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Use of quality engineering tools and methods for the analysis of production processes - case study

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Abstract

The article presents the application of selected quality engineering methods for solving a problem with product quality in the production process of plastic bags. Defects present in the product were identified and hierarchized by the number of defects in the total production volume. Next, using the Ishikawa diagram, the main causes for the occurrence of the most significant defect, i.e. "foil sticking together" were identified. The scale of the problem for the various causes was determined using FMEA, corrective and preventive measures were proposed and their effectiveness estimated. Thanks to the analysis it was possible to take actions which lead to a decrease in the number of faulty products and introducing preventive measures to reduce the risk of problems occurring in the future.

Key words: *quality; improvement; ishikawa;fmea; polyethylene; process*

1 Introduction

Practical application of improvement requires using multiple methods and tools of quality management and quality engineering [1]. In the source literature the terms quality management method and quality engineering method are used because the difference between them refers not to the methods themselves, but the scope of their use in relation to certain problems [2,3]. These methods are used in order to improve the productivity, limit wastage and streamline the processes that take place in an organisation [4,5]. An important approach to defining quality, especially in the case of assessing the quality of industrial products from an engineering perspective, is dividing it into three components: project quality, execution quality and operational quality. All these components must be taken into account if we are to speak of a product's high quality [6]. At the stage of product manufacturing (production process) the role of quality assurance becomes gradually limited and quality control becomes the primary focus, including monitoring and adjustment. At this stage, project quality is transformed into execution quality through the manufacturing processes. The aim of these actions is to obtain the highest possible conformity between the project quality and execution quality [3].

2 Presentation of the plastic bag production process

In the case analysed, the manufacturing of polyethylene bags is conducted using a plastic extruder combined with one-stage blowing. A simplified map of the process has been presented in Figure 1.

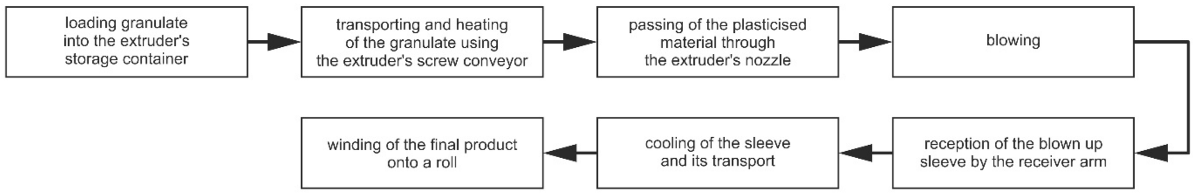

Fig. 1 – The plastic bag manufacturing process [3]

3 Research problems

The main research problem is the elimination or reduction of the influence of the most significant defects present in the production process. During the manufacturing process of PE-LD products defects and nonconformities were discovered over a two-month observation period, which have been presented in Table 1.

Table 1 – Defects in the production process of plastic bags

Problem present in the production process	Amount [kg]
foil sticking together	12320
foil hard to seal	6040
foil smudging	2138
inability to put overprint on the foil	540
improper foil thickness	250
other problems	<100

A significant problem present in the production process is the “foil sticking together” defect consisting in layers of the foil being electrostatically attracted to each other, which hinders opening the bag. This is especially important when the client uses automated production lines that use arms which open the bags before filling them with a product. This defect was present in products with a total mass of over 12 tons in the period analysed. Therefore, the company decided to eliminate this particular problem.

3.1 Process analysis

In order to correctly determine the root causes of the problem of foil layers sticking together, the Ishikawa diagram was used, as presented in Figure 2.

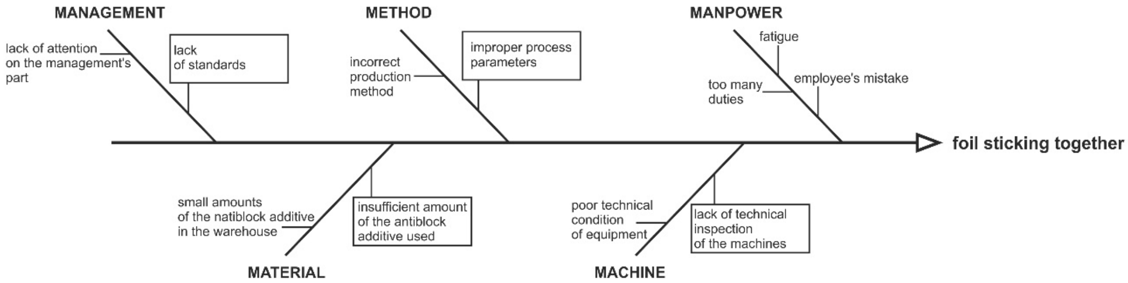

Fig. 2 – Ishikawa diagram for the “foil sticking together” problem

Analysis of the problem using the Ishikawa diagram allowed us to identify the following main causes of the problem:

1. Lack of technical inspection of the machines in the technological chain. The cause of this situation was rush connected with completing the production order and a lack of time necessary for thorough maintenance of the machine.
2. Too high a transport speed of the foil band in the entire technological process. Due to increasing the transport speed the foil becomes electrically charged, which affects the properties of the final product.
3. The pressure of the foil transport rollers. In this case there is increased friction between the surface of the roller and the foil, which increases its temperature and chargest it electrically.
4. Insufficient amount of the antiblock additive used. Using this additive in the right proportions allows for a significant reduction in the occurrence of the foil cohesion phenomenon. Due to the cost of the additive and an increase in competitiveness, the company strives to lower the final price of the product by lowering the proportions in which the additive is used, which consequently leads to the foil sticking together and inability to separate it.
5. Lack of standards which have to be met by the final product. There are no concrete, systemic guidelines pertaining to the requirements, control and verification of the final product.

On the basis of the causes identified, an FMEA was conducted, which allowed us to create a hierarchy of causes and formulate corrective and preventive measures. The FMEA sheet is presented in Table 2.

Table 2 – The FMEA sheet for the “foil sticking together” defect

Causes of the defect	Corrective measures	S	O	D	RPN	Preventive measures	S	O	D	RPN
lack of technical inspections of the machines	scheduling of the Maintenance Department’s works	3	4	4	48	work sheets and reports	3	2	2	12
improper process parameters	control lists	8	8	3	192	implementation of a monitoring system	8	4	1	32
insufficient amount of the antiblock modifier	introduction of measurement containers	9	8	8	576	work instructions and control list	9	3	2	54
lack of standards	employee training	5	6	10	300	systemic instructions	5	2	3	30

The most important cause responsible for the formation of the “foil sticking together” defect (RPN = 576) is the insufficient amount of the antiblock additive in the production process. Another significant cause (RPN = 300) is the lack of standards and regulations pertaining to the technical parameters of the foil and ways of controlling them. Incorrect choice of the process parameters placed third with a RPN of 192. The least important cause turned out to be the lack of periodical technical inspections of the machines.

3.2 Process improvement

As a result of the Ishikawa analysis and FMEA conducted a number of corrective and preventive measures have been proposed.

For the cause of an insufficient amount of the antiblock modifier, introducing containers with the right capacity was proposed as a corrective measure in order to ensure the right amount of the additive is applied. Preventive measures consisted in implementing a detailed instruction for preparing mixtures along with a control list.

In the case of the absence of standards defining the product’s properties and ways of controlling them, the corrective measure is training the employees in terms of controlling the important characteristics of the product. The preventive measures consisted in developing a unified set of important product characteristics along with systemic instructions pertaining to the place and methods of control, as well as modifying the training schedule for new employees.

The problem consisting in an incorrect choice of process parameters was solved by introducing control lists for the operators and the process engineer which facilitate systematic control of the process parameters. Installing sensors along with an computerised process monitoring system was proposed as a preventive measure.

For the cause consisting in an insufficient frequency of technical inspections of the machines and equipment taking part in the production process, a system for scheduling the works of the

maintenance department was put into place which takes into account the necessary inspections and repair works, and coordinated with the production planning department. Work sheets for the maintenance department employees and obligatory monthly reports on the scheduled works conducted were introduced as a preventive measure.
The total RPN indicator for the problem analysed was successfully reduced from 1116 to 128.

4 Conclusions

Based on the analysis of the plastic bag production process, defects were discovered which caused returns from the clients and economic losses. The most significant errors in the process detected were: foil sticking together, foil hard to seal, smudging of the foil, impurities accumulating, problems with foil feed, electric discharges. Using the FMEA method, the causes of defects were put into a hierarchy; the analysis allowed for determining the defects which generate the biggest losses and should be eliminated first through corrective and preventive measures. The defects which should be eliminated in the first place are: foil sticking together and lack of standards and regulations pertaining to the foil's technical parameters and ways of controlling them. In the next stage of the analysis, improvement and preventive measures were proposed based on previous analyses using the FMEA method and the Ishikawa diagram. The following corrective measures were proposed:

– For the insufficient amount of the antiblock modifier, introducing containers with the right capacity was proposed as a corrective measure in order to endure the right dosage of the modifier being applied, while the preventive measures consisted in implementing a detailed instruction for creating mixtures along with a control list.
– For the lack of standards defining the properties of the product and ways of controlling them, the corrective measure is employee training with regards to controlling the important characteristics of the product. As a preventive measure, a unified set of important product characteristics was drawn up along with systemic instructions specifying the places and methods of product control, and the training plan for new employees was modified.
– For the incorrect choice of process parameters control lists for the operators and technology facilitating systematic process parameter controls were introduced as corrective measures. Installing sensors along with a computerised process monitoring system was proposed as a preventive measure.
– For the insufficient frequency of inspections of the machines and equipment taking part in the production process, a system for scheduling the work of the maintenance department

was put into place which takes into account the necessary inspections and repairs, and coordinated with the production planning department. As a preventive measure, work sheets for the maintenance department employees were introduced along with obligatory monthly reports on the scheduled works conducted.

A significant improvement in the plastic bag production process was observed after the implementation of the improvement and corrective measures.

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