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Identifying variables that influence manufacturing product quality

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Abstract In the article a risk analysis of the production process of selected products in a plant producing votive candles was conducted. The Pareto-Lorenz diagram and FMEA method were used which indicated the most important areas affecting the production of selected elements of candles. The synthesis of intangible factors affecting production in the audited company was also carried out with particular emphasis on the operation of the production system. The factors determining the validity of studies was examined, describing the principle of BOST 14 Toyota management. The most important areas of the company were identified, positively affecting the production process.

Key words – quality, analysis BOST, Toyota Principles, FMEA method

1. Introduction

Modern technological processes should be characterized by a production rate of products, reproducibility and repeatability and stability of individual technological operations. These above attributes affect the fulfilment of the requirements for individual process steps. Caring for the quality of the products is undoubtedly a complex process because of the multiplicity of factors determining it. The basic variables that affect the quality of the product include (VOGT K., KUJAWIŃSKA A. 2013):

- the quality of the material,
- the quality of the process,
- the quality of the equipment,
- quality of personnel,
- the quality of the environment,
- the quality of the measurement.

All variables globally a high quality of the final product, and therefore should be considered together, not forgetting that each of the components is the result of the impact of the following variables in a given category (ULEWICZ R. 2003).

2. Incompatibility structure of selected products

During the manufacture of the devices incompatibilities were found causing the withdrawal of products from sale. In order to investigate this situation, the analysis of non-conformity was carried out with the

Pareto-Lorenz diagram. (BORKOWSKI S., KRYNKE M., INGALDI M. 2012). Analysis was subjected to two types of products: tube replacement votive candles and base trim and stabilizing the votive candles. These products are manufactured by an extrusion and injection machine. Discrepancies that arose during production are included in Table 1. In Figure 1 a Pareto Lorenz diagram is used, which presents the structure of incompatibility and their participation in the analyzed 30-day study period. The analysis of the data shows that the most common non-conformities appearing in replaceable votive candle tubes extruder is cut structure. Often, there is repeated non-conformity associated with inadequate wall thickness of the product. There are also jagged edges of the product, the dirt surface and the wrong colour. Cut in the tube structure votive candle is usually caused by the presence of dirt in the head slit extruder.

Table 1. Types of non-conformity in the manufacturing of interchangeable tube votive candles and decorative coasters

Tube replacement votive candle		**The stand of ornamental and stabilizing**	
Symbol noncon-formity	Name non-conformity	Symbol noncon-formity	Name non-conformity
N1	Cut structu-re	N1	Shortage of material
N2	Too thin	N2	Plastic trap
N3	Jagged edges	N3	Flaws surface
N4	Too thick	N4	Wrong colour (pigmen-tation)
N5	Dirt surface	N5	Surface stains (oil, grease)
N6	Wrong colour	N6	Inadequate strength (rupture)
		N7	Deformation

Source: own study.

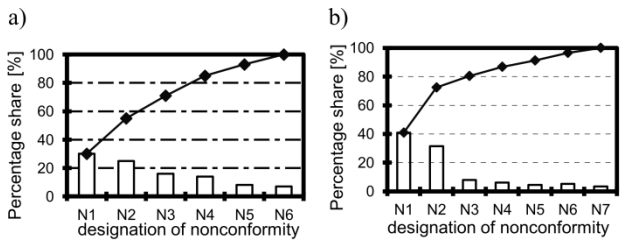

Fig. 1. Diagram Pareto-Lorenz for non-conformity: a) removable tube votive candle, b) the stand stabilizing candle

Źródło: opracowanie własne.

In order to prevent the occurrence of the non-conformity in the head, application of the technology of the extruder slit through the use of a self-cleaning grid on which dirt settles (for example, grains of sand) present in the granules. Elimination of non-conformity associated with inadequate wall thickness of the tube is possible by adjusting the modernization of the extruder and the exact adjustment of the machine.

The highest percentage of non-conformity stand-stabilizing votive candle on an injection molding machine is a detail exhibiting deficiency or excess plastic material. To a much lesser extent there are non-conformities caused by surface flaws, the wrong color, surface dirt, cracks and deformations.

In the case of the production tube votive candle elimination of non-conformities N1, N2, N3 or confusion caused by the structure, cut too thinly and jagged edges of the tube will reduce the number of defective products by 71%. In contrast, the production of decorative bases, eliminating the non-conformity caused by a deficiency and an excess of material and structural bosses, representing 28.6% of all non-conformity will limit the number of complaints by 72.4%.

3. Analysis of the causes and consequences of any non-conformity

The analysis of the causes and consequences of non-compliance in the selected articles was performed using the FMEA method. It is a method for systematically identifying potential defects of the product (or process), to determine their possible causes and risks which together carry the defect by identifying the number of priority risks (LPR). On this basis, developing actions aimed at minimizing or eliminating the causes of these defects is essential (MAZUR M., ULEWICZ R. 2007, KNOP K., SELEJDAK J. 2009).

In Figure 2 a summary of non-conformity levels in which LPR analyzed two products is presented: votive candle tubes and decorative coasters. The resulting figures show that the highest value of priority risk of non-conformity due to *LPR* has cut into the structure of the work. Acceptable *LPR* level exceeds the mismatch caused by jagged edges of the product. For the customer, such goods are of no value, so corrective action to eliminate these inconsistencies should be

taken. One key step that should be taken in order to reduce the risk of extinction of this discrepancy is the modernization of the extrusion head by mounting the mesh on which the deposit may get contaminated with the pellet plasticizing zone. On the other hand, to eliminate the inconsistency caused by the occurrence of jagged edges after cutting the upper waste, cutting blades should be replaced or properly sharpened and repeat this step each time the inconsistency occurs.

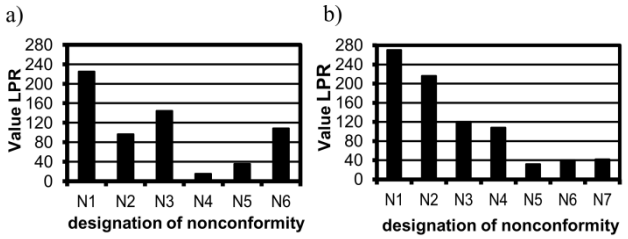

Fig. 2. Summary of the LPR levels for non-compliance: a) removable tube votive candle, b) non-conformity stands and decorative candle stabilizing

Source: own study

The most significant non-compliances are discrepancies characterized by a deficiency and an excess of plastic materials in the structure of the piece. Priority number two non-compliance risk is much higher than the threshold level LPR = 120. Both discrepancies are caused by a similar factor, in the case of shortage of material to the operating cycle, accompanied by the injection pressure being too low or too raw material parameters have been chosen carelessly. In the case of plastic lugs on the part of the raw material injection, pressure was too high, which resulted in the spilling of material out of the mold detail. In order to avoid confusion caused by short shot or a stalk of raw materials, the structure of the piece should be monitored on a regular basis in order to control the injection parameters and settings for optimal injection pressure of raw material.

4. Analysis of areas for company improvement based on Toyota principle 14

Considerations for for improvement were performed by the BOST method (BORKOWSKI S. 2012a,b,c). The study examines the factors that describe Toyota management principle 14 contained in the E8 BOST survey conducted among production workers. The aim of the study was to obtain answers and opinions of people having direct contact with the conditions under which the system operates production. In contrast, the test results are the opinions of employees on the most important areas for improvement due to the nature of the industry and processing. Figure 6.3 graphically illustrates the importance of areas for improvement (where: ZT – the employment of workers; SM – incentive system; PT – portfolio of technologies; JK – quality; UM – maintenance of machines; RE –boss-employee relationship; DA – documentation; PN – the flow of information; WS – cooperation with customers; WD – cooperation with suppliers, cooperators. on a scale of 1÷10, 10 – the most important factor).

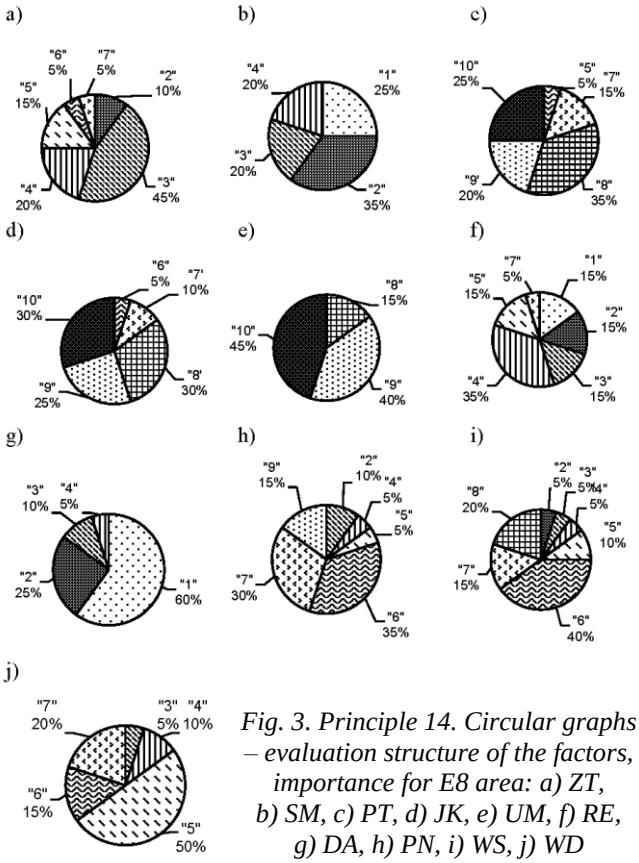

Fig. 3. Principle 14. Circular graphs – evaluation structure of the factors, importance for E8 area: a) ZT, b) SM, c) PT, d) JK, e) UM, f) RE, g) DA, h) PN, i) WS, j) WD

Source: own study

The employment factor (ZT) was evaluated by production workers in the range of 2÷7 ratings of dominance rating of 3, indicated by 45% of respondents. Incentive System (SM) was quite poorly in the range of 1÷4 ratings. This demonstrates the very important

factor of improvement of the system from the point of view of workers. The portfolio of technologies (PT) rated quite highly. Evaluation was mainly at the level 7÷10 Quality factor (JK) also played an important role in the opinion of employees, which was assessed in the range of 6÷10 The most important factor was in the improvement, maintenance, respondents machines (UM). This area was rated at 8÷10, where the majority of all allocated is 10 ratings. The employer/employee relationship (RE) has been recognized as a factor that gives opportunities to improve the production system. Similarly, the documentation has been assessed agent (DA), which according to the respondents, is considered the least important in terms of improving the whole system. It was rated at level 1÷4. Most of the ratings were 1 for a neutral area such as the flow of information (PN), which according to the staff has been assessed at a medium level of importance. Similarly, co-operation with customers (WS) and co-operation with suppliers, co-operators (WD) were assessed.

5. Summary

The subject of study was a company operating in the plastics processing industry. The analysis of the study found that the main and most important area is the economy of machinery equipment and their proper operation. This is due to the fact that the company is mainly involved in mass production. The BOST study among production workers showed the greatest need for improvement was maintenance of machines. According to people close to and participating in the production process, it is also an important aspect of resource technology to reduce the risk of non-conforming products. In order to improve the system particular attention should be paid to technological development and modernization, as well as proper handling of machinery and equipment. It is important to the employees directly involved in the use of machinery to keep machines at the correct level, conducting ongoing inspections and maintenance, not only when the machine shows a decline in efficiency but also when running without charge, because such conduct save on expenses. An important factor indicated by the employees is the quality of manufactured products. The least important areas that affect the improvement of the quality of products and thus achieve measurable benefits by the company mentioned are documentation, the incentive system and the employee-supervisor relationship. The most important, in terms of production workers, is to improve areas such as machine maintenance, quality and technology portfolio.

Bibliography

1. BORKOWSKI S. 2012a. *Dokumenty zawierające wymyślony termin (TOYOTARYZM) oraz zawierające nazwę i strukturę opracowanej metody (BOST).* Potwierdzenie daty. „AAK" KANCELARIA PATENTOWA s.c. Częstochowa.
2. BORKOWSKI S. 2012b. *Toyotaryzm. Wyniki badań BOST. Wydawnictwo Menedżerskie PTM*. Warszawa.
3. BORKOWSKI S. 2012c. *Zasady zarządzania Toyoty w pytaniach. Wyniki badań BOST*. Wydawnictwo Menedżerskie PTM. Warszawa.
4. BORKOWSKI S., KRYNKE M., KNOP K. 2012. *Evaluation of the Development Concept Factors of a Company from Automotive branch*. Chapter 6. Quality Control as Process Improvement Factor. Monography. Editing and Scientific Elaboration Stanisław Borkowski, Manuela Konstanciak. Ofic. Wydaw. Stowarzyszenia Menedżerów Jakości i Produkcji. Częstochowa. s. 84-99.
5. KNOP K., SELEJDAK J. 2009. *Implementation of FMEA method to improvement of quality food product.* Chapter 12. Quality and Processes Improvement. Monography. Editing and Scientific Elaboration Borkowski S., Czaja P. Endi Miletić. Sisak.
6. MAZUR M., ULEWICZ R. 2007. *Wykorzystanie metody FMEA dla zapewnienia jakości procesu wytwarzania linki sprzęgła samochodowego.* Nowe technologie i osiągnięcia w metalurgii i inżynierii materiałowej. VIII Międzynarodowa Konferencja Naukowa. T.1. Częstochowa.
7. ULEWICZ R. 2003. *Quality control system in production of the castings from spheroid cast iron*, Metalurgija, Volume 42, Issue 1, s. 61-63.
8. VOGT K., KUJAWIŃSKA A. 2013. *Analiza wpływu wybranych czynników pracy na skuteczność kontroli wzrokowej*. Inżynieria Maszyn, R. 18, z. 1, s. 40-51.