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PDCA cycle as a part of continuous improvement in the production company - a case study

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Abstract

The paper presents a case study of the practical use of Deming cycle in a manufacturing company, from the plastics processing industry, from the sector of small and medium-sized enterprises. The paper is a study of literature in the field of continuous improvement and characterized by a cycle of continuous improvement, called the Deming cycle, or PDCA cycle. This cycle was used as a solution to quality problems which occurred during production of photo frames: discolorations and scorches on the surface of the frame. When measures were introduced to reduce the number of nonconformities, a decrease by more than 60% was observed.

1. Introduction

Continuous improvement is a set of repetitive actions, which are designed to increase the capacity to meet the requirements. It is one of the eight quality management principles.

Actions concerning continuous improvement include (BAGIŃSKI J. 2004, IMAI M. 2007):

- analyzing and evaluating the existing situation to the identify the area for improvement,
- setting targets that relate to improvement,
- searching for solutions to achieve the objectives,
- evaluation of these solutions and making a selection,
- implementation of solutions,
- measurement, verification, analysis and evaluation of the results of implementation to determine whether the objectives have been achieved,
- formalizing changes.

Using the principle of continuous improvement is associated with using consistent, comprehensive organizational approach to improve the achievements of the organization, ensuring the participation of people skilled in the use of methods and tools of continuous improvement, the constant products, processes and systems improvement, understood as the goal of every person in the organization, establishing the objectives and reference state to direct the continuous improvement, and also the recognition and accepting the improvements.

William Edward Deming, a prominent American researcher, similarly to Japanese, believed that management staff and all employees should be involved in the process of continuous improvement. He created 14 principles that later became the basis of the philosophy of quality in the organization and continuous improvement cycle PDCA (Plan - Do - Check - Act), called the Deming wheel. Deming cycle is a sequence of actions that aim at improvement. This cycle is also designed to solve quality problems and implement new solutions. PDCA model is extremely versatile and it can be successfully used in any type of business. Owing to this cycle, an enterprise experiences an 80% reduction of costs of "problems" of the order of 20 to 30% of the initial level (e.g. the product quality defects) on average (PRACA ZBIOROWA 2014). Most often it is used (ŁUCZAK J., MATUSZAK-FLEJSZMAN A. 2007):

- in the process of continuous improvement,
- during the implementation of changes,
- during a downtime between one phase of a project and the next,
- during the implementation of a new solution,
- during the review of a process improvement

Before the PDCA cycle is begun, it is essential to ensure that the existing standards are stable (IMAI M. 2007). The cycle is the so called SDCA (Standardize - Do - Check - Act)

(JAGUSIAK-KOCIK M 2014). Only when the cycle functions (this means that the standard has been implemented) and stabilized), it can increase, improve standards, by means of PDCA cycle.

Figure 1 shows the PDCA model, indicating a possible critical area.

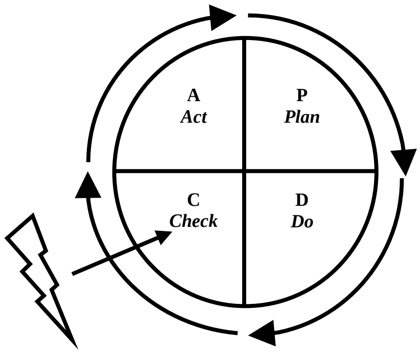

Fig 1. PDCA cycle with indicating the critical area

The first step of Deming cycle - "Plan" (P) is associated with recognizing the possibility of changes, namely, its improvement and scheduling it. It sets the objectives for improvement and designs an action plan which will enable this objective. It is necessary to identify the problem, analyze the causes affecting it, generate solutions, and develop a plan of implementation. During this step, every action can be supported by tools and methods such as Ishikawa diagram, Pareto-Lorenz diagram, process mapping or brainstorming.

In the next step - "Do" (D) the developed plan in order to make changes in the process is implemented in a company (in order to raise its productivity or quality and to eliminate the causes of problems). It takes place with the support and understanding of the management. In this phase, tools such as an action scheme, benchmarking, flow diagram or check sheet can be used.

"Check" (C) step equals checking, testing, whether solutions introduced to a company brought adequate results. The measurements are taken and they are compared with the values folded in the plan. Control sheets, control charts, process capability indices can be used to help. If the implementation of solutions proved to be appropriate, it is followed by 4 PDCA cycle step - "Act" (A), if not - one shall return to step 1 - "Plan" (P) (this is a critical area in the process of improvement).

The last step of the PDCA cycle "Act" (A) is connected with the application of the implemented solutions. When these solutions are proven, they are considered the norm and lead to standardization and monitoring of the activities. This step may be necessary in case of tools such as process mapping, an action scheme or benchmarking (FRANZ J. K., LIKER J. K. 2016., KIRAN D. R. 2016).

PDCA cycle is contained in a circle and never ends. The knowledge gained from the last stage becomes the basis for the next cycle; improvement is not seen as the end and does not bring satisfaction with the current situation.

There are modifications of the PDCA cycle, such as:

- PDSA cycle (Plan - Do - Study - Act),\
- EPACA cycle (Evaluate - Plan - Action - Check - Amend),
- PDAC cycle (Plan - Do - Act - Challenge).

The work will show an example of an application of the PDCA cycle in a manufacturing company from the sector of small and medium-sized enterprises (SMEs). In the references, such as IMAI M. 2007 examples of this cycle in large enterprises can be found, for example Ricoh, Canon and Nissan. A small number of publications rarely provide a case study using the universality of this cycle in Polish conditions in the sector of small and medium-sized enterprises, which have become a kind of factor in a dynamic and stable economic development. Still, such companies experience many barriers on the market, both external and internal. Barriers of external nature are primarily, any risks from the market, including competitors' activities, the decline in the number of orders and the difficulty in finding new markets, and human resources barriers: lack of qualified workers, low mobility of workers or even unwillingness to work in such companies. A significant problem entails external financial barriers, primarily related to the size of the capital and the terms of the provision of banking services (e.g. complicated procedures, regulations or high bank charges). Among the external barriers there are also social barriers, legal barriers and the ones related infrastructure. While the barrier of an internal nature is, above all, linked to insufficient management, production barriers and barriers related to the size of the business. The aim of the work is to show how using the PDCA cycle can solve quality problems and implement solutions which are a part of continuous improvement in the company of the sector of small and medium-sized enterprises. The result can overcome some barriers within a company and help to deal barriers outside the company more effectively.

2. Experimental

The object of the research is a company from the sector of small and medium-sized enterprises (small, employing up to 49 people) engaged in the production of decorative elements made of plastic. Its basic assortment mainly includes mainly picture frames and paintings in a variety of shapes and colours, as well as gift baskets also available in different colour combinations and different dimensions. The company also produces containers for small items and gadgets for individual orders (e.g. key chains, pens, lighters). The main customers are wholesalers and shops with ornaments and souvenirs, as well as the company contracting specific gadgets. The company has a machine park consisting of injection moulding machines, pad printers machines and robots. The production takes place in the slots and it can be described as small-lot production.

In order to improve the process and quality of products, the research company has implemented a quality management system according to ISO 9001:2015. Given the increasing demands of customers and the presence of competition on the market the company is also trying to improve every element of its business through the use of selected tools and methods of quality management and lean management techniques. The versatility and simplicity presented in the initial part of the work of Deming cycle were recognized in the researched company while trying to solve quality problems that occurred during the production of picture frames. The frame is manufactured in the shape of a heart in red colour, and made of polypropylene. Proceedings at the Deming cycle involve in the following steps:

In step I - planning (P) a company focuses on the detailed identification of the problems which occur during the production of picture frames, and determines the order. It was noticed that problems were connected with discolouration on the surface of frames (because if it a frame did not look appropriate as its colour was not distributed evenly, in some places there were bright red streaks) and scorches (black and brown lines and tracks). After identifying, "naming" these problems, the next step was to collect data about the process. Discrepancy resulting from discolorations on the surface of the frame occurred during the process of mixing the pigment and was visible on the front of the frame, and at its top. While the scorches appeared in one location in the frame which proved that they do not result from the drying process, but they probably during the injection material into the mold. In order to determine the causes of such a situation and to minimize the probability of discrepancies, the analysis of the causes of problems was necessary, as was the need to devise a plan to implement solutions. For this purpose, a traditional quality management tool known as Ishikawa diagram was used (BORKOWSKI S. 2012, JAGUSIAK-KOCIK M., KNOP K. 2016, KARDAS E. 2016, KRYNKE M., JAGUSIAK-KOCIK M. 2016, ULEWICZ R., NOVÝ F. 2013). Ishikawa diagram is the result of a brainstorming of a working group the employees of the production department and the head of production department. As a result of brainstorming three main groups of causes, which could affect discolorations on the surface of a photo frame was identified. These groups and an example of causes presented in Figure 2.

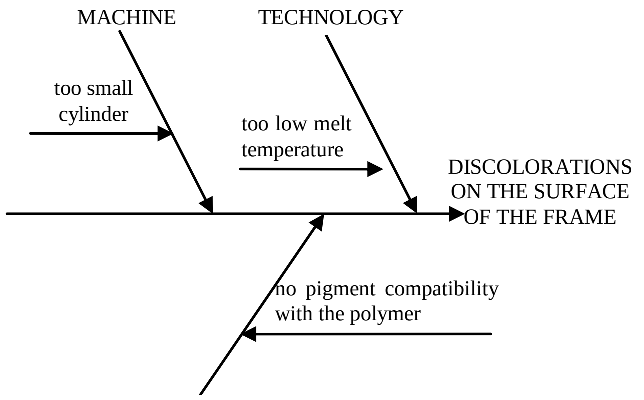

Fig. 2. Ishikawa diagram for nonconformity connected with discolorations on the surface of the photo frame

In the "Machine" group the following causes were specified: too small cylinder, too large dispenser, damaged the pigment dispenser (for which he gives pigment irregularly, unevenly) and static electricity pigment, which adheres to the hopper. The next group of causes "Technology" specified causes such as too low alloy temperature, too low back pressure during dispensing material and inadequate dosing pigment. The "Material" group distinguished while the following causes which may affect the discolorations on the surface of the photo frame: no pigment compatibility with the polymer, poor solubility of pigment and the granules are too large, both material and pigment.

Figure 3 shows the Ishikawa diagram for groups of causes and an example of causes, which may affect the next observed discrepancy during the production of picture frames - scorches. It revealed that employees from working group, during a brainstorming session also identified, as in the case of discolorations nonconformity, causes related to the malfunction of the machine, technological causes, material and also causes structural (form). In the "Machine" group there were causes identified which can be associated with the occurrence of retention in the plasticizing unit and the nozzle sealable a needle and with a small diameter nozzles and improper adhesion of the injection machine nozzle. The "Material" group specified the following causes which may affect the scorches on the surface of the photo frame: different size of pellets, too high content of regrind, and insufficient resistance of the polymer to thermal loads. "Technology" causes are related to a very high speed injection molding, high temperature of the cylinder and a high channels temperature. Last group - "structure" (form) revealed the following causes: incorrect construction of channels, too large differences in temperatures on the hot zones channels and too small channels diameter in the form.

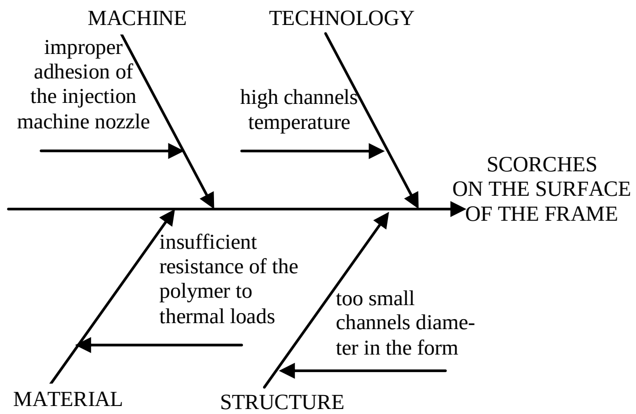

Fig. 3. Ishikawa diagram for nonconformity connected with scorches on the surface of the photo frame

After identifying the causes which might have affected the problems, the working group also began searching for potential solutions by means of brainstorming. A plan to implement solutions was devised and made visible on the shop floor, in the form of a clear and explicit for each employee. In the plan (created as a table) found an accurate description of the solutions could be found, the place of the implementation, the person responsible for the execution of those tasks and the planned beginning and end of these activities. The plan how to implement the solutions also included a description of the possible outcomes.

Step II - doing (D), which is connected with implementing the elaborated plan was associated with the removal of the causes of problems happening during in the production of photo frames. An action scheme to help in accomplishing the designed task was created. In the case of discrepancy connected with discolorations on the surface of photo frames, the following actions were undertaken: the pigment dispenser was checked in terms of its size and accuracy. A small failure which could contribute to irregularity, and uneven pigment distribution was noticed. There was no excessive static electricity of the pigment. Slightly raised temperature of the alloy and the injection speed was increased. It was checked whether the pigment is appropriately adjusted to the material and size of the granules of the tested material and pigment.

The analysis of the causes of discrepancy related with scorches on the surface of the photo frame focused on the injection machine nozzle, checked diameter and adhesion, as well as the retention space in the plasticizing unit. Similarly, in the case of the reasons that could affect the discolorations of the surface of the frame, a verification of the size of the granules was done. Adequate resistance of polypropylene on included in the process heat load was certified. The temperature channels were slightly exceeded and there were differences in temperature on the hot zones channels. Consequently, the temperatures were corrected.

In step III - checking (C) it was checked, if the applied actions brought expected effect of minimizing the number of discrepancies of the photo frames. The results, presented in the implementation plan, assumed a reduction in the number of nonconformities number by 60% after the first implementation of solutions. After measuring, using control charts by number of nonconformities *np*, a decrease in the number of faulty products by more than 60% was shown. The objective set in I step of Deming cycle was reached which made it possible to proceed to final step IV - act (A).

Step IV - act (A) uses the implemented solutions. After the step III proved that they had brought the expected result which started their standardization and monitoring of their activities. In the production hall instructions for employees were displayed in a visible and comprehensible form. Moreover, improvements to the existing procedures for the injection process of the photo frames were introduced. In these procedures, besides fixed points, were precisely characterized ways to solve problems and persons responsible for their implementation were specified.

3. Summary and conclusion

PDCA is contained in a circle and endless which allows to consider all the implemented and applied solutions an indicator for further improvement activities. The company has achieved its objective, which reduced the number of discrepancies by more than 60%, but this should not lead to a halt in the improvement of the production process of photo frames. The next step should include development of a new action plan, or reusing Deming cycle as a cycle for improvement, by which the number of faulty photo frames is reduced compared to that achieved in the shown example.

The case study presented in the paper in relation to the company from the SME sector proves that the PDCA cycle is a series of versatile, simple to implement and can be successfully used in any company that uses or intends to apply the principle of continuous improvement in respect to some or all areas of its business. It helps to overcome internal barriers resulting form, for example, wrong management and to minimize the impact of external barriers.

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PDCA循環作為生產公司持續改進的一部分 - 一個案例研究

關鍵詞
連續的提高
PDCA循環
生產
塑料

摘要

本文介紹了在塑料加工業，中小型企業部門的製造公司中實際使用戴明循環的案例研究。
本文是對持續改進領域的文獻的研究，其特徵在於一個持續改進的循環，稱為Deming循環或PDCA循環。該循環用作對在照相框生產期間發生的質量問題的解決方案：框架表面上的變色和燒焦。 當採取措施減少不合格數時，觀察到減少超過60%。