CzOTO 2021, volume 3, issue 1, pp. 162-169

THE IDENTIFICATION OF PROBLEMS IN PRODUCTION PROCESS USING ELEMENTS OF SECOND TOYOTA'S MANAGEMENT PRINCIPLE – CASE STUDY

doi: 10.2478/czoto-2021-0017
Date of submission of the article to the Editor: 12/01/2021
Date of acceptance of the article by the Editor: 31/03/2021

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Abstract: The paper presents a case study of the practical use of BOST surveys to identify problems that are the most important in production process. The research object is company from electrical industry. It was made the identification and of areas geneating problems from the second Toyota's management principle point of view. Analysis of the research results was presented in the form of tables, histograms, radar chart and some statistical tools. Some production workers of the company with the help of BOST questionnaire survey showed, which factors are the most important. The aim of the analysis is to present which factors are the most important by building the significance sequences of obtained results. The results obtained for the type of small and medium-sized enterprises overlap with the results of tests verified in other enterprises.
Keywords: BOST method, improvement, Toyota management principle, importance hierarchy, statistical analysis

1. INTRODUCTION

Survey and research method determined as BOST was formed as a result of author's fascination in Toyota Motor Company (Borkowski, 2016). The BOST method defines relations between material resources and human resources and between human resources and human resources and is named Toyotarity (Borkowski, 2012). The BOST method describes Toyota's management principles with its characteristic factors (Gao and Low, 2015). Each of these principles described with an appropriate set of factors. Apart from Toyota's principles described with applied factors and respondents' features the set of research problems also contains elements of the roof of Toyota's house, which describe the mission of enterprises (Liker and Franz, 2011). Toyota's management principles are divided into sections that contains a set of factors describing principles: 1; 2; 3; 4; 6; 7; 14 and elements of the roof of Toyota's house (Knop and Mielczarek, 2018). Respondents may assess the significance of a given factor by placing one of the numbers within the range of scale in an appropriate box (Borkowski et al., 2013). A preliminary condition for classification of the companies to BOST study was confirmed information about implementation of Toyota management principles in the workstations in analyzed company. In selected enterprise the population of respondents was chosen, which consisted from production workers of the examined enterprise, having a contact with manufacturing process. The researched company is a producer of electrical installation equipment and is one of the leading Polish producers of this type of products. Production started in the 1950s. At that time, boxes, installation connectors, sockets and plugs were produced. Now, it mainly manufactures surface-mounted and flush-mounted equipment and electrical accessories and also specializes in the production of extension cords, connectors, splitters, plugs, portable sockets, transformers, boxes, taps, push-and-turn dimmers, loudspeaker sockets, frames, boxes, etc. All products have safety certificates confirming the compliance of the products with the applicable standards and the high quality of the manufactured products.

2. METHODOLOGY OF RESEARCH AND PRESENTATION OF RESULTS

Second Toyota management principle is based on the conviction that appropriate process leads to appropriate results (Amasaka, 2012). If the process is designed properly, then good results will come automatically. Constant improvement of organization is possible through application of small steps approach. In this study the BOST method was used during tests. The BOST questionnaire form was filled out, by 30 respondents i.e. nearly half of production workers. In the purpose to form an opinion it is essential to know the opinion of workers from different ranks in enterprise. It lets on better look on the enterprise by eyes of workers. Respondents were asked to answer the following question: Which factor is the most important in the production process? (fill the blanks with 1; 2; 3; 4; 5; 6; 6 – the highest factor).

CP		Continuous system of problem detection
PE		Production layoff after quality problem detection
SZ		Standard tasks, processes, documents
EU		Granting authorization to subordinates
ST		Usage of only reliable technology
SW		Usage of visual control

Table 1 present a percentage list of significance rates of factors in the enterprise producing electrical articles.

Table 1.
Structure rating [%] of importance ratings for factors of E3 area.

Evaluation	**Indicating the factors**					
	CP	**PE**	**SZ**	**EU**	**ST**	**SW**
1	3.2	0.0	22.6	35.5	3.2	35.5
2	3.2	6.5	25.8	35.5	0.0	29.0
3	16.1	19.4	32.3	12.9	9.7	9.7
4	9.7	16.1	12.9	16.1	38.7	6.5
5	29.0	22.6	6.5	0.0	25.8	16.1

Data presented in the above-mentioned table prove that employees of the examined enterprise consider *Continuous system of problem detection* (CP) as the most important element of production process. The results contained in Table 1 were graphically presented with the use of histogram (Selejdak, 2015).

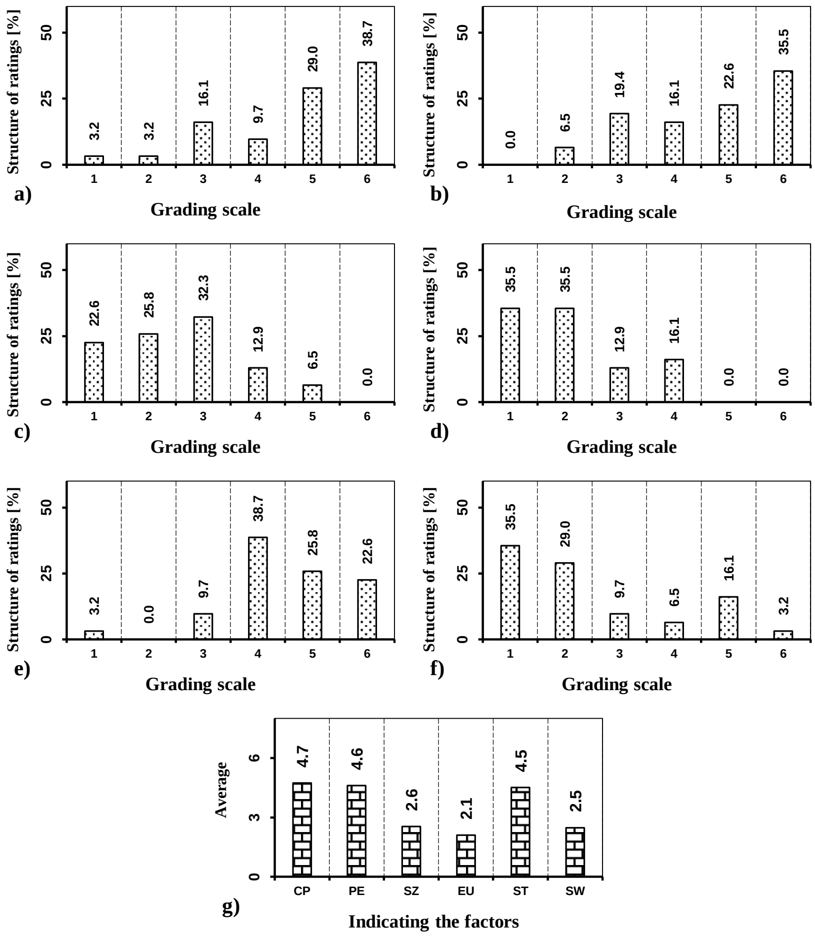

Fig. 1. Histograms – rating structure of the importance of area factors a) CP, b) PE, c) SZ, d) EU, e) ST, f) SW, g) average

The data in this figure allows the creation of the following significance sequence of analyzed factors: CP > PE > ST > SZ > SW > EU. In this enterprise the factor *Continuous system of problem detection* (CP) is the most important in the realization of the production process. In such conditions of production there is no place for an individual interpretation of procedures or management, therefore the factor *Granting authorization to subordinates* (EU) takes the last place in the sequence. The sequence of factors in graphical form was introduced in Fig. 2

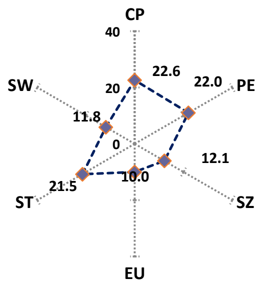

Fig. 2. Radar chart percentage structure for average ratings

The main task of summing histograms is to check the correctness of the performed calculations. They concern the average assessment of the importance of a given factor and the correctness of the calculation of its percentage share. The summing histograms for the obtained results are presented in Fig. 3.

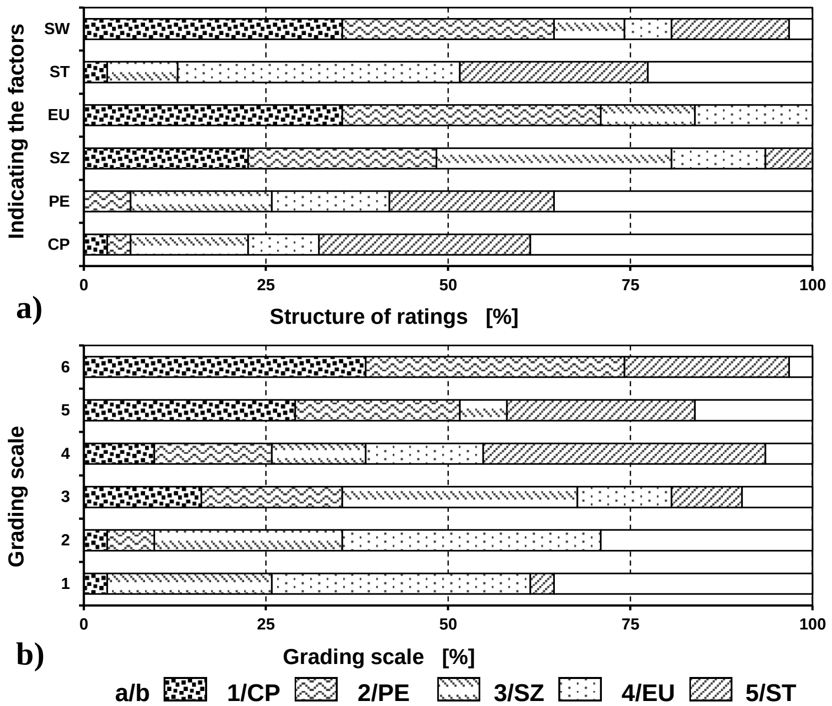

Fig. 3. Summing histograms. Comparison: a) structure of ratings, b) importance of factors in rating in grading scale

Assessments will be presented, which the percentage is on the line of 25% (Q1), 50% (median), and 75% (Q3) of the cumulative value. Summarizing the information obtained from the histogram of factors importance in the rating scale, we state:

- The first quartile is achieved for factors CP, PE
- The median is reached for the factors CP, SZ, EU, ST
- The third quartile is achieved for factors EU, ST

In both analyzed cases, it can be stated that the first quartile is achieved for higher rating scales.

3. STATISTICAL ANALYSIS OF THE RESULTS

Summarize making statistical analysis of studied area five statistical tools were used: arithmetic average, standard deviation, the coefficient of variation, skewness and excess coefficient (Fig. 4). The aim of application of this statistical tool is to show distribution of evaluation for individual factors (Knop, 2018). The aim of application of this statistical tool is to show distribution of evaluation for individual factors (Borkowski and Ulewicz, 2009).

The average level of the measurable feature was presented with the help of the average (Uçurum et al., 2016). Superficial analysis of the Fig. 4a notes that there is not a great difference between the average values. The highest average rate was granted to the *Continuous system of problem detection* (CP), *Production layoff after quality problem detection* (PE), and *Usage of only reliable technology* (ST). In the case of the average rate the minimum of 2.1 was recorded for *Granting authorization to subordinates* (EU). Standard deviation is the biggest for the factor *Usage of visual control* (SW) – on the level 1.59 and the smallest for SZ – 1.18.

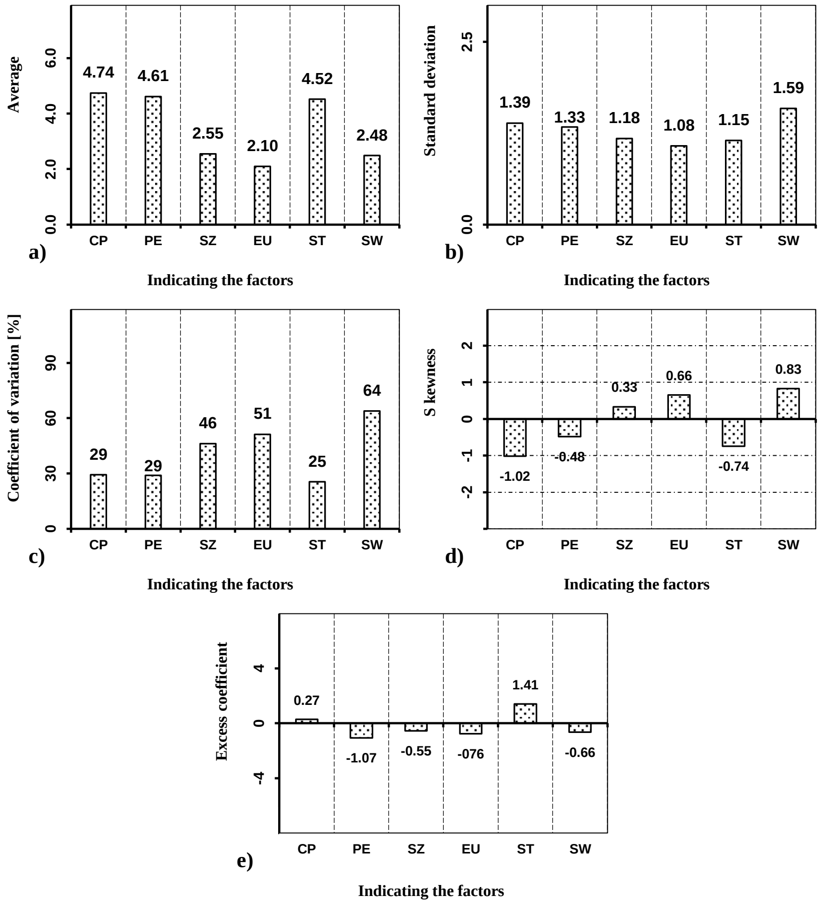

Fig. 4. Principle 2. Comparison: a) average, b) standard deviation, c) coefficient of variation, d) skewness, e) excess coefficient for factors

The range for the variation coefficient acquired distribution rates amounts from 25% to 64%. Using the data sheet we have found that the dispersion force of a statistical group of importance rates: variation weak features (anyone factor), variation moderate features (group of rates for three factors), variation strong features (group of rates for three factors), variation very strong features (anyone). The measurement of skewness is a classic coefficient of asymmetry: (0.0 - 0.4) - very weak distribution asymmetry, (0.4 - 0.8) – weak distribution asymmetry, (0.8 - 1.2) - moderate distribution asymmetry, (1.2 - 1.6) – strong distribution asymmetry, (more than 1.6 – very strong distribution asymmetry). The analysis of skewness of the factor importance rates distribution describing the second Toyota management principle, comes down to the following facts that the greatest asymmetry force occurred for the distribution of importance rates for *Continuous system of problem detection* (CP) and amounted to -1.12. The distribution of rates for the rest of factors indicates weak and moderate skewness. The last factor for analyzing is excess coefficient. It determines the measure of distribution and concentrating the results in surroundings of the average. For appropriate interpretation of results the following statement is necessary: We < 0 – distribution is characterized by lower than standard peakedness, We = 0 distribution is characterized by standard peakedness, We > 0 – distribution is characterized by peakedness higher than standard. For the factor *Continuous system of problem detection* (CP) and *Usage of only reliable technology* (ST) excess coefficient that is measure the concentration of the disintegration, is positive. It is attesting to the fact that the graph is quite stiff and slender. For remaining factors kurtosis is negative, i.e. flatter, and value of individual factors are less concentrated, than at the normal distribution. This statistical tool confirm that distribution of results is logical and can be helpful for evaluation actual state in enterprise.

4. CORRELATION ANALYSIS

Respondents differ in terms of their personal features: gender, education, age, work experience, mobility, mode of employment. These relationships were presented in forms of graphs. Each of these Figures also contains three characteristic lines on each side of the 0 axis. It should be noted that their distance from the 0 axis is the same in all the Figures, because they represent the value of a critical coefficient for various levels α (0.05; 0.10; 0.2). Such approach is conditioned by the fact that in this type of test the problem of correlation is not raised (Knop, 2015). Justification for α = 0.2 may be the fact that the tests involved participation of people whose opinions are diversified and in order to capture correlations the adopted level of probability is acceptable.

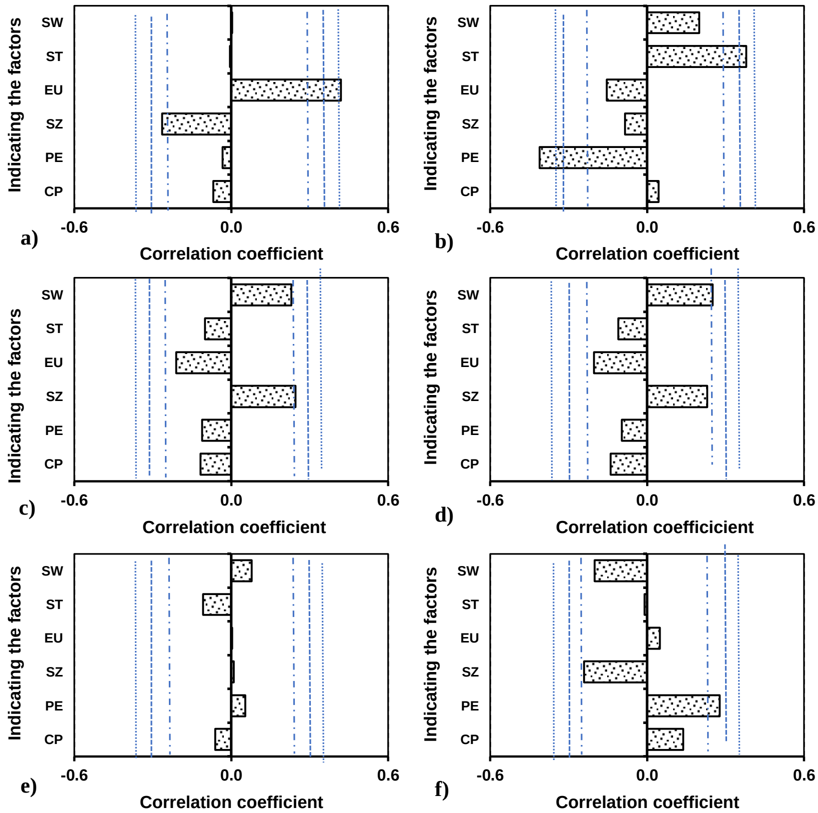

Fig. 5. Correlation graphs of evaluations depending on the respondents' feature: a) gender, b) education, c) age, d) work experience, e) mobility, f) mode of the employment. α = 0.2 (internal lines), α = 0.1 (central lines), α = 0.05 (external lines)

Analyzing the correlation graph for factors depending on the respondents' gender (Fig. 5a), it is possible to notice that *Production layoff after quality problem detection* (PE) factor demonstrated the relation of levels of the significance (α=0.2; α=0.1; α=0.05) between results of the assessment and gender of respondents.

As a result of the analysis of correlation graphs of factor assessments depending on the education of the respondents it can be concluded that in this case there is no correlation for two factors *Usage of only reliable technology* (ST) and *Granting authorization to subordinates* (EU). It is possible to state, that one SZ of six factors demonstrated the relation of levels of the significance between results of the assessment and age of respondents. In the case of the correlation graph depending on the work experience of respondents factor SW demonstrating the correlation relationship. It is possible to state, that none of six factors demonstrated any the relation of levels of the significance (α=0.2; α=0.1; α=0.05) between results of the assessment and mobility of respondents The last graph shows the positive correlation of the factor *Production layoff after quality problem detection* (PE) at the level of α = 0.2. Significance sequences of factors describing the second Toyota management principle are an interesting element. They contain a logical order conditioned by organization of production. Acquired results and their multidimensional analysis confirm the accuracy of factors choice describing the second Toyota management principle.

5. SUMMARY

The subject of the research was a company that manufactures electrical products. The key to success is the production of high-quality, reliable, functional and safe products. The starting point for changes (improvement) is recording the existing condition. The present situation is known best by participants of the processes implemented in a given enterprise. Data obtained from BOST analysis allowed to know the opinions of the representative group of workers in the topic of functioning of the enterprise concerning the competent organization of a production process. All the company's products have safety certificates that confirm the compliance of the products with the applicable standards. As a result of the BOST survey conducted, an analysis of the factors that are the most important in production process. According to the respondents, the most important factor in the production process is the *Continuous system of problem detection* (CP), with an average value of 22.6%. The second position, almost on the same level, exceeding 22.0% was taken by the following factor *Production layoff after quality problem detection* (PE) and *Application of reliable technolog*y (ST) (21.5%). These are the factors closely connected with technological aspects of production relating to fluent production rhythm with simultaneous application of reliable methods and technologies. The factor that respondents considered the least important in the production process was *Granting authorization to subordinates* (EU), which received an average rating of 10.0%. The BOST survey research allowed to obtain information about the most important factors for the company's employees in the production of electrical products. The above fragment of the analysis showed differences in the importance of factors describing Toyota's second Toyota management principle and it has revealed diversity in the significance of factors. In this way, the usefulness of the presented BOST method for the assessment of the functioning of the production process was demonstrated.

Reference

Amasaka, K., 2012. *Science TQM, New Quality Management Principle, The Quality Management Strategy of Toyota Introduction,* Bentham Sc., U Arab Emirates.

Borkowski, S., 2012. *BOST Method as the Instrument of Assessment Process Functioning according to Toyota Principles,* University of Maribor, Maribor.

Borkowski, S., 2016. *Scientific Potential of Toyotarity and BOST Method*, Polish Quality Institute, Warsaw.

Borkowski, S., Rosak-Szyrocka, J., Klimecka-Tatar, D., Jagusiak-Kocik, M., Sygut, P., 2013. *Determination of the technology place in the metal company on the basis of the Toyota's management principles*, METAL 2013 - 22nd International Conference on Metallurgy and Materials, Conference Proceedings, 1691-1696.

Borkowski, S., Ulewicz, R., 2009. *Instruments of Production Processes Improvement,* PTM, Warsaw.

Gao, S., Low, S.P., 2015. *Toyota way style human resource management in large Chinese construction firms. A qualitative study,* International Journal of Construction Management, 15(1), 17-32.

Knop, K., 2015. *Statistical analysis of responses concerning the importance of human and production or services issues in various companies*, Production Engineering Archives, 7(2), 40-44.

Knop, K., 2018. *Statistical Control of the Production Process of Rolled Products*, Production Engineering Archives, 20, 26-31, DOI: 10.30657/pea.2018.20.06

Knop, K., Mielczarek, K., 2018. *Assessment of Production Processes Functioning in the Case of Air Bag Production*, MATEC Web Conf., 183, 04009, DOI: 10.1051/matecconf/201818304009

Liker, J.K., Franz, J., 2011. *The Toyota Way to continuous improvement*, McGraw Hill.

Selejdak, J., 2015. *Use of the Toyota Management Principles for Evaluation of the Company's Mission,* Production Engineering Archives, 1(1), 13-15, DOI: 10.30657/pea.2013.01.04

Uçurum, M., Çolak, M., Çınar, M., Dışpınar, D., 2016. *Implementation of Statistical Process Control (SPC) Techniques as Quality Control in Cast Iron Part Production,* Journal of Engineering Precious Research and Application, 1(3), 14-24.