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Analysis of technological process on the basis of efficiency criterion

B. Krupińska*, D. Szewieczek
Division of Quality Management
Institute of Engineering Materials and Biomaterials, Silesian University of Technology, ul. Konarskiego 18a, 44-100 Gliwice, Poland
* Corresponding author: E-mail address: beata.krupinska@polsl.pl

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ABSTRACT

Purpose: Technological process is a basic determinant of correctness of industrial company's functioning on the market. In this connection they should treat with the priority all activities connected with technology, technology management and controlling, that is with their continuous improvement.

Design/methodology/approach: The created model made it possible to analyze the chosen technological processes for the sake of efficiency criteria, which describe the relationships: operation – material, operation – machine, operation – man, operation – technological parameters.

Findings The in this thesis conducted analysis includes hypothetical technological processes of producing typical machine pieces. Within their scope also the nonmaterial parameters of technological process have been taken into account, which resulted from arts of applied samples and projecting of the technological process.

Practical implications: One has worked out an application that allows to analyze the efficiency of technological process in aspect of nonmaterial values and has used neuronal nets to verify particle indicators of quality of a process operation. Indicators appointment makes it possible to evaluate the process efficiency, which can constitute an optimization basis of particular operation.

Originality/value: As a result of this analysis gained data enabled to optimize the technological process by estimating influence of the analyzed parameters on the whole of process and optimization conducting of any process.

Keywords: Production Planning and Control; Technological efficiency; Technological process; Optimization, neural nets

1. Introduction

Technical progression within the scope of material engineering increases the demands and expectation towards the products quality.There is a lot of rules that allow its creation, like e.g. modeling of the production technology, multi – criteria optimization by the use of computer. From the qualitative and correctness of choose of technology point of view comprehensive technological processes assessment makes up the basis of technological efficiency analysis. During a technological effectiveness analysis one can use particle determinants of effectiveness that characterize an operation taking into account following criteria: operation – material, operation – machine, operation – a man, operation – technological parameters (Fig.1). In such a way conducted analysis shows the influence of particular criterion on the process effectiveness and determines the optimization direction.

Taking into consideration the variety of operation within the technological processes one can use the importance determinant of operation that describes an operation importance in the whole process. In order to appoint this determinant one has to work out the matrix by the mean of showing the relation between all the operations. It allows to systematize an operation according to the weight influencing the process course correctness.

Indicators selection allows to evaluate the efficiency indicator of particular operations (K_{iX}) (1).

$$K_{iX} = \frac{W_{EM} + W_{EPM} + W_{EPC} + W_{EX} + W_{PD}}{5} \quad (1)$$

As a result of this one can show the ineffective operations as the same time taking info account the importance of an operation expressed by the use of an indicator of operation importance (W_{WK}). The value of components of an operation effectiveness (K_{iX}) allows to determine the area of its improvement, and as a resulr improvement of the whole technological process. That means, that such an analysis can be used as a tool not only of efficiency analysis but also to improve the process continuously, and at the end its optimization. The determined indicators of operation efficiency will be used to determine the value of efficiency for the sake of the art of applied processing (E_{OC}, E_{OU}, E_{OPZ}, E_{OPG}), and as a result to fix the technological efficiency of the whole process
(E_{PT}) (2).

$$E_{PT} = \frac{\sum_{i=1}^{n} E_{OBi} + W_{POL}}{n+1} \quad (2)$$

2. Creation of computer application that allows the determination of particular indicators and a final efficiency evaluation and optimization of particular operations (AEPT)

Taking into account the prepared model of technological efficiency analysis (Fig.1) one has created a system of computer assist. To analyze the technological efficiency an application was created that partly makes it easier to calculate the technological efficiency of the process.

AEPT (Analysis of Efficiency of the Technological Process) program makes it possible to prepare a final report that shows the conducted analysis of technological efficiency for the chosen process. The algorithm of data introducing complies with the model of determination of technological efficiency (Fig.1).

Stage I **–** after setting program from menu „application" in motion we choose the "new calculation" function in order to supplement the technological card consistent with the analyzed process.

Stage II – Next following the to the program enclosed instruction one should fulfill *"matrix of operation importance"* in order to determine the indicator *(W_{WK})* for the operation in the analyzed process. After having created the matrix operations of the process are systematized by the AEPT program for the sake of their importance for the given process

Stage III – Stage of determination of particular indicators of operation efficiency. Determination of a material efficiency indicator (W_{EM}), indicator of machines work efficiency (W_{EPM}), indicator of humans work efficiency (W_{EPC}), efficiency indicator characterizing the operation kind during the proceeding *(W_{EX})*, indicator of material selection *(W_{PD})*.

After getting the value of particular indicators of an operation we receive the technological operation efficiency *(K_{iX})* systematized in accordance with the results of matrix of operation importance (Fig.2)

Stage IV – Determination of technological efficiency for the sake of the applied proceedings (E_{OU}, E_{OC}, E_{OPZ}, E_{OPG}) and the technological efficiency of the whole process (E_{PT}) (2)

Stage V – Creation of graphs that show values of indicator of operation importance (W_{WK}), operation efficiency (K_{iX}) and technological efficiency for the sake of the applied proceeding (E_{OU}, E_{OC}, E_{OPZ}, E_{OPG})

Stage VI – Creation of final report. Program results are written in form of report showing the conducted analysis of technological efficiency and one can save it in a txt version and print.

Stage VII – Showing by the use of program operations that require being improved. After estimating the minimal acceptable value K_{iXmin} , the program points At operation, that $K_{iX} < K_{iXmin}$ and marks particular indicators that decrease its value red marking.

Stage VIII – Optimization with the use of artificial neuron nets (point 3). Modification of particular indicators allows to estimate how the value of operation efficiency indicator (K_{iX}) will be changing, and to determine the value (K_{iX}) for single operations in the technological process.

3. Application of artificial intelligence tools to the optimization technological process

Basis for creating the computer model based on artificial neurons nets were partial, technical efficiency indicators and also normalized parameters of technological process (fig.1). From many indicators to learn the neuron nets W_{zm}, T_{RZ}, W_m, W_{EX}, W_{PD}. have been applied. To practice the neuron network 200 vectors have been used, that have been divided suitable into files: learning (60%), validating (20%) and testing (20%). Calculations have been made in the STATISTICA Neural Networks program. To estimate the marked values of K_i an average mistake has been used for the testing files, determined by the dependence (3):

$$E_{Ki} = \frac{1}{n} \cdot \sum_{i=1}^{n} \left(\left| x_{zi} - x_{oi} \right| \right) \quad (3)$$

where: E_{Ki} – mistake for the indicator K_i, n – number of data in the testing file, x_{zi} – i- measured value, x_{oi} – i- calculated value.

For determination of the indicator of process efficiency Ki many neuron networks have been used. However best results gave the experiment when using the multi-ply perceptron with structure 5-9-1, learned by algorithm of reverse propagation and concentration gradients. The chart shows the mistakes value and quality of the applied neuron nets (table 1).

Table 1.
Quality indicator of the applied network

Type of network	Error test.	Quality test.
MLP 5-9-1	0,02942	0,9428132

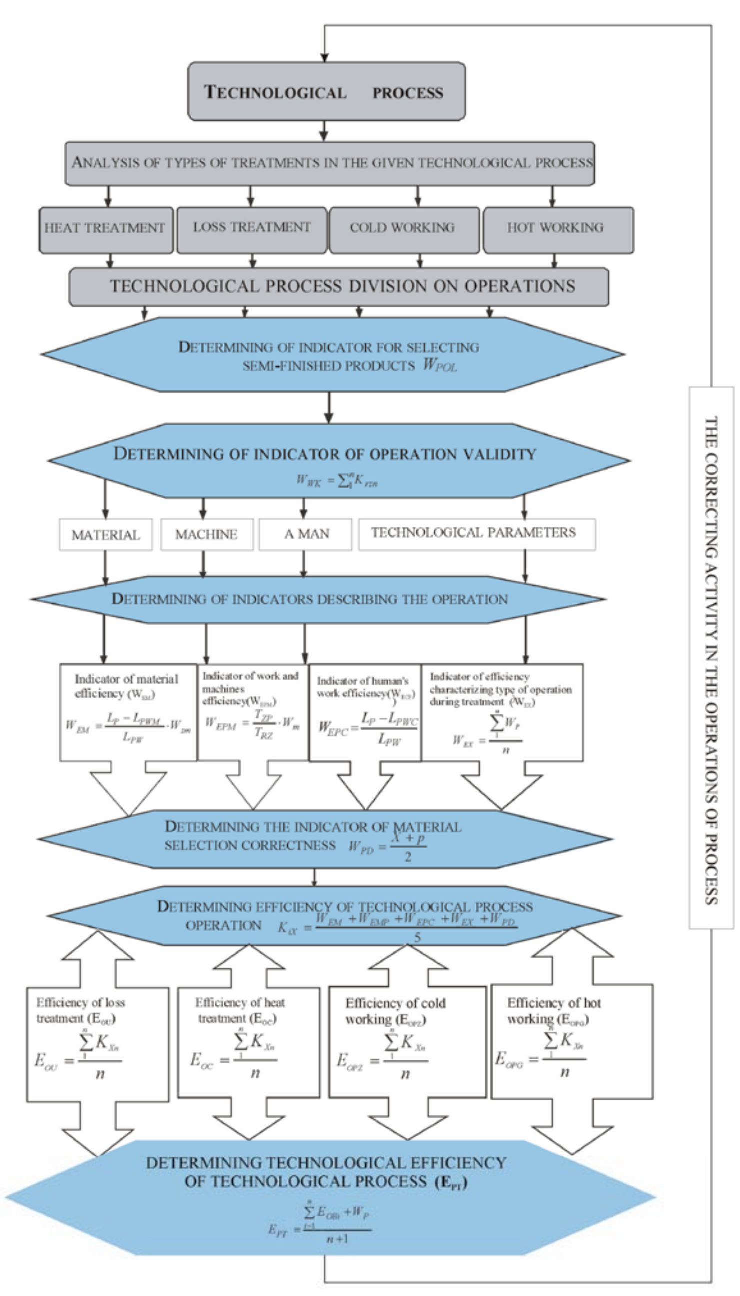

Fig. 1. The model of efficiency analysis

Comparison of real values of the efficiency indicator with values calculated by means of neuron nets have benn presented on the diagram 3.

4. Conclusions

For the sake of complexity of technological efficiency analysis one has created an AEPT computer analysis from which result: operation efficiency indicators with distinguished indicators with minimal acceptable values, values of efficiency of the applied samples, value of technological process efficiency. As a result of the conducted efficiency analysis with the use of computer application (AEPT) we get a final report with the indicators values that are expressed in the table and graph forms.

In order to automate the process, to determine the efficiency of technological operation (K_{iX}) and possibly to optimize it, one has applied one of artificial intelligence tools – neuron nets.

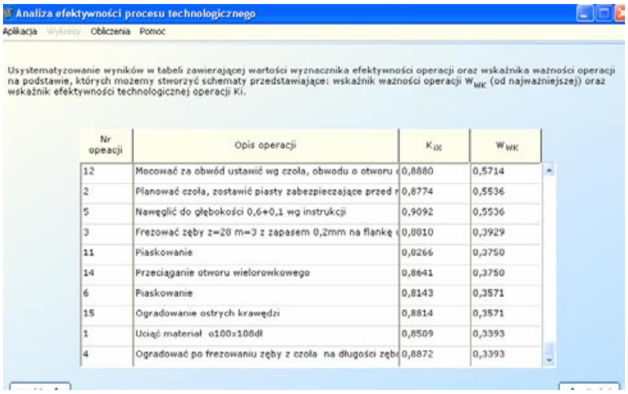

Fig. 2. AEPT program window showing the efficiency of technological operations *Kix* of the analyzed process, systematized according to the value of an indicator of operation importance W_{WK}.

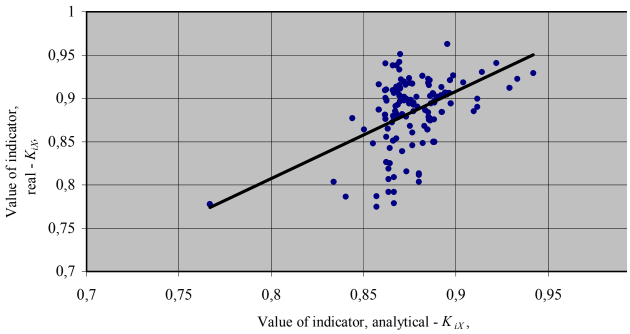

Fig. 3. Comparison of real values with calculated values of the indicator K_{iX}

The model with the use of neuron nets that has been worked out allows to calculate the efficiency indicator (K_{iX}) with average mistake equal to 0,02, what goes to show that determination of value indicator (K_{iX}) by means of nets is very accurate. Estimating the accuracy of efficiency calculations one should take into account the fact, that the average mistake that occurs during the control of nets didn't exceed 3,89% of the value scope of the operation efficiency indicator form the bracket 0 to 1. Similar values of nets quality assessment indicators are calculated for the text and verification set, confirm the correctness of the prepared model and point at the ability of the proposed neuron net for application during the determination of indicator of operation efficiency.

The created computer analysis of ef technological process efficiency (AEPT) makes it possible to automate the process of analysis and optimization. It makes it possible to conduct a detailed analysis of technological efficiency which follows a final report covering data from the technological process and calculated values of operation importance indicator (W_{WK}), particular efficiency indicators, efficiency for the sake of proceedings kind.

The program shows not effective operation, by the same time distinguishing the values of particular indicators with the law efficiency values.

Application of neuron nets allows to determine the value of technological efficiency of an operation. (K_{iX}) without the necessity of detailed analysis as well of the whole process as of the particular operation. It makes it also possible to optimize operation efficiency by means of checking value of operation efficiency in the case of change in value of particular partial efficiency indicators.

The use of neuron nets allows to calculate the operation efficiency indicator (K_{iX}) with the average mistake equal to 0,02 what confirms a high accuracy of the net working.

References

[1] M. Białko, Methods and use of artificial intelligence, Koszalin: Wyd. Uczelniane Politechniki Koszalińskiej, 1996 (in Polish).

[2] L.A. Dobrzanski , W. Sitek, M. Krupinski, J. Dobrzanski: Computer aided method for evaluation of failure class of materials working in creep conditions, *Journal of Materials Processing Technology* (Elsevier), Volume: 157-158, Complete, December 20, 2004, pp. 102-106

[3] L.A. Dobrzański: Basis of science about materials and metallographic. Engineering materials with basis of material projecting, WNT, Warszawa 2002 (in Polish).

[4] L.A. Dobrzański: The principles of selection of engineering materials from cards of profiles, WNT, Warszawa 2001

[5] M. Dudek-Burlikowska: Quality estimation of process with usage control charts type X-R and quality capability of process Cp, Cpk, Journal of Materials Processing Technology 162-163 (2005) (Elsevier) pp.736-743

[6] B. Krupińska: Optimization of the chosen technological processes for the sake of their efficiency (Ph.D), Gliwice 2005.

[7] B. Krupińska, D. Szewieczek: The attempt of evaluation of the chosen technological gear wheel process on the basis of its efficiency operation, The 13th International Scientific Conference on Achievements in Mechanical and Materials Engineering - AMME'2005, Worldwide Congress on Materials and Manufacturing Engineering and Technology - COMMENT'2005, 16th-19th May 2005 Gliwice – Wisła, pp.363-370

[8] D.G. Luenberger: Theory of optimization, PWN, Warszawa 1984 (in Polish).

[9] J. Michalska: The usage of The Balanced Scorecard of the estimation of the enterprise's effectiveness, Journal of Materials Processing Technology 162-163 (2005) (Elsevier) pp. 751-758

[10] S. Osowski, The neuronal nets to processing of information. Oficyna Wydawnicza Pol. Warszawskiej, Warszawa 2000 (in Polish).

[11] M. Roszak, S. Tkaczyk: Chosen aspects of evaluation of productive processes on the example of productive chains of sections type V29, Journal of Materials Processing Technology 162-163 (2005) (Elsevier) pp. 770-776

[12] G. Rummler, A. Branche: Increasing the efficiency of organization, PWE, Warszawa 2000 (in Polish).

[13] D. Szewieczek, St. Tkaczyk, B. Wojtaszek: Measurement and control of the technological process by means of the analysis of its effeciency, 12th Interational Scientific Conference AMME Gliwice-Zakopane 2003.

[14] D. Szewieczek: The thermal processing of metal materials, Wyd. Pol. Ś., Gliwice 1998 (in Polish).

[15] R. Tadeusiewicz, The elementary technical innovation of neuronal nets with the example - programs. Akademicka Oficyna Wydawnicza PLJ, Warszawa 1999 (in Polish).