certification is made by partial or final noticing of the project, considering the economical requirements established on the base of the specialty norms or on the base of standards that are in elaboration, with a rapid extension.

The ergonomic certificate presents a double function. At the dealer, it is an element of the fabrication dossier, constituting one of the technical quality control criteria. At the customer, it is an addition of the technical book of the machine, furnishing information about the optimization of the relation man-work.

By consequence, the ergonomic certificate contains data about the mode to conceive the work place, in relation with the ergonomic needs for the human operator and ergonomic characteristics of environment, the environment in which the system man-work mean.

In anterior papers [5] there where presented propositions about the principial modifications of the method to elaborate the ergonomic certificate for machine-tools, and the transposition of the method on the computer, in order to automate the elaboration of an ergonomic global index.

Conformably to these papers, we can define a global index able to characterize from an ergonomic point of view the product.

That index can be obtained as a sum of all allotted notes.

The index able to characterize from an ergonomic point of view the product (named by us "index of ergonomic certificate of the product") is obtained as a ratio between the sum of the notes allotted on the basis of criteria considered necessary and possible and the product between the numbers of these criteria

$$I_{ae} = \frac{\sum_{i=1}^{n} N_i}{n \times N_{\max}} = \frac{\sum_{i=1}^{n} N_i}{n \times 5} \qquad (1)$$

where: n is the number of the allowed notes;

N_i – the note on the i criterion;

M_{max} – the maximal note allowed on the each criterion;

I_{ae} - index of ergonomic certificate of the product.

In this way it results an index I_{ae} under unitary and positive.

This index is more favorable to the product if it is more adjacent to the unity (value 1).

This index permits the comparison from an ergonomical point of view of many similar or alike. Generalizing, we can imagine a system to compose the certificate ergonomic indexes for all the machines from an industrial bay, section or enterprise that can have the final form:

$$Y_{aeg} = \frac{\sum_{j=1}^{p} I_{aej}}{\sum_{j=1}^{p} \left(n_j \times N_{\max j} \right)} \qquad (2)$$

where: n_j is the number of the assigned notes;

p – the number of the machine-tools from the analyzed group;

N_i – the note on the i criterion;

M_{maxj} – the maximal note allowed on the criterion for the j machine-tool;

I_{aej} – the index for the ergonomical certificate of the product j;

Y_{aeg} - the index for the ergonomical certificate of the group of products.

3. THE ERGONOMIC CERTIFICATE OF THE WORKING PLACE

As it was shown [6], it becomes necessary the ellaboration of a method for the determination of an ergonomic global index of the working place. The proposed mathematical model permits the computation of a score and of a table.

$$K_{erg} = \frac{\sum I_{di}}{\sum I_{nm} + N_p} \qquad 3)$$

where: K_{erg} is the ergonomic global index of the working place;

i – the number of the questions at which the answer is "yes";

$\Sigma I_{d\,i}$ – the sum of the part indexes (the number of the positive answers at the questionnaire's questions) with the assignation that if for each question the answer is "yes", then $\Sigma I_{d\,i}$; = i;

ΣI_{nm} – the sum of the part indexes (the number of the negative answers at the questionnaire's questions) with the assignation that if for each question the answer is "no", then ΣI_{nm}; = m;

N_p – the stress position coefficient.

A such certificate analyses not only the ergonomicity of the machine-tool, but the environment in which it works, completing the information about the possibilities of the work condition increase in the fundamental purpose of the increase of the working capacity of the human factor.

4. THE ERGONOMIC CERTIFICATE OF THE SAFETY OF THE WORKING PLACE

Further we are proposing a method for the determination of an ergonomic index of the safety of the working place similar in principle to the method for the determination of the ergonomic global index of the working place.

Withal there are analyzed the ergonomic factors that define the working place safety starting from lists with problems, organized as questions lists or as tables with problems to analyze.

As suit of the made analysis, we propose an appropriate mathematical model, able to permit the estimation of a score or of a ratio. We propose a similar proceeding with these used before, respectively we define a global ergonomic index of the working place's security having the form:

$$P_{erg} = \frac{\sum I_{dip}}{\sum I_{nmp}} \quad (4)$$

where: P_{erg} is the ergonomic global index of the working place's security;

i – the number of the questions at which the answer is "yes";

ΣI_{dip} – the sum if partial indexes (the number of positive answers at the questionnaire's questions), with the assignation that if for each question the answer is "yes", then $\Sigma I_{dip}; = i$;

ΣI_{nmp} – the sum of partial indexes (the number of the negative answers at the questionnaire's questions) with the assignation that if for each question the answer is "no" then $\Sigma I_{nmp}; = m$.

5. THE ELLABORATION OF AN ERGONOMIC GLOBAL INDEX OF THE ERGONOMY OF AN ASSEMBLY MACHINE-TOOL, ENVIRONMENT, SECURITY

For the elaboration of an ergonomic global index of the working place security we begin from a problems inventory that must be studied at the level of the work processes in the purpose to analyze the manner to realize the working place security, to reciprocal adapt between the man and his machine, between the man and his work inside of a given working place and of a certain productive activity. The check list is used as an analysis instrument, having the role to admit the identification of the disaccords existing in the system executants - work mean - environment.

The elaborated checklist contains the questions that can be put and that cover the three named aspects: the ergonomicity of the machine-tool, the ergonomy of the working place and the safety of the working place

As it results from the ideas presented up, the determinations of three types of indexes are based on check lists, respectively on lists with possible questions at which answers must be given.

The answers can be of type "yes", "no" or "it is not the case", or can be appreciation by notes from 1 to "n", where "n" are generally 5. The methods presented in the specialty literature are not complete and concludent, and, for these reason, we propose the reformulation of the check list method presented in the specialty literature conformal to the principles down formulated.

The first principle envisages that the questions' formulation must be made in such manner that the positive answers indicate only satisfied or correct ergonomical conditions, and the negative answers indicate no ergonomic or unrealized conditions.

In this way we can assure the coherence of the table by the possibility to sum separately the positive answers and the negative ones and we can give finally a "score" or a ratio that reflects the ergonomicity of the ensemble man-machine-environment

A second principle consists in the assignation of numerical indexes for the questions at which this thing is possible.

A third principle asks the separation of the questions with multiple answers, giving a note for each response (ask).

Using these principles, the ask list was revised, resulting a model that permit the calculus of a score or of a ratio

The proposed method permit the assignation of notes on a scale (for example from 1 to 10) obtaining values better discriminated for the ergonomic global index of the security of the working place, that means that is an advantage for the users.

In our model we choose as global index of the working place E_{erg} the ratio between the sum of the indexes from the column in which the convenient answers from an ergonomic point of view are "yes" and the sum of the indexes from the column in which the answers convenient from an ergonomic point of view are "no".

$$E_{erg} = \frac{\sum Y_{di}}{\sum Y_{nm}} \quad (5)$$

where: E_{erg} is the global index of the working place security;

i – the number of the answers at which the answers is "yes";

ΣY_{di} – the sum of the part indexes (the number of positive answers at the questionnaire questions), précising that if, for each question the answer is "yes". then $\Sigma Y_{d\,i}; = i$;

ΣY_{nm} – the partial indexes' sum (the number of negative answers at the questionnaire questions); cu précising that if, for each question the answer is "no". then $\Sigma Y_{nm}; = m$.

We are showing that we can imagine others definitions for the four ergonomic indexes, but we consider that the proposed definitions are the simplest and the easier to use.

6. THE USE OF THE COMPUTER FOR THE DETERMINATION OF THE GLOBAL ERGONO-MIC INDEX OF THE WORKING PLACE

The large use of the computer admitted the self-acting and unitary determination of all ergonomic certificates. In this idea we are proposing such computational program, able to determinate the three proposed ergonomic indexes and some global indexes. For example, we can determinate a global general index, including in a single model the three aspects of the ergonomic activity, or we can determinate a global index describing simultaneously the ergonomicity of the working place and the security of the working place.

The program begins with a first screen that presents the authors and gives general information about the possibilities to run it. A second screen realizes the control of the type of the ergonomic certificate to be determined.

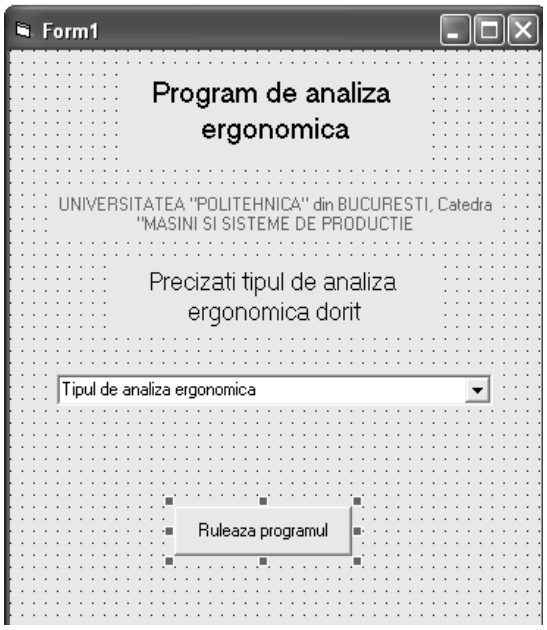

Fig. 1. Second screen of the program deciding the way to suit for the program

So, it is possible to set the program for the determination of the ergonomic certificate of the product, the ergonomic certificate of the working place and the ergonomic certificate for the security of the working place from the point of view of the human protection against work accidents. The program can be improved by adding using the same principles modules for the determination of the global indexes.

The program was made using Microsoft Office Suite, because its applications (Word, Excel, Access and Visual Basic) are integrated and can be used together with versatility. Each screen of the program is connected in a direct or inverse connection with the the precedent or the next screen, and each screen has a connection to a contextual help. In this way, it is possible to correct data and begin again the run sequence, and the user is informed about the needs of the moment and about the way too suit.

After the run command appears a screen in which it is to complete the table with the responsibilities of the members of the team. The team is formed from a respondent charged with the ergonomic evaluation and some members (usually 4) from different field of activity, forming a multidisciplinary team. The table becomes printable after it adjunction.

The next step is the display of an Excel table with the questions of the list and with fields for the answers, in which the users give the appropriate answers of the questions. The last line offers a number that represent the base for the calculus according to the mathematical model for the determination of the wanted certificate or index.

The completion of the rubrics from the program table is realized using data basis.

The call of the data basis is realized by commands from the screen in which the data are necessary.

The data bases were made in Access, considering it integration in the Visual Basic mean. In the same time, in the last screen of the approach of the program is calculate and presented the ergonomic certificate and indications about the situation of this certificate in a hierarchy. This hierarchy needs supplementary studies.

The run can be carried on with the approach of others ergonomic certificates

The logic of the program imposes the use of a great number of data bases having a lot of common points for the three ergonomic certificates. For this reason, the realization of a single complex program containing the three sides of the approach are more efficient then the use of separate programs for each certificate.

The elaboration and the completion of the data bases uses standard and norms existing in the specialty literature and represent a constant concernment of the authors. We can tell with assurance that in this field of the standard and norms it is very much to do, in order to complete the data and too obtain fine resolutions of the appreciations.

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