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Key Performance Indicators (KPIs) as a Tool to Improve Product Quality

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INTRODUCTION

A characteristic feature of present times is very fast social, economic and technological development. Every organization is focused on continuous improvement. The main purpose of these activities is to strengthen or improve the position on product sales market and increase the profit level achieved by the company. In the literature there are many methods, tools and techniques with the help of which it is possible to increase the efficiency of work of the whole organization, and above all the production process. These are methods and tools of quality management, but also economic indicators, which can be used as an analysis of the current company's condition. The values of indicators should constitute the basis for the use of quality management tools in order to improve the processes implemented in the company (Skrzypek, 2000). The presented paper shows the use of 5 WHY (Hamrol, 2008; Iwasiewicz, 1999; Karaszewski, 2006; Sęp & Pacyna, 2011) method as a tool for an in-depth analysis of the reasons that cause the unsatisfactory level of one of the selected KPIs.

Efficiency is a very difficult issue to define. It is often confused with the concept of effectiveness or productivity. It is not a proper interpretation, because efficiency should be understood as the most efficient use of resources in the process of satisfying human needs.

Efficiency is usually presented as a percentage, but sometimes it is considered in relation to different criteria depending on the specifications and needs of the company. In traditional approach to efficiency it has always been associated with relying on the organization's financial results. However, nowadays it is assumed that the measurement of efficiency should refer to financial as well as qualitative and quantitative indicators, the so-called non-financial. Very

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important is the type of activity, for which the efficiency measurement will be carried out. Each company should individually formulate and define clear criteria for the efficiency measurement, as well as select the tools and measures, with the help of which a given efficiency measurement will be carried out. This is not an easy task due to the wide range of measures, often lack of appropriate competence in their selection, as well as high costs associated with obtaining key information to formulate the measures (Koliński, 2011; Borowiecki, 1988; Rutkowska, 2013; Mstiskova & Balog, 2018). There is a wide selection and distribution of performance indicators to be used in different areas of the company (Wawak, 1998; Parmenter, 2010). This paper draws attention to the Key Performance Indicators, as those that are the most universal and enable control of the intended objectives in different company areas.

Key Performance Indicators (KPIs) can be a benchmark in relation to other companies or departments determining efficiency and effectiveness in action. They can be used as a control tool in the company to check whether the assumed goal is being achieved. These indicators enable tracking the progress or drop in performance for a given objective. KPIs present the results of work as well as functioning of the whole organization. They are also defined as a tool of managerial control to identify ineffective areas of the company, make decisions quickly and react immediately to problems and emerging difficulties. They are also a support for the effective use of resources and continuous improvement of processes. Key performance indicators enable the reduction of a large amount of information to a small amount of key and detailed data, presenting the goal achievement.

The starting point for selection of each key performance indicator should be an assumed and defined strategic objective, which may include individual operational objectives with appropriate values defined by KPIs. All the key indicators should have set numerical values, which will represent the achievement of assumed objectives. Each company has its own specific activity, industry, size or strategy of KPIs. These indicators may be similar, but they will never be identical in two organizational units. When formulating indicators, it is important to consider what should distinguish a given enterprise from its competitors. It should not be limited only to financial indicators, but it is also not advisable to exaggerate the number of data analysed because of the unclear and blurred assessment image (Bielawa, 2013; Parmenter, 2010; Osiadacz, 2011). It is important to remember to select only those indicators that are influenced by employees and those that are measurable over a certain period of time.

A very important element right after the development and selection of appropriate key performance indicators is the monitoring of changes taking place in the process and current comparison of achieved results with intended objectives. Each company that decides to use the tool, which is KPIs, should have an IT tool adapted to the company's needs, to control, supervise and compare all the obtained data in it. Another important step is to develop a further plan of action, because only in this way even the smallest enterprises will

be able to provide and create an early warning and response system for themselves. This system will allow for a sufficiently quick reaction in the production unit and the company will have a chance of success in the current era of constant changes on the market (Grycuk, 2017; Plamenter, 2010).

DESCRIPTION OF RESEARCH METHODS

The paper presents the use of KPIs as a tool to improve the quality of the company's flagship product – a hydraulic connector. The company is located in Silesia and deals with the production and sale of hydraulic details such as metal connectors used in hydraulic and refrigeration systems. The company also manufactures machine tooling to connect hydraulic hoses to fittings on its own.
In order to search for areas which have a negative impact on the quality of product, selected KPIs for the product "hydraulic connectors" were analysed. In the conducted research, such indicators were taken into account:

- Defective product ratio in relation to finished products
- Average delivery time of finished products to customers
- Quantitative and qualitative complaints ratio in relation to finished products.

Then, after analysing the KPIs, an analysis was carried out of the reasons for increasing number of submitted complaints regarding the hydraulic connector. This analysis was carried out using the method of analysis of the complaint content reported by external customers.
After identification of the main reason for complaint, the 5 WHY method was applied in order to search for the direct cause of complaint. The next step in the study was to propose corrective and preventive solutions in the production process of hydraulic connectors, which would lead to reduced number of complaints in the future.
The research period covered the years 2018 and 2019.

PRESENTATION OF OBTAINED RESEARCH RESULTS

Based on the analysis carried out in the company in question, quality indicators were determined for the production activities over a given period of time. Calculated indicators are:
1) Defective product ratio in relation to finished products.
This indicator shows the percentage share of defective hydraulic connectors identified during the inspection process in relation to total connectors production in 2018 and 2019.
2018:

$$\frac{Number\ of\ finished\ products\ [units]}{Number\ of\ defective\ units\ [units]}\ x\ 100\% = \frac{66153000}{463542}\ x100\% =\ 0{,}70\ \%\quad (1)$$

2019:

$$\frac{Number\ of\ finished\ products\ [units]}{Number\ of\ defective\ units\ [units]}\ x\ 100\% = \frac{67180000}{510568}\ x\ 100\% = 0{,}76\ \%\quad (2)$$

It should be noted that there was an increase in the number of produced hydraulic connectors in 2019 in relation to 2018. There is also an increase in the

ratio of defective products in relation to finished products, which may indicate the possibility of a negative trend appearing in the company.

2) Average delivery time of finished products to customers.

This indicator shows the average waiting time for delivery of an order to the customer, from the moment of placing an order to the moment of receiving it. It is shown on the example of 10 selected, quantitatively comparable orders for hydraulic connectors for 2018 and 2019 respectively, which is visible in Tables 1 and 2.

Table 1 Average order delivery time in 2018

	Date of order placement	Date of order delivery	Waiting time [weeks]
1.	15-01-2018	12-02-2018	4
2.	03-02-2018	17-03-2018	6
3.	19-03-2018	22-04-2018	5
4.	23-03-2018	27-04-2018	5
5.	02-04-2018	28-05-2018	8
6.	07-04-2018	28-04-2018	3
7.	13-05-2018	24-06-2018	6
8.	30-06-2018	28-07-2018	4
9.	03-09-2018	14-10-2018	5
10.	12-11-2018	10-12-2018	4

$$W_{śt} = \frac{Waiting\ time\ (weeks)}{Number\ of\ orders} = \frac{(4+6+5+5+8+3+6+4+5+4)}{10} = 5 \quad (3)$$

In 2018, the average waiting time for an order was 5 weeks, which means that the company needed an average of 5 weeks to receive, execute and deliver to a specific customer.

Table 2 Average order delivery time in 2019

	Date of order placement	Date of order delivery	Waiting time
1.	05-01-2019	16-02-2019	6
2.	20-01-2019	24-02-2019	5
3.	18-04-2019	06-06-2019	7
4.	26-05-2019	23-06-2019	4
5.	09-06-2019	04-08-2019	8
6.	21-09-2019	16-11-2019	8
7.	07-10-2019	18-11-2019	6
8.	03-11-2019	01-12-2019	4
9.	16-11-2019	14-12-2019	5
10.	21-11-2019	23-12-2019	5

$$W_{śt} = \frac{Waiting\ time\ (weeks)}{Number\ of\ orders} = \frac{(6+5+7+4+8+9+6+4+5+6)}{10} = 6 \quad (4)$$

The value of average order delivery time in 2019 was 6 weeks, which shows that the order delivery time in 2019 was extended by 1 week compared to the previous year.

3) Quantitative and qualitative complaints ratio in relation to finished products.

This indicator presents the number of complaints from external customers with regard to finished products in the form of hydraulic connectors in relation to their year-round production in 2018 and 2019.

2018

$$\frac{Number\ of\ finished\ products\ [szt]}{Number\ of\ complained\ products\ [units]}\ x\ 100\% = \frac{66153000}{1980}\ x\ 100\% = 0{,}0029\ \%\qquad (5)$$

2019

$$\frac{Number\ of\ finished\ products\ [szt]}{Number\ of\ complained\ products\ [units]}\ x\ 100\% = \frac{67180000}{2320}\ x\ 100\% = 0{,}0035\ \%\qquad (6)$$

The value of complaint rate in 2019 is definitely higher than in 2018. One of the elements that have an impact on this fact is the increased number of connectors produced in 2019, but it is also a clear signal that the company should start looking for the problem sources in this area.

ANALYSIS OF THE COMPLAINT CAUSES

Receiving a complaint very often gives an opportunity to observe both the emerging problems in the company and their causes. It is a kind of guidance to identify the area where a given error occurs or the sources of its occurrence. During a detailed analysis of the complaint, it is possible to determine exactly at what production or transport stage a specific error occurred.

Due to the upward trend in the rate of qualitative and quantitative complaints in 2019 in relation to 2018 of finished products, an analysis of the causes of individual types of complaints was carried out, which was presented in Tables 3 and 4.

Analyzing Table 3, it can be noted that the most common cause of complaint in 2018 was the corrosion of connectors. A significant share of these complaints was also due to the order's incompleteness, which is classified as a quantitative complaint. Complaints in this area concerned incorrect quantity of elements in the order, i.e. too small or too large.

Table 3 Reasons for complaints in 2018

	Reasons for complaint	Number of submissions [pcs]	Number of submissions [%]
Quality complaints			
1.	Mechanical damage to the element	245	12,37
2.	Non-uniform color of details – discoloration	271	13,69
3.	Incorrect diameter of connectors	199	10,05
4.	Inadequate length and/or width and/or thread type	278	14,04
5.	Inappropriate connector dimensions length and/or connector wall width	169	8,53
6.	Corrosion of connectors	321	16,21
7.	Delayed delivery time	189	9,55
Quantitative complaints			
8.	Incomplete order	308	15,56

The results presented in Table 4 show that in 2019 the largest share of external complaints was also due to corrosion of connectors. Taking into account the analysis results, it can be concluded that a serious problem for the company is the appearance of a product defect, consisting in the corrosion of connectors during use.

Table 4 Reasons for complaints in 2019

	Reasons for complaint	Number of submissions [pcs]	Number of submissions [%]
Quality complaints			
1.	Mechanical damage to the element	289	12,46%
2.	Non-uniform color of details – discoloration	321	13,84%
3.	Incorrect connector diameter	119	5,13%
4.	Inadequate length and/or width and/or thread type	105	4,53%
5.	Inappropriate connector dimensions length and/or connector wall width	217	9,35%
6.	Corrosion of connectors	732	31,55%
7.	Delayed delivery time	287	12,37%
Quantitative complaints			
8.	Incomplete order	250	10,77%

In order to determine the cause of corrosion in hydraulic connectors, the 5 WHY method was used, which was presented in Figure 1.

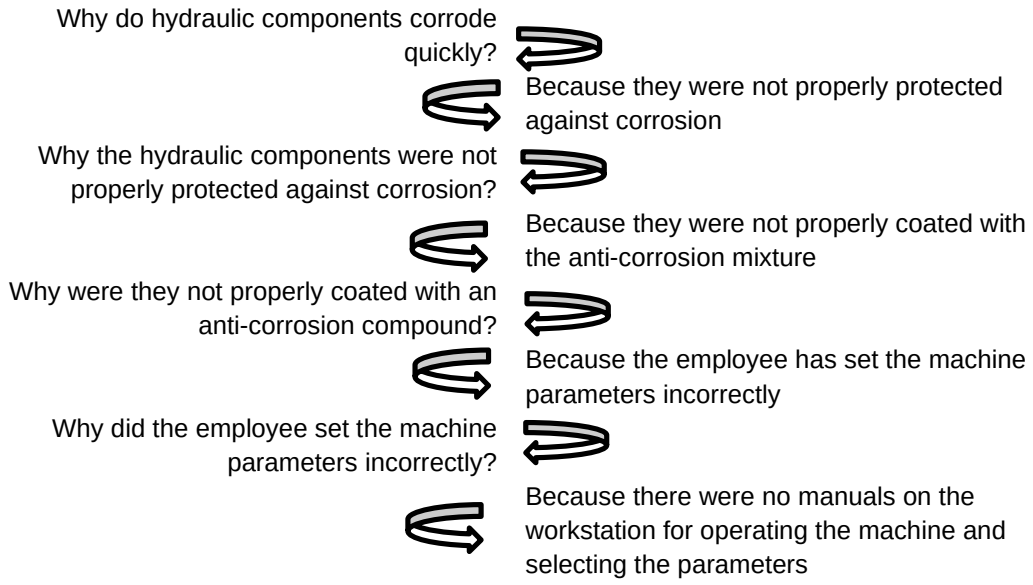

Fig. 1 Analysis of the causes of corrosion in the hydraulic connector using method 5 WHY

The 5 WHY analysis showed that the source of complaints regarding the corrosion of hydraulic connectors was an inaccurate coating of the components with anti-corrosion mixture. This was due to incorrectly set parameters of the machine, which was supposed to cover the connector with anti-corrosion mixture. The employee incorrectly entered the parameters into the machine, because the machine's operating manual and the production card for a given batch of hydraulic connectors, which at that time was to be protected against corrosion, were not available during the full shift. The production card of particular product contains all the necessary information that an employee at a particular workstation must have in order to correctly set the machine parameters that he operates on the shift. Lack of machine manual and production card at the workstation resulted in incorrect information being entered

into the machine, and this caused an incorrectly coated element with a layer of anti-corrosion mixture. Due to the identified situation, it was decided to formulate a proposal concerning a number of changes for the company's existing system, which were presented in Table 5.

Table 5 Proposals of new solutions in the current situation

	Current situation	Proposed solution
1.	Lack of systematic control of workstations in the company.	Control of each workstation before the start of a shift by the supervisor confirmed by an annotation on the production card of a given product.
2.	Lack of 100% control over the finished products.	Introduction of additional control of finished products directly before the stage of packing the order to the customer.
3.	Lack of self-control over the employee.	Introducing additional bonus systems for employees for the smallest percentage of products not meeting the requirements.
4.	Lack of supervision over the respect of implemented rules by middle level employees by the top-level management.	Control carried out by the top-level management of annotations in the product documentation concerning checking the equipment of workstations with necessary instrumentation and workstation instructions.

DISCUSSION OF RESULTS

The use of KPIs to improve product quality turned out to be a good solution for the company. It is expected that the use of economic indicators to improve the quality of manufactured products should be a common phenomenon. Thanks to the application of such a solution, it was possible to identify the company's problem, which was solved by using the quality management method. The analysis of 5 WHY method resulted in a number of new solutions being proposed in the company, which consequently reduced the number of quality complaints concerning the corrosion of hydraulic connectors, as well as reduced the percentage of all complaints submitted by customers regarding non-compliant products. Currently, after the introduction of changes, it is possible to immediately identify defective products that should not be delivered to the company's contractors. Reduction in the number of submitted complaints resulted in much lower costs related to repair or replacement of hydraulic components with new ones. The lack of necessity to complain about the purchased products also has a positive impact on the company's customers, who are more satisfied with the company's services and also advertise good quality products and services provided by the company on the market.

CONCLUSIONS

The analysis of trend of the Quantitative and qualitative complaints ratio in relation to finished products in 2018 and 2019 showed an upward trend, which resulted in the decision to identify the causes of such a phenomenon. The analysis of complaints enabled to determine that the most frequent cause of complaints in 2018 and 2019 was corrosion of hydraulic connectors, which accounted for as much as 31.55% of all complaints in 2019. With the use of

5 WHY method, it was possible to determine the main source of corrosion in hydraulic connectors, which in turn enabled to develop a number of solutions, which include among others control of each workplace before the start of a working shift and motivating employees to self-control through additional bonus systems, thanks to which it is possible to minimize the cause of component corrosion.

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REFERENCES

Bielawa, A. (2013). Przegląd kryteriów i mierników efektywności przedsiębiorstw nastawionych projakościowo. WNEiZ, 34, pp. 23-36.

Borowiecki, R. (1988). Efektywne gospodarowanie środkami trwałymi w przedsiębiorstwie. Warszawa- Kraków: PWN.

Grycuk, A. (2017). Kluczowe wskaźniki efektywności (KPI) jako narzędzie doskonalenia efektywności operacyjnej firm produkcyjnych zorientowanych na Lean. Przegląd Organizacji, 2, pp. 23-34.

Hamrol, A. (2008). Zarządzanie jakością z przykładami. Warszawa: PWN.

Iwasiewicz, A. (1999). Zarządzania jakością. Warszawa- Kraków: PWN.

Karaszewski, R. (2006). Nowoczesne koncepcje zarządzania jakością. Toruń: TNOIK .

Koliński, A. (2011). Przegląd metod i technik oceny efektywności procesu produkcyjnego. Logistyka, 5, pp. 1083- 1091.

Matisková, D and Balog, M. (2018). Criteria for the Optimization of Production Processes in Machining of Metallic Materials. Management Systems in Production Engineering, 26(4), pp. 227-230.

Osiadacz, J. (2011). Narzędzia identyfikacji potrzeb innowacyjnych w przedsiębiorstwach. Wrocław: PARP.

Parmenter, D. (2010). Kluczowe wskaźniki efektywności (KPI). Gliwice: Helion.

Rutkowska, A. (2013). Teoretyczne aspekty efektywności – pojęcie i metody pomiaru. Zarządzanie i Finanse, 1(4), pp 439-453.

Sęp, J. and Pacyna, A. (2011). Metody i narzędzia zarządzania jakością. Rzeszów: Oficyna Wydawnicza Politechniki Rzeszowskiej.

Skrzypek, E. (2000). Jakość i efektywność. Lublin: UMCS.

Wawak, T. (1998). Ekonomiczne mierniki oceny jakości. Kraków: EJB.

Abstract.
The literature includes a wide selection and distribution of performance indicators to be used in different areas of the company. The paper highlights the Key Performance Indicators (KPIs) as those that are the most universal and allow the control of intended targets in different areas of the enterprise. KPIs are financial and non-financial process measures used to assess the degree of achievement with regard to strategic and operational objectives in a company. They are also used to measure the effectiveness of all activities undertaken in an organizational unit. The paper presents the possibility of using KPIs to improve the quality of manufactured products, by analyzing the trend of selected indicators. This analysis gave an impulse to undertake improvement actions in the company consisting in the use of quality management method – in this case 5 WHY leading to the initiation of preventive and corrective actions in the occurrence of defective products.

Keywords: Key Performance Indicators, quality, efficiency, product, 5 WHY