EVALUATION OF THE MANUFACTURING OF COMPONENTS FOR COMBINE HARVESTERS USING BOST METHOD

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Abstract

This study presents the evaluation, based on the principles of Toyota management (BOST method) of functioning of the manufacturing process in production of components for combine harvesters such as: straw chopper knives and knife sections. These parts perform specific motion during work and require maintaining the dimensions and weight within specific tolerances. Therefore it is important to ensure the appropriate technology and quality control. The term technology is present in the description of the principle 1 and principle 2 of Toyota management, whereas visual control is contained in the description of the principle 2 and principle 7 of the Toyota management. This helped find three Toyota principles as a tool for evaluation of the manufacturing of combine harvesters. It was demonstrated that, according to the respondents, development of technology (principle 1) and using exclusively the reliable technology (principle 2) take the top positions in the rankings of importance. Participation in production locations is the factor that takes the second place in the ranking of importance of the types of visual quality control (principle 7). The study also characterizes the respondents of the enterprise studied (area E12 in the BOST method).

Keywords: combine harvesters, technology, quality control, principles of Toyota management, BOST method

1. INTRODUCTION

Nowadays, with high increase in costs of materials, energy and labor, intense competition, changes in consumer values and the need for implementation of new products necessitates more emphasis on quality and development of new technologies. Even more enterprises are using the tools of managing quality (traditional and modern) in order to identify or prioritize of non-conformities and are investing in technologies that affect competitive position of the organization. Quality control and immediate detection of non-conformities in processes are becoming important at all stages. The role of control is to identify whether products and processes meet the requirements adopted at the stage of design. It is also aimed at determination of equipment and process capability to attain design quality.

2. CHARACTERISTIC OF THE PRESENT STUDY

The focus of the present study is an enterprise that manufactures combine harvesters and forage harvesters. The combine harvesters are sold in the European market, whereas foragers are bought by the customers from all over the world. The enterprise employs around 1,000 employees, who work for design, research and development, quality and production divisions. Combine harvesters are manufactured exclusively to orders. Customers specify detailed requirements for a combine harvester with authorized dealers and the plant receives the information about the demand for a harvester. Combine harvester manufactured in the enterprise analyzed allows for fast harvesting and reduces the number of grain lost to minimum level and ensures high efficiency of crops for each type of plant and in all conditions.

The pressure in the enterprise is placed on development of technologies and quality control. Both traditional and modern tools for quality management are useful as they help identify non-conformities present in the production process and immediate reaction in case of detection. The enterprise also uses such techniques as

Jidoka, Poka-Yoke, TPM or SMED. The employees participate in a variety of trainings, courses and they have adequate education or qualifications. Continuous improvement is becoming very important and causes that enterprises are very successful and have reputation of reliable manufacturers of high-quality products.
Adequate technologies and quality control are essential at each stage of the production process and during production of each component. The study characterizes selected components of combine harvester: straw chopper knives and knife sections.

Straw chopper knives are located in the rear part of the combine where the whole straw chopper unit is assembled. Their role is to chop the straw in order for it to leave the threshing unit and be spread in the field. The knives are attached to the drum. They are screwed with pairs of bolts to the protruding parts of the drum (one knife per side). The drum is rotating at the speed of 3,300 rpm and moves the knives which are rotated between the fixed knives. Comparison of the straw chopper knives in the enterprise studied with the knives manufactured by competitors reveals differences in weight and other properties of the product. Very strict weight tolerances (<1g) are used in the enterprises, whereas the respective differences in the knives manufactured by competitors are ca. 6g. Bigger differences in the weight cause imbalance of the shaft and accelerated wear of the parts (bearings, belts). With regard to hardening of the knives, the enterprise uses induction hardening, which minimizes the risk of cracking and causes that the cutting edge is very hard, whereas total hardening is used by competitors, which might lead to cracking during contact with hard items and consequently leads to shorter life of the cutting edge.

Knife sections are fixed with two bolts to a cutting bar in the header, one next to another and then the bayonets are screwed so that the knives remain inside the bayonet. The whole mechanism works so that the knives attached to the bar are moving with respect to the bayonet in a manner similar to scissors. Similar to straw chopper knives, they are hardened using induction hardening, which helps improve their life and reduces the risk of cracking. In order to minimize grain loss, especially during harvesting of excessively ripe crops, it is essential to ensure clean cutting of the plant. The knives should be of best possible quality. Therefore, the technology of induction hardening used ensures the durability, which is of essential importance in the case of contact of knifes with foreign bodies such as stones.

3. RESEARCH METHODOLOGY

BOST questionnaire [1,2,3] is based on the principles of Toyota manufacturing system [4]. The questionnaire was created by Prof. Stanisław Borkowski, the director in the Institute for Production Engineering in the Faculty of Management of the Częstochowa University of Technology. The questionnaire is suitable for both production enterprises and service-providers (for both managers and employees) and the questions (areas) contained in the questionnaire are related to the Toyota roof and principles of Toyota. Each BOST questionnaire contains a characterization of the respondent, definition of the character of the enterprise and evaluation of the managers according to the principles of Toyota. The questionnaire contains a ranking of importance and the respondents evaluate the importance of each factor on a particular scale.

The study focused on the areas which are connected with technology and quality control. After BOST questionnaire was carried out among 42 employees in the enterprise studied, three areas were chosen for detailed analysis [5, 6]. First of them was marked as the area E2 and it is connected with the principle 1 of Toyota management ("Base your management decisions on a long-term philosophy, even at the expense of short-term financial goals"). In this area, the respondents evaluate which of the factors (customer's good - DK, independence and responsibility of employees - SP, innovativeness of product - IP, development of technology - RT, cooperation with partners - WK, care for the enterprise's culture - PR, trust in relationships with employees - ZP) determine the concept of development in the enterprise studied. The importance of the above factors is evaluated by the respondents on a scale of 1 to 7.

Another area (E3) relates to the principle 2 of Toyota management ("Create a continuous process flow to bring problems to the surface"). In this area, respondents are asked to evaluate, on a scale of 1 to 6, which of the

factors (continuous system of detecting problems - CP, stopping production after detection of the quality problem - PE, standard tasks, processes and documents - SZ, delegating authority - EU, using only reliable technologies - ST, using visual control - SW) is the most important to the production process. The last area selected for detailed analysis is the area E7, connected with the principle 7 of Toyota principle ("Use visual control so no problems are hidden"), and the employees who fill out the BOST questionnaire choose between such factors as cleanliness, order - CS, flow - EP, information boards - TI, participation in production places - UP, monitoring - ME, graphical presentation of the results - GW and answer to the question of "Which factor is the most important to visual control?". The importance of the above factors is evaluated by the respondents on a scale of 1 to 6. Apart from the analysis of these areas, a characterization of the respondent profile was carried out, marked as the area E12. Six personal data are recorded in the questionnaire (gender - MK, education level - WK, age - WI, working experience - SC, mobility - MR, type of employment - TR).

4. ANALYSIS OF THE RESULTS

Fig. 1 presents the respondents' characteristic in the enterprise studied (area E12 in the BOST questionnaire), which manufactures combine harvesters, divided into:

- gender (MK): 1 - men, 2 - women
- education level (WK): 1 - primary, 2 - vocational, 3 - secondary, 4 - higher
- age (WI): 1 - under 25 years, 2 - 26÷35 years, 3 - 36÷45 years, 4 - 46÷50 years, 5 - 51÷55 years, 6 - 56÷60 years, 7 - 61÷65 years, 8 - over 65 years
- working experience (SC): 1 - under 5 years, 2 - 6÷15 years, 3 - 16÷20 years, 4 - 21÷25 years, 5 - 26÷30 years, 6 - 31÷35 years, 7 - 36÷40 years, 8 - over 41 years
- mobility (MZ) - present job is: 1 - first, 2 - second, 3 - third, 4 - fourth, 5 - fifth, 6 - sixth or more
- type of employment (TR): 1 - normal mode, 2 - transferred, 3 - due to better financial conditions

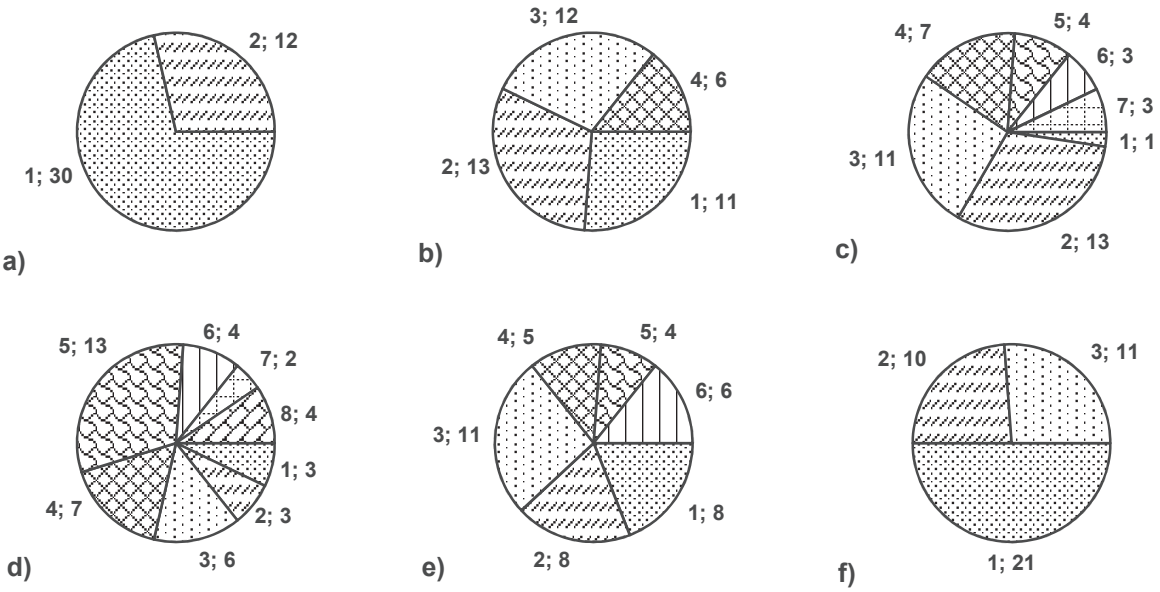

Fig. 1 Respondents characteristic with consideration of: a) gender, b) education level, c) age, d) working experience, e) mobility, f) type of employment; it concerns company, which manufactures combine harvesters

Fig. 1a shows that men (30 people) dominate in the enterprises studied. With respect to education level (**Fig. 1b**), the biggest group is employees with vocational education (13 people), secondary education (12 people) and primary education (11 people). Another factor is the age of the respondents. **Fig. 1c** shows that the respondents include employees aged 26 to 35 years (13 people) and those aged 36 to 45 years (11 people).

With respect to the working experience (**Fig. 1d**) in the enterprise studied, the biggest group is respondents with the longest working experience (from 26 to 30 years - 13 people). In 11 respondents, the enterprise studied is the third workplace (**Fig. 1e**), whereas for 16 of them, it is the first (8 people) or the second (8 people). **Fig. 1**f reveals that the most of the employees (21 people) were employed in a normal mode.

Furthermore, **Fig. 2** presents analysis of distribution of the evaluation for the area E2 which contains the concept of technology (in the form of the factor of development of technology).

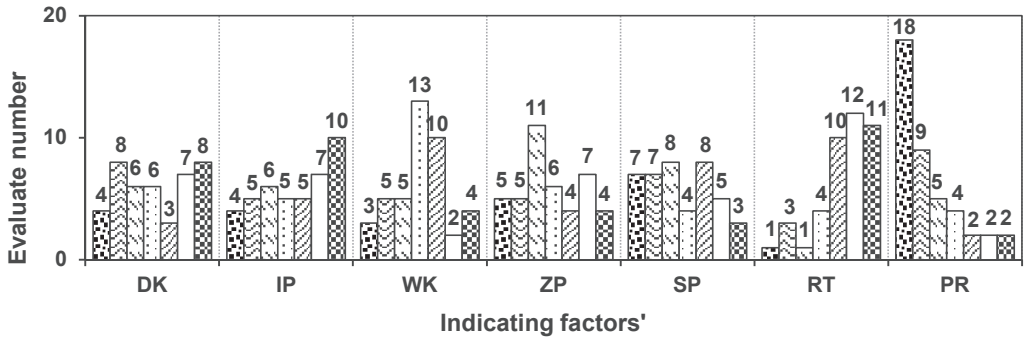

Fig. 2 Principle 1: Distribution analysis of evaluations E2 area factors; it concerns company, which manufactures combine harvesters

The histogram presented in **Fig. 2** shows that the employees who filled out the BOST questionnaire evaluated the factor of development of technology (RT) as the most decisive in the concept of development of the enterprise studied. This is suggested by the high number of high evaluations (5, 6 and 7). These evaluations were given by over 78% of the respondents (33 employees). The importance of this factor is determined by the fact that the factor obtained the lowest scores (1 and 2) from only 4 respondents. The employees also gave high evaluation to the customer's good (DK) and product innovativeness (IP) as the factors determining the concept of development in the enterprise, giving them over 30% of the scores 6 and 7. Furthermore, the factor which was evaluated by the respondents as the least decisive in the concept of enterprise development is the factor of the care for the enterprise's culture (PR), with 27 employees giving the lowest scores (1 and 2) and only 4 of them evaluating this factor with the highest scores (6 and 7).

The next figure (see **Fig. 3**) shows a spatial presentation of the results obtained for the number of evaluations in the area E3 for the enterprise studied. One of the factors in this area is connected with using reliable technologies only.

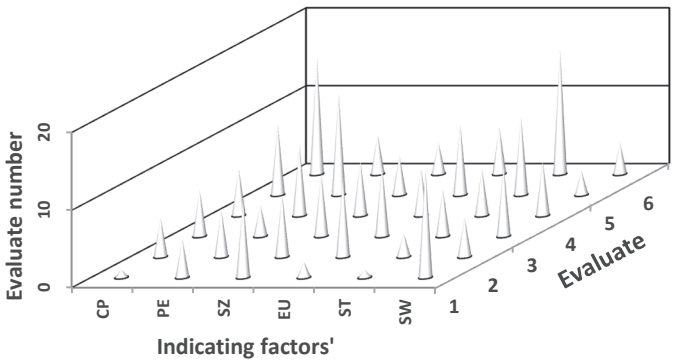

Fig. 3 Principle 2: E3 area - spatial presentation of the research results: evaluation number; it concerns company, which manufactures combine harvesters

The spatial presentation of the results obtained for the number of evaluations in the area E3 shows that the responding employees indicated the factor of using reliable technologies only (ST) as the most important to the production process. In this case, higher evaluations are accompanied by higher number of evaluations. The highest evaluation was found in 16 respondents. Similar evaluation was found for the factor of continuous

system of detecting problems (CP). An increase in the number of evaluations with improved evaluation can also be found in this case. The least important factor in the production process is the factor connected with the use of visual control (SW).

Fig. 4 shows, in the form of radar graphs, the structure of evaluations [%] for importance of the factors in the area of E7 in the enterprise studied.

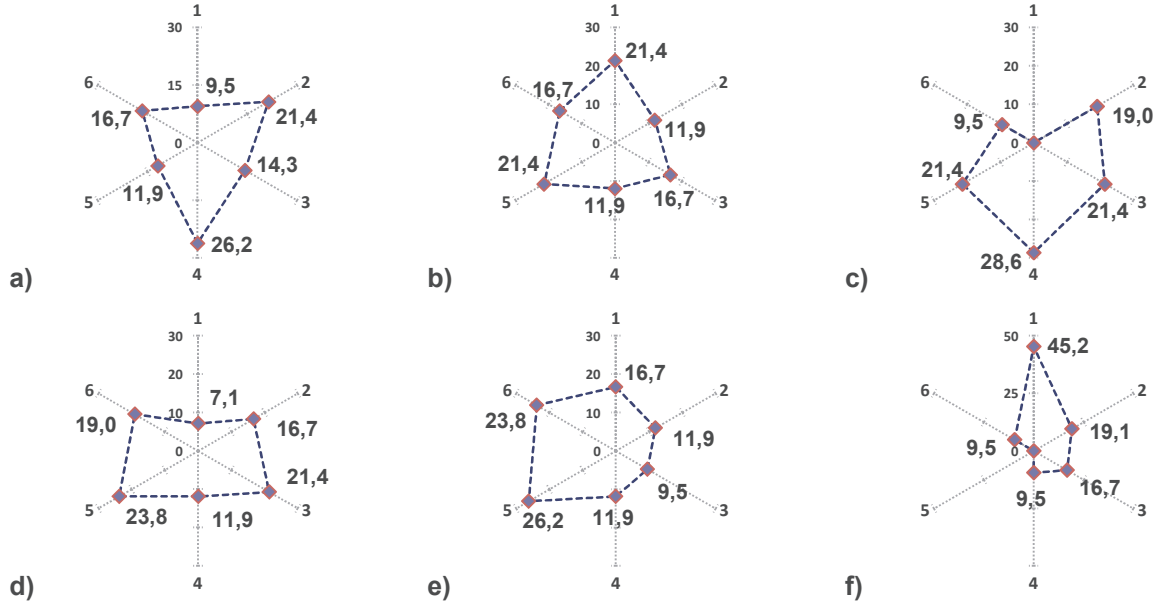

Fig. 4 Principle 7: Radar graphs - evaluation structure for: a) CS, b) EP, c) TI, d) UP, e) ME, f) GW; it concerns company, which manufactures combine harvesters

The radar charts, which present the structure of evaluations for the factors in the area E7, reveal that the respondent employees evaluated monitoring (ME) as the most important element of visual control. This confirms the highest number of evaluations 5 and 6 (these evaluations were assigned by 50% of the respondents). Another important factor in the visual control is participation in the production places (UP) (over 40% of the respondents evaluated this factor as 5 and 6. Furthermore, the factor which is evaluated as the least important element of the visual control is the factor connected with graphical presentation of the results (GW). Over 45% of the respondents assigned the lowest score (1) to this factor.

CONCLUSION

The BOST questionnaire allowed for identification of the employees'/respondents' opinion about the factors which determine the concept of development of the enterprise studied, which are the most important in the production process and visual control. The questionnaire showed the managers what the strategy of combine harvester manufacturing can be based on. It should be noted that all the factors mentioned in the areas E2, E3 and E7 form the wholeness and none of them can be neglected during actions taken. According to the respondents, development of technology determines the concept of enterprise development the most, whereas using reliable technologies only is the most important factor in the production process. The choice of these factors shows that the employees perceive the problem of technology as the most important in the enterprise. Based on the area E7, which concerns the most important elements of visual control, the employees indicated monitoring and participation in production places as the most important factors. Continuous observation of each element of the process, using e.g. Poka-Yoke method or Andon method, guarantees detection of each non-conformity in the process and an immediate reaction.

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