sciendo QPI 2021, volume 3, pp. 198-204

IDENTIFICATION OF THE IMPACT OF WORKLOAD LEVELING FACTORS (HEIJUNKA) - BOST METHOD CASE STUDY

doi: 10.2478/cqpi-2021-0018

Date of submission of the article to the Editor: 23/06/2021
Date of acceptance of the article by the Editor: 16/09/2021

Krzysztof Mielczarek[1] – *orcid id: 0000-0003-3701-0192*
[1]Czestochowa University of Technology, **Poland**

Abstract: The article presents a case study of the practical use of BOST surveys to identify the most important areas in the execution of production process. It was made the identification of areas from the four Toyota's management principle point of view. The research object is company producing the different metal products. Some production workers of the company with the help of BOST questionnaire survey showed, which factors are the most important in production process. In frames of the work it was the presentation of research methodology and content four Toyota's management principle. Based on the survey results of carried out on the population of production workers, a series of importance areas for improvement was formulated. 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, importance hierarchy, Toyota's management principle, statistical analysis

1. METHODOLOGY OF RESEARCH AND PRESENTATION OF RESULTS

Toyota Production System (TPS) is based on scientific principles and assumes that all separate elements work well for the benefit of the entirety (Gao and Low, 2015). The Toyota's management style has its origins in textile industry (Amasaka, 2012). Management in reference to automotive industry has elements of an American management with consideration of a Japanese culture. Toyotarity is a scientific discipline examining human - machine and human - human relationships with the inclusion of a process-based approach, Japanese culture, especially of Toyota (Borkowski, 2012). Survey and research method determined as BOST was formed as a result of author's fascination in Toyota Motor Company (Liker and Franz, 2011). This method describes the Toyota's management principles with its characteristic factors (Ohno, 2008). Set of factors is called an area. Some principles are divided into two or even three areas. Respondents may assess the significance of a given factor by placing one of the numbers within the range of scale in an appropriate box. 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. The examined object is a metal plant with over 50 years on Polish market specializing in the production of rolled and forged-rolled products. Among the numerous assortment of the smelter, the most important can be distinguished: forging slabs, billets for forging, pipe and cylinder bars, round bars, flat bars, head sections, angles, channel bars, hoops, and rings. The production volume classifies the steel mill to small-sized steel mills, while the manufacturing assortment makes the steel mill an important plant in the supply of steel products to the shipbuilding, construction, and many other industries, both on the domestic and foreign market. In selected enterprise the population of respondents was chosen, which consisted from production workers of the examined enterprise, having a contact with manufacturing process in the workplace. (Knop and Mielczarek, 2018). Stability of the basic production process is crucial for continuous manufacture of the product consistent with the highest quality standards. The control of its particular elements and the awareness of their significance among employees is the key factor to optimization of the whole process (Mielczarek, 2015). In this study the BOST method was used during tests (Borkowski, 2016). Respondents were asked to answer the following question: Which elements are most important in the execution of the production process? Enter 1, 2, 3, 4 in the box (4 – the most important factor) (Selejdak, 2015).

RO		Balanced workload for employees
RM		Balanced workload for machines
KW		A short series of products
RD		Regularity of supplies

The questionnaire survey was carried out in the researched enterprise producing metal products amongst 30% production workers. Such a large group of directly production workers will allow to precise identification the most important areas the surveyed enterprise. Results of the survey have been presented in Table 1

Table 1.
Principle 4. Numerical summary of E5 area importance ratings. Concerns the production of a metal products

Evaluation	Factor indication			
	RO	**RM**	**KW**	**RD**
1	11	9	4	8
2	7	9	6	10
3	8	6	7	11
4	6	8	15	3

The results of the study were detailed in the analysis. Based on the results of the BOST survey it can be stated that according to employees the most important factor influencing realization of the production process is *A short series of product* (KW).

2. STRUCTURE OF RATES GRANTED TO FACTORS FROM THE BOST QUESTIONNAIRE

On the basis of the results presented in Table 1 the following histograms have been created. The aim of application of this tool is to show distribution of evaluation for individual factors (Knop, 2015).

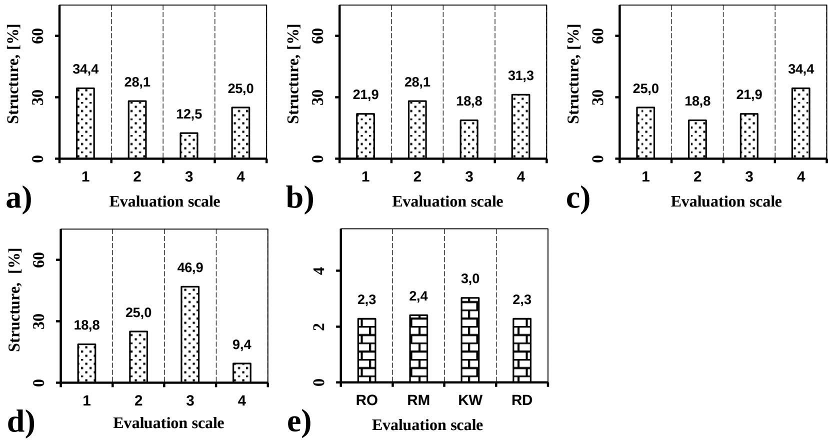

Fig. 1. Principle 4. Histograms – evaluation structure of importance structure in area E5: a) RO, b) RM, c) KW, d) RD, e) average

Fig. 1 presents the average assessments of the importance of the discussed factors. Based on this, we can clearly define that the most important factor for the respondents is *A short series of products* (KW). On the basis of the results of the BOST survey the important series have been shown. It demonstrates a significance sequence of the E5 area factors for each significance rate of factors describing the fourth Toyota management principle (Liker and Hoseus, 2008).

Table 2.
Principle 4. Place of factors E5 in importance series for individual evaluations Concerns the production of a metal products

Evaluation	Place of factors in importance series			
	1	2	3	4
1	RO	RM	RD	KW
2	RD	RM	RO	KW
3	RD	RO	KW	RM
4	KW	RM	RO	RD

On the basis of Table 2 was presented importance series of factors for individual evaluations. Summing up, a range of important factors in examined enterprise is following:

For evaluation “1” the importance series is: KW>RD>RM>RO. It proves that the factor of *A short series of products* (KW) has received the smallest number of rates “1” – 12.5% and takes the last place in the significance sequence for this rate. For evaluation “2” the importance series is: KW>RO>RM>RD. In the case of rate “3” the following significance sequence of analyzed factors has been developed: RM>KW>RO>RD. For a maximum rate “4” respondents declared that in the analyzed enterprise the following significance sequence describing levelling of production has been achieved: RD>RO>RM>KW.

As a supplement, Fig. 2 presents the structure of importance of factor assessments in the form of radar charts.

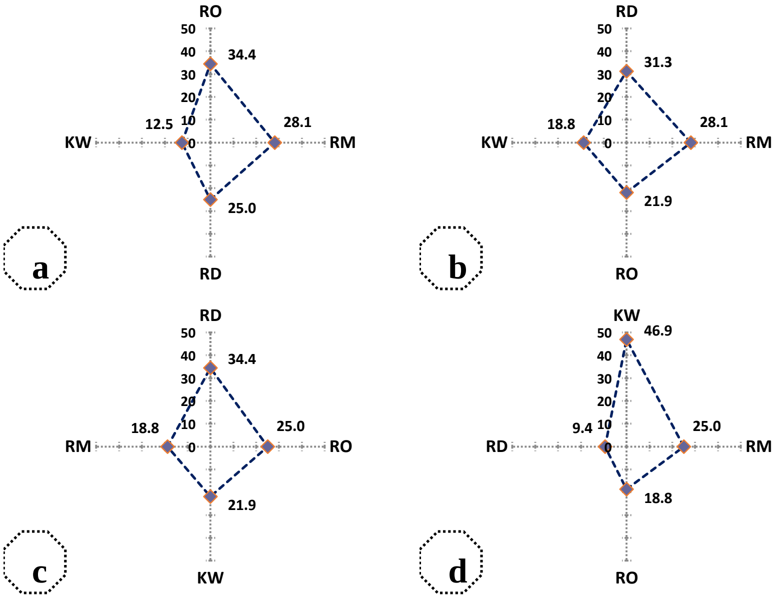

Fig. 2. Principle 4. Radar charts of importance factor of E5 area for evaluations: a) „1", b) „2", c) „3", d) „4"

According to respondents in the enterprise producing metal products the most important factor, conditioning levelling of production is *A shorts series of products* (KW), the next factor is *Balance workload of machines(* RM). The order of these factors is logical since employees are the most important factor, because they have to manually fix and control devices, take off processed parts and assemble them. Part of the materials are supplied from the outside, therefore in order to maintain continuity of production, regularity of supplies is also a very significant factor.

3. STATISTICAL ANALYSIS OF THE OBTAINED RESULTS

Making statistical analysis of studied area six statistical tools were used: arithmetic average, variance, standard deviation, the coefficient of variation, skewness and excess coefficient.

The average level of the feature was presented with the help of the average (Borkowski and Ulewicz, 2009. Analyzing Fig. 3a concerning the result of average it was taken the conclusion that the majority of respondents judged the response concerning *A short series of product* (KW) on the level 3.03. The smallest value of the average amounting 2.28 fell for *Regularity of supplies* (RD) and *Balanced workload of employees (*RO). Standard deviation (Knop, 2018). (Fig. 3b) is the biggest for the factor *Regularity of supplies* (RD) on the level 1.16 and the smallest for *Balanced workload for machines (*RM) - 0.96. Deviation Qx is the smallest for factor *Regularity of supplies (*RD) - 1.25.

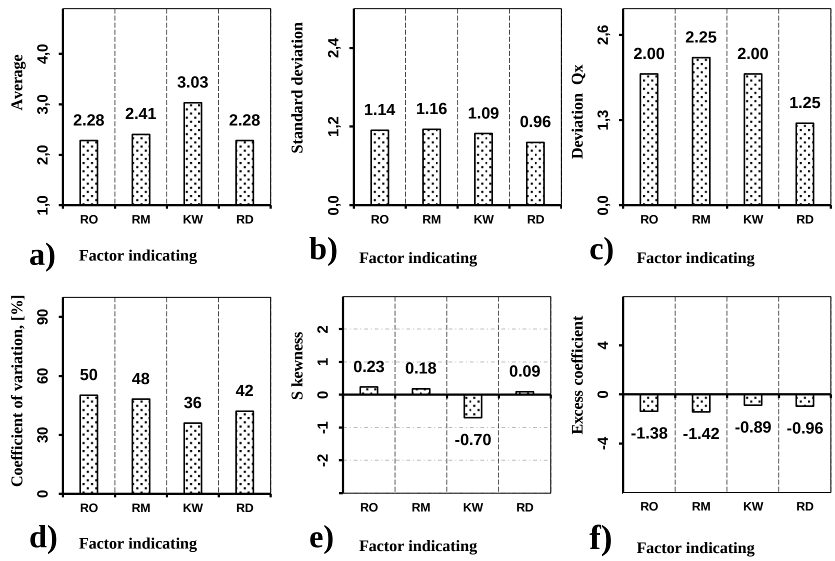

Fig. 3. Principle 4. Comparison: a) average, b) standard deviation, c) deviation Qx, d) coefficient of variation, e) skewness, f) excess coefficient for E5 area factors

The fourth analyzed statistical measure determining the area of the changeability being a difference between greatest and smallest value is coefficient of variation (Fouad and Mukattash, 2010) (Fig. 3d). In order to assess factors with the use of variation coefficient it is necessary to prepare the following statement: 0 - 20% – weak variation of feature, 20 - 40% - moderate variation of feature (Wheeler, 2000). The biggest diversity it is possible to observe for balanced workload of employees - RO. The measurement of skewness is (Fig. 3d) 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 distribution of rates for *A short series of product* (KW) indicate weak negative skewness. The last factor for analyzing is excess coefficient (Fig. 3f). 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 (Ignaszak and Sika, 2012). For all factors the distribution of rates is characterized by lower than standard peakedness. This statistical tool confirm that distribution of results is logical and can be helpful for evaluation actual state in enterprise.

4. CONCLUSION

Innovative BOST questionnaire survey, which are an attempt to convert Toyota's management principles into questions was described. The starting point for changes (improvement) is recording the existing condition. 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 and its influence on the quality of produced goods. Research was carried out amongst production workers of the company from metal industry. It allowed detailing factors which in the greatest degree can contribute for improvement processes in the company and the ones which have this smallest contribution. As a summary, it is presented in the form of a graphical chart for assessing the importance of factors

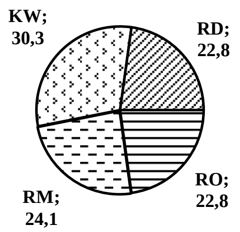

Fig. 4. Principle 4. Circular chart - significance rates for factors of the E5 area

Analyzing Fig. 4, it can be concluded that the factor *A short series of products* (KW) 30.3% has the highest average score, which proves that this factor has the greatest significance for the respondents. In addition, the two factors of four Toyota Management Principle *Regularity of supplies* (RD) and *Balanced workload of employees (* RO) are of equal importance to respondents. The last factor *Balanced workload for machines* (RM) is the least important for the respondents, as it obtained the lowest average grade of only 24.1%. Employees have revealed a general understanding of the significance of particular factors, they have not clearly omitted any factor and indicated that all the aspects mentioned in the survey have influence on the final result. Based on the analysis of the obtained results, the answer to the problem question is as follows: The most important factor for the respondents, thanks to which it is possible to improve the production in a selected company, is *A short series of products* (KW) factor. This may contribute to the identification of key areas for the functioning of the enterprise. It is an important element of research for small and medium enterprises. The results of research are consistent with the research carried out in other such enterprises. The above fragment of analysis has revealed diversity in the significance of factors describing the four Toyota management principle. In this way the usefulness of the presented BOST method has been proved for assessing a production process of goods of high-quality requirements. In the respondents' opinion the proposed set of factors has been arranged in a way characteristic for the enterprise producing a metal product. The acquired significance sequence of factors describing the fourth management principle is logical, thus confirming the correctness of their selection and the research results can be used in another small and medium-sized enterprises.

REFERENCES

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

Fouad, R.H., Mukattash, A., 2010. *Statistical Process Control Tools: A Practical guide for Jordanian Industrial Organizations*, Jordan Journal of Mechanical and Industrial Engineering, Volume 4, Number 6, 693-700.

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.

Ignaszak, Z., Sika, R., 2012. *Specificity of SPC Procedures Application in Foundry in Aspect of Data Acquisition and Data Exploration*, Archives of Foundry Engineering, Vol. 12, Issue 4, 65-70. DOI: 10.2478/v10266-012-0108-8

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(2015), vol. 7, 40-44.

Knop, K., 2018. *Statistical Control of the Production Process of Rolled Products*, Production Engineering Archives, 20(2018), 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.

Liker, J.K., Hoseus, M., 2008. *Toyota Culture: The Heart and Soul of the Toyota Way.* McGraw-Hill, New York.

Mielczarek, K., 2015. *Factors Describing the Concept of Plastics Company Development,* Production Engineering Archives, 8/3(2015), 32-35. DOI: DOI: 10.30657/pea.2015.08.08

Ohno, T. 2008. *System produkcyjny Toyoty. Więcej niż produkcja na dużą skalę.* Wrocław, ProdPress.com.

Selejdak, J., 2015. *Use of the Toyota Management Principles for Evaluation of the Company's Mission,* Production Engineering Archives, 1/1(2013), 13-15. DOI: 10.30657/pea.2013.01.04

Wheeler, D., 2000. *Understanding Variation: The Key to Managing Chaos*, 2 Revised Edition, SPC Press.