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An Importance of the Roof of the Toyota House Factors in the Food Industry

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Abstract. The article presents a case study of the practical use of BOST surveys to identify the most important areas in the functioning of enterprise in perception of the company mission by their employees. This is an important element in the consciousness of the worker and is part of the delegation and self-organization to the lowest level. The research object is company from food industry. Some production workers of the company with the help of BOST questionnaire survey showed, which factors are the most important. 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.

Introduction

Toyota Production System (TPS) is based on scientific principles and assumes that all separate elements work well for the benefit of the entirety [1]. The Toyota's management style has its origins in textile industry. Management in reference to automotive industry has elements of an American management with consideration of a Japanese culture. Toyotarity is a concept that is legally protected by confirming the date. This document contains the following definition of Toyotarity: "*Toyotarity is a field of scientific research dealing with human-machine relations and human and human taking into account the process approach, Japanese culture, particularly Toyota, oriented towards continuous improvement with the use of knowledge*" [2]. The primary research tool of toyotarity is the BOST method. It presents Toyota management principles in the form of distinctive sets of issues, describing a particular principle, these sets are called areas. Survey and research method determined as BOST was formed as a result of author's fascination in Toyota Motor Company [3]. This method describes Toyota's management principles with its characteristic factors [4]. The presented questionnaire has a ranking scale. Respondents may assess the significance of a given factor by placing one of the numbers within the range of scale in an appropriate box. After the description of the main part of this method its further elements will be outlined briefly. The BOST method allows assessing the significance of factors describing the 14 Toyota management principles [5]. Complement of carried out research there is interpretation of BOST questionnaire results. It lets better look on the enterprise by eyes of their workers. In the purpose to form an opinion it is essential to know the judgement of workers from different ranks in enterprise. BOST is survey where the questions are matched to judge enterprise and its immaterial stores are possible [6].

Methodology

The research company is a medium-sized enterprise from the food industry located in south part of the Silesian region and operating in the industry since 1990. The company produces a wide range of food products, among the most important, are: concentrates, dinner accessories vinegar,

Materials Research Proceedings 34 (2023) 252-261 https://doi.org/10.21741/9781644902691-30

spices, sauces, juices and fruit preserves. The company currently employs over 100 employees. Company is competitive with foreign countries – exporting its products to many countries. An organizational structure of the company can determine as linear, flat. There are not a large number of managerial ranks what quicken the flow of information and the procedure of deciding. Production managers are responsible for the course of an entire production process and for creating and correct implementing of new ideas or the technology. New workers before working on full-time must have an internal examination in the company. Thanks to this procedure the enterprise has the guarantee that a new worker will be performed tasks competently. The quality control is present at every stage of the production, having conceived from careful selection of sub-suppliers, through the control of materials delivered by them and sub-assemblies, the control of half-finished products processing in every phase, and on final goods finishing. It is supposed to assure that the product is safe and is characterized by good quality. The department manager may have supervision over a certain number of employees. The department employee has a strictly defined supervisor. Significant decisions are made by the owners who consider the beliefs and suggestions of the crew during the consideration.

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 [7]. 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. This article presents an analysis of the answers given to the question contained in the BOST questionnaire, referring to the roof of Toyota's house – called mission of enterprises.

Employees have answered the following question: *"Which factor is the most important in your enterprise? Fill in the blanks with 1; 2; 3; 4; 5 (where 5 the most important factor)*" (Table 1).

Table 1. *Questionnaire form*

JA		Quality
KO		Cost
CR		Execution time
BP		Work safety
MZ		Attitude of the crew

Statement of responses obtained in studies that concerned the company mission is presented in Table 2. The presented results are part of a research BOST covering a range of issues relating to Toyota management principles which were carried out in a company from food industry. The questionnaire survey was carried out amongst 60% production workers. i.e. more than half of workers. Such a large research group of directly production workers will allow to precise identification the most important areas in the surveyed enterprise.

Table 2. *Roof of the Toyota house: evaluation structure (%) of factors importance for E1 area (it concerns production of food products)*

Evaluation	**Factor indication**				
	JA	**KO**	**CR**	**BP**	**MZ**
1	0	10.0	13.3	20.0	56.6
2	3.3	63.3	13.3	13.3	6.7
3	677	6.7	40.0	16.7	30.0
4	26.7	3.3	33.3	30.0	6.7
5	63.3	16.7	0	20.0	0

Materials Research Proceedings 34 (2023) 252-261 https://doi.org/10.21741/9781644902691-30

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: MZ > BP > CR > KO > JA. It proves that the factor of *attitude of the crew* (MZ) has received the biggest number of rates "1" – 56.6% and takes the first place in the significance sequence for this rate. For evaluation "2" the importance series is: KO > BP > CR > MZ > JA. In the case of rate "3" the following significance sequence of analysed factors has been developed: CR > MZ > BP > JA > KO. For a rate "4" respondents declared that in the analysed enterprise the following significance sequence describing importance of factors: CR > BP > JA > MZ > KO. For a maximum rate "5" respondents declared that in the analysed enterprise the following significance sequence has been achieved: JA > BP > KO > (CR; MZ). The results of the study were detailed in the analysis. As is clear from the date presented in Table 2 it can be concluded that the largest number of respondents (63.3%) indicated *quality* (JA) as the most important factor in a company. As a supplement, Fig.1 is presenting radar graphs made for evaluations of importance the research factors.

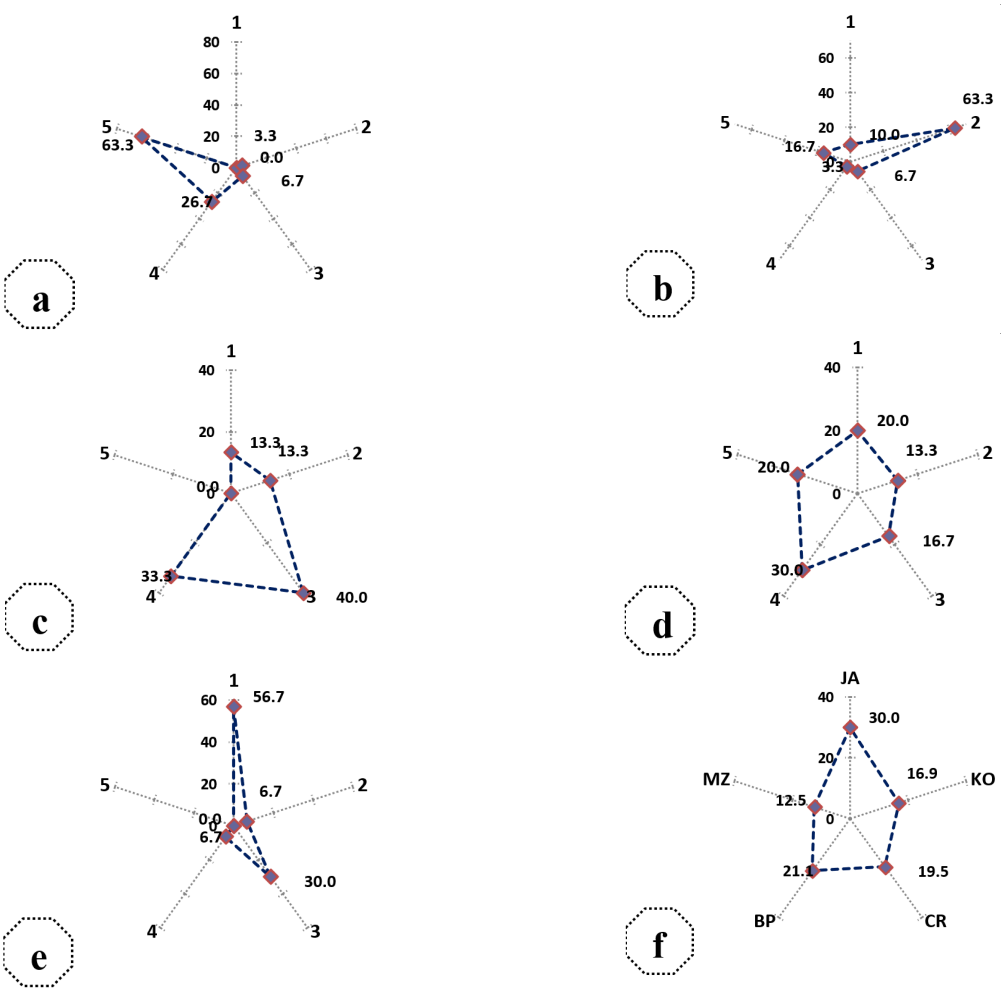

Fig.1. *Elements of the roof of the Toyota house. Circle graphs – structure of evaluations for: a) JA, b) KO, c) CR, d) BP, e) MZ, f) average – it concerns the enterprise producing food products (source: own study)*

On the basis of carried out analysis it was state, that *quality* (JA) is the most important factor for 63.3% respondents. *Costs* (KO), as well as *attitude of the crew* (MZ) are the most important only for 16.7% and 20% of respondent's respondents.). From Fig.1f results that in the enterprise a

Materials Research Proceedings 34 (2023) 252-261 https://doi.org/10.21741/9781644902691-30

quality (JA) is the most important element - 30.0%. *Work safety* (BP) were on a next place 21.1% and farther *execution time* (CR) 19.5%. Factor *attitude of the crew* (MZ) turned out to be the least crucial factor 12.5%.

Statistical Analysis of the Results from the BOST Questionnaire

Making statistical analysis of studied area six statistical tools were used: arithmetic average, variance, standard deviation, the coefficient of variation, skewness and kurtosis. The aim of application of this statistical tool is to show distribution of evaluation for individual factors [8].

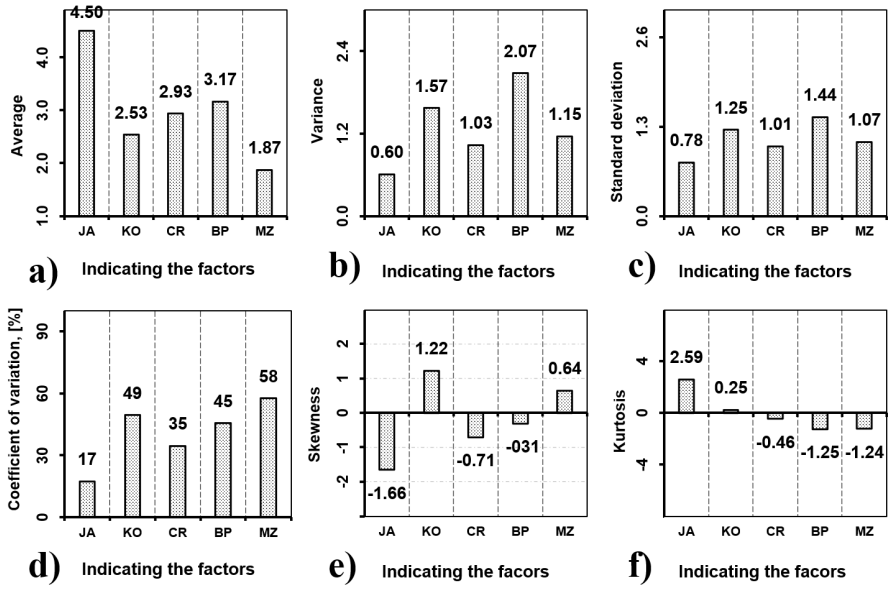

Fig.2. *Elements of the roof of the Toyota house. Comparison: a) averages, b) variance, c) standard deviation, d) coefficient of variation, e) skewness, f) kurtosis for factors in E1 area (source: own study).*

The average level of the measurable feature was presented with the help of the average. Analyzing the result concerning average it was taken the conclusion that the majority of respondents judged the *quality* (JA) on the level 4.50. The smallest value of the average amounting 1.87 fell for *attitude of the crew* (MZ). In case of variance there are small differences between factors. The highest level was achieved by the factor *work safety* (BP) 2.07, and the lowest – 0.60 – by the factor *quality* (JA). On Fig.2c was determined a standard deviation. It described provided all examined individuals features are different from average. It results from them that *work safety* (BP) having the biggest standard deviation. The next analyzed statistical measure determining the area of the changeability being a difference between greatest and smallest value is coefficient of variation [9]. The biggest diversity it is possible to observe for *attitude of the crew* (MZ). It is providing about the nonconformity of polled workers in this topic. The analysis of skewness of the factor importance rates distribution describing roof the Toyota house management principle, comes down to the following facts that the greatest asymmetry force occurred for the distribution of importance rates for *quality* (JA) and amounted to -1.66. The distribution of rates for the rest of factors indicates weak and moderate skewness [10]. The last factor for analyzing is kurtosis. It determines the measure of distribution and concentrating the results in surroundings of the average [11]. It is possible to conclude that all factors are characterized by bigger flattening in the attitude to the normal distribution. For appropriate interpretation of results the following statement is necessary: We < 0 – distribution is characterized by lower than standard peakedness, We = 0

Materials Research Proceedings 34 (2023) 252-261 https://doi.org/10.21741/9781644902691-30

distribution is characterized by standard peakedness, We > 0 – distribution is characterized by peakedness higher than standard [12]. For the factor *quality* (JA) and *cost* (KO) kurtosis that is measure the concentration of the disintegration, is positive. 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 enterprises.

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 enterprises concerning the most important elements in the company [13]. Fig.3 show the structure of ratings of the importance of factors related to the construction of the roof of a Toyota house. Division of drawings into two parts (according to the structure of assessments - Fig.3a and according to the importance of factors– Fig.3b.

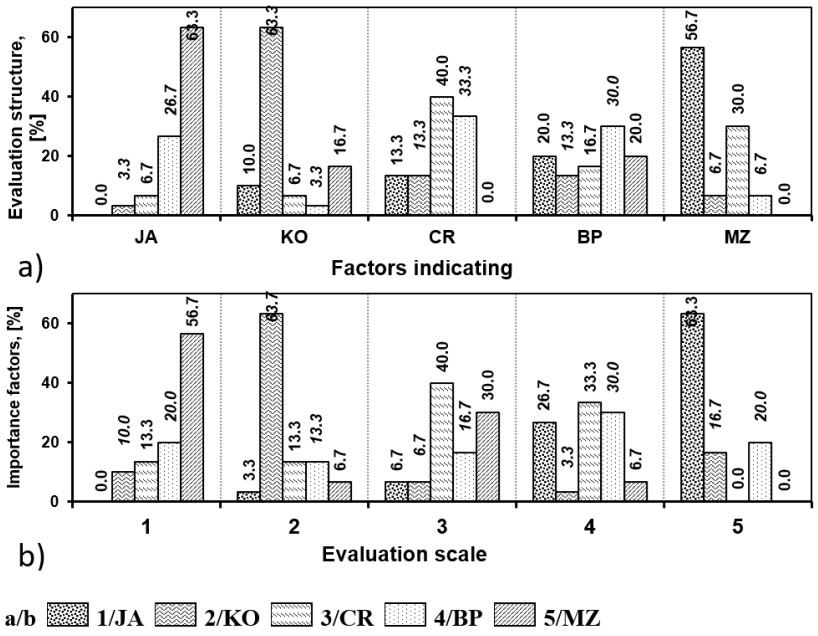

Fig.3. *Elements of the roof of the Toyota house. Comparison: a) structure of factor ratings, b) the importance of factors in rating scales (source: own study).*

Based on the analysis of Fig.3a, the statement was based that the distribution of ratings of the factors that were rated the highest is characterized by the concentration of the number of occurrences of a given rating on the right. It can therefore be concluded that the most important area of the company's activity among the elements of the roof of the Toyota house was considered by the respondents is *quality* (JA), as it received 63.3% of "5" ratings, i.e. the majority of employees rated this factor as the most important. None of the participants in the BOST study ranked quality as the least important aspect. It also shows that the *cost* (KO) received the most "2" ratings. 63.3% of the respondents identified it as the second most important area of the company's operation. The *execution time* (CR) factor can be described as a factor of medium importance from the point of view of the respondents, as it received the highest scores of "3" (40%) and "4" (33.3%), and no one considered it the most important factor (assessed "5" - 0%). The structure of *work safety* (BP) ratings is relatively uniform and ranges from 16.7% for a '3' to 30% for a '4'. The respondents considered the *attitude of the crew* (MZ) as the least important area of company activity, as evidenced by the highest number of "1" ratings – 56.7%.

Materials Research Proceedings 34 (2023) 252-261 https://doi.org/10.21741/9781644902691-30

Analysis Fig 3b revealed the following facts that the respondents most willingly gave a "1" rating to *attitude of the crew* (MZ) – 56.7%, considering it the least important area, while *quality* (JA) did not receive a single such rating. Employees considered the *quality* (JA) the most important, as evidenced by the largest number of "5" ratings given to this factor.

Influence of Respondents' Features on Factor Importance Evaluation – Correlation Graphs

To the purpose of a wider statistical analysis of respondent's replies it was carried out correlation analysis [14]. On the base of Fig.4a it is possible to state that the gender is feature of respondents which is entering correlations *cost* (KO) and *work safety* (BP). Examining the relation between education of respondents we can notice that in this case she appeared correlation for work safety (BP) on all α level.

Age has no significant impact on the assessment of any of the analyzed factors. Analyzing the correlation between the factors and job seniority it is possible to notice that this feature is entering correlation with the *attitude of the crew* (MZ) on all α level. In the case of the relation between the mobility and factors it was noticed that the mobility correlating with only one factor execution time (CR). This correlation is only on two α level. Analysis the relation between factors and the way of employment it was showed that the way the employment was entering correlations with only one factor cost (KO) on all α level.

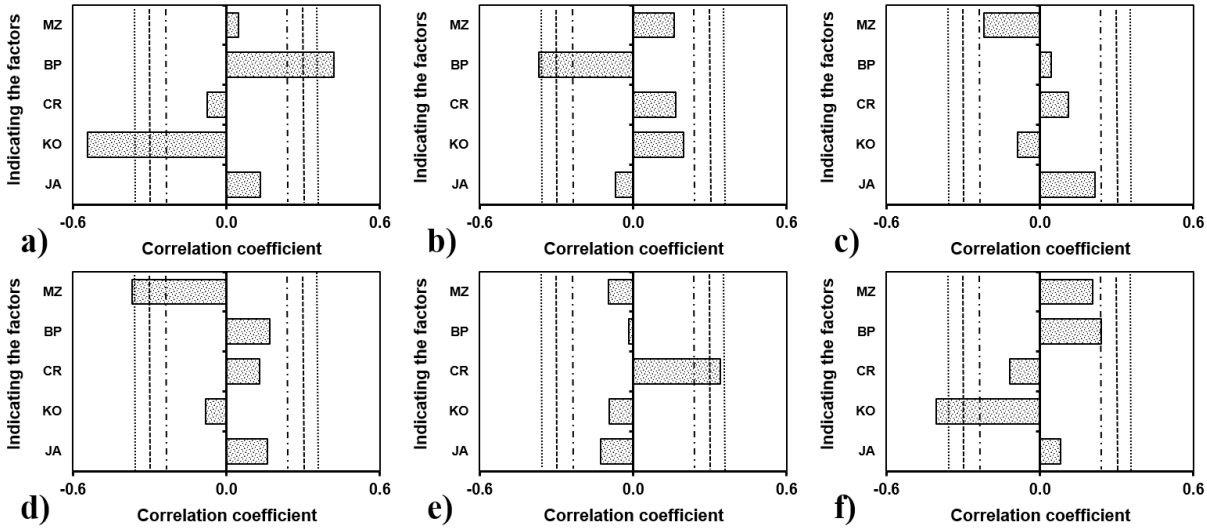

Fig.4. *Correlation graphs for factors in E1 area depending on the respondents features: a) gender, b) education, c) age, d) job seniority, e) mobility, f) way of employment. It concerns the enterprise producing food products [own study].*

The next stage of results analysis includes interpretation of graphs for voices distribution. Fig.5 is presenting interpretation of evaluation for the factor *quality* (JA) depending on individual features of the respondent.

Materials Research Proceedings 34 (2023) 252-261 https://doi.org/10.21741/9781644902691-30

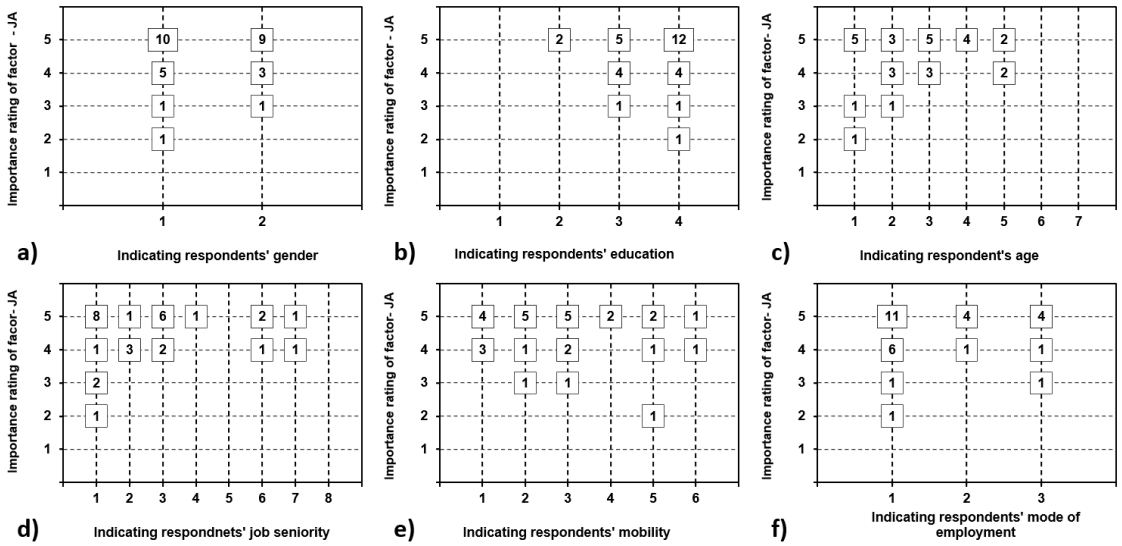

Fig.5. *Roof of the Toyota house – the map of evaluation number for quality (JA) factors depending on the respondent's feature: a) gender, b) education, c) age, d) job seniority, e) mobility, f) mode of the employment; it concerns the enterprise producing food products (source: own study).*

Analyzing the graph of the evaluation of the importance the factor *quality* (JA) depending on the respondent gender we notice that the most of men (10) granted this factor the evaluation "5" and 9 women granted the same evaluation. Analysing the respondents' education, it is possible to state, that persons with the higher education on "5" gave 12 votes, on "4" 4 voices. Analysing replies from the work experience point of view of, the most often been a granted assessment "5" from persons with work experience 1-5 years The lowest evaluation for factor *quality* (JA) granted 8 persons which researched enterprise is the first place of employment. The analysis of the dependence of grades on the mode of employment shows that 11 people employed on a regular basis, 4 employed on a transfer basis and 4 employed due to finances assess quality (JA) as the highest.

Summary

Surveyed studies have shown the effectiveness of the selection of specific factors in the purpose of determining a series of validity. The use of this knowledge will enable effective use of the company's resources in improving the indicated areas. As a result of the research work, it was found that the most important area requiring improvement is quality. 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. Innovative BOST questionnaire survey, which are an attempt to convert Toyota's management principles into questions was described. Data obtained from BOST analysis allowed to know the opinions of the representative group. Research was carried out amongst production workers of the company from food 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. 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 roof of the Toyota house. 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 different type of groceries. The acquired significance sequence of factors describing this 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. Factor *quality* (JA) has been judged with the highest evaluation by men than by women. In the researched company a quality of products, as well as a tidiness in production sectors, and in the entire company. Functioning of the production system, although now is working perfectly, it is possible still to be improved. The quality of offered products can be improved through applying tools of the quality management. The practical use of BOST surveys gives the opportunity to benefit from the practical knowledge of employees at the company's production level. This may contribute to the identification of key areas for the functioning of the enterprise.

Toyotarity aims at continuous improvement of quality [15]. It is a specifically Japanese approach, but it yields beneficial effects wherever the processing of challenging materials such as metals [16-18], alloys [19], and special coatings [20, 21] like DLC [22] is involved, significantly modifying the properties of surface layers [23]. Quality improvement is particularly desirable in areas with critical requirements, such as the military [24], structural welding [25], and construction [26, 27]. To effectively implement this approach, sophisticated design tools [28] and analytical tools [29] are necessary, which reduce the complexity of the problem and allow for an understanding of the structure of controlled factor relationships [30-32], including the use of non-parametric methods [33-35]. Resampling techniques [36] enable the estimation of result uncertainties, even in the case of relatively small-scale measurements.

References

[1]S. Gao, S.P. Low. Toyota way style human resource management in large Chinese construction firms, A qualitative study, Int. J. Constr. Manag. 15 (2015) 17-32. https://doi.org/10.1080/15623599.2015.1012139

[2]S. Borkowski. Scientific Potential of Toyotarity and BOST Method, Polish Quality Institute, Warszawa, 2016.

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

[4]K. Knop. Indicating and analysis the interrelation between terms – visual: management, control, inspection and testing, Prod. Eng. Arch. 26 (2020) 110-120. https://doi.org/10.30657/pea.2020.26.22

[5]K. Knop. Importance of visual management in metal and automotive branch and its influence in building a competitive advantage, Pol. J. Manag. Stud. 22 (2020) 263-278. https://doi.org/10.17512/pjms.2020.22.1.17

[6]J.K. Liker, J. Franz. The Toyota Way to continuous improvement, McGraw Hill, New York, 2011. ISBN 978-0071477468

[7]M. Matuszny. Building decision trees based on production knowledge as support in decision-making process, Prod. Eng. Arch. 26 (2020) 36-40. https://doi.org/10.30657/pea.2020.26.08

[8]K. Knop. Statistical Control of the Production Process of Rolled Products, Prod. Eng. Arch. 20 (2018) 26-31. https://doi.org/10.30657/pea.2018.20.06

[9]M. Krynke. Risk Management in the Process of Personnel Allocation to Jobs, System Safety: Human-Technical Facility-Environment (2020) 82-90. https://doi.org/10.2478/czoto-2020-0011

[10] M. Ingaldi. A new approach to quality management: conceptual matrix of service attributes, Pol. J. Manag. Stud. 22 (2020) 187-200. https://doi.org/10.17512/pjms.2020.22.2.13

[11] D. Klimecka-Tatar. Context of production engineering in management model of Value Stream Flow according to manufacturing industry, Prod. Eng. Arch. 21 (2018) 32-35. https://doi.org/10.30657/pea.2018.21.07

[12] M. Krynke et al. Cost Optimization and Risk Minimization During Teamwork Organization, Manag. Sys. Prod. Eng. 29 (2021) 145-150. https://doi.org/10.2478/mspe-2021-0019

[13] J. Selejdak. Use of the Toyota Management Principles for Evaluation of the Company's Mission, Prod. Eng. Arch. 1 (2013) 13-15. https://doi.org/10.30657/pea.2013.01.04

[14] K. Knop, K. Mielczarek. Assessment of Production Processes Functioning in the Case of Air Bag Production, MATEC Web Conf. 183 (2018) art.04009. https://doi.org/10.1051/matecconf/201818304009

[15] T. Lipiński, R. Ulewicz. The effect of the impurities spaces on the quality of structural steel working at variable loads, Open Eng. 11 (2021) 233-238. https://doi.org/10.1515/eng-2021-0024

[16] M. Mazur et al. The structure and mechanical properties of domex 700 MC steel, Comm. - Sci. Lett. Univ. Žilina 15 (2013) 54-57. https://doi.org/10.26552/com.C.2013.4.54-57

[17] R. Ulewicz et al. Structure and mechanical properties of fine-grained steels, Period. Polytech. Transp. Eng. 41 (2013) 111-115. https://doi.org/10.3311/PPtr.7110

[18] P. Jonšta et al. The effect of rare earth metals alloying on the internal quality of industrially produced heavy steel forgings, Materials 14 (2021) art.5160. https://doi.org/10.3390/ma14185160

[19] A. Dudek et al. The effect of alloying method on the structure and properties of sintered stainless steel, Archives of Metallurgy and Materials 62 (2017) 281-287. https://doi.org/10.1515/amm-2017-0042

[20] N. Radek et al. Technology and application of anti-graffiti coating systems for rolling stock, METAL 2019 – 28th Int. Conf. Metall. Mater. (2019) 1127-1132. ISBN 978-8087294925

[21] N. Radek et al. Formation of coatings with technologies using concentrated energy stream, Prod. Eng. Arch. 28 (2022) 117-122. https://doi.org/10.30657/pea.2022.28.13

[22] N. Radek et al. Microstructure and tribological properties of DLC coatings, Mater. Res. Proc. 17 (2020) 171-176. https://doi.org/10.21741/9781644901038-26

[23] N. Radek et al. The influence of plasma cutting parameters on the geometric structure of cut surfaces, Mater. Res. Proc. 17 (2020) 132-137. https://doi.org/10.21741/9781644901038-20

[24] W. Przybył et al. Microwave absorption properties of carbonyl iron-based paint coatings for military applications, Def. Technol. 22 (2023) 1-9. https://doi.org/10.1016/j.dt.2022.06.013

[25] N. Radek et al. The impact of laser welding parameters on the mechanical properties of the weld, AIP Conf. Proc. 2017 (2018) art.20025. https://doi.org/10.1063/1.5056288

[26] A. Bakowski et al. Frequency analysis of urban traffic noise, ICCC 2019 20th Int. Carpathian Contr. Conf. (2019) 1660-1670. https://doi.org/10.1109/CarpathianCC.2019.8766012

[27] J.M. Djoković et al. Selection of the Optimal Window Type and Orientation for the Two Cities in Serbia and One in Slovakia, Energies 15 (2022) art.323. https://doi.org/10.3390/en15010323

[28] L. Cedro. Model parameter on-line identification with nonlinear parametrization – manipulator model, Technical Transactions 119 (2022) art. e2022007. https://doi.org/10.37705/TechTrans/e2022007

[29] J. Pietraszek, E. Skrzypczak-Pietraszek. The uncertainty and robustness of the principal component analysis as a tool for the dimensionality reduction. Solid State Phenom. 235 (2015) 1-8. https://doi.org/10.4028/www.scientific.net/SSP.235.1

[30] J. Pietraszek et al. The parametric RSM model with higher order terms for the meat tumbler machine process, Solid State Phenom. 235 (2015) 37-44. https://doi.org/10.4028/www.scientific.net/SSP.235.37

[31] R. Dwornicka, J. Pietraszek. The outline of the expert system for the design of experiment, Prod. Eng. Arch. 20 (2018) 43-48. https://doi.org/10.30657/pea.2018.20.09

[32] J. Pietraszek et al. Challenges for the DOE methodology related to the introduction of Industry 4.0. Prod. Eng. Arch. 26 (2020) 190-194. https://doi.org/10.30657/pea.2020.26.33

[33] J. Pietraszek. Fuzzy regression compared to classical experimental design in the case of flywheel assembly, LNAI 7267 LNAI (2012) 310-317. https://doi.org/10.1007/978-3-642-29347-4_36

[34] J. Pietraszek. The modified sequential-binary approach for fuzzy operations on correlated assessments, LNAI 7894 (2013) 353-364. https://doi.org/10.1007/978-3-642-38658-9_32

[35] J. Pietraszek et al. The fuzzy approach to assessment of ANOVA results, LNAI 9875 (2016) 260-268. https://doi.org/10.1007/978-3-319-45243-2_24

[36] J. Pietraszek, L. Wojnar. The bootstrap approach to the statistical significance of parameters in RSM model, ECCOMAS Congress 2016 Proc. 7th Europ. Congr. Comput. Methods in Appl. Sci. Eng. 1 (2016) 2003-2009. https://doi.org/10.7712/100016.1937.9138