SILESIAN UNIVERSITY OF TECHNOLOGY PUBLISHING HOUSE

SCIENTIFIC PAPERS OF SILESIAN UNIVERSITY OF TECHNOLOGY 2020
ORGANIZATION AND MANAGEMENT SERIES NO. 142

QUALITY MANAGEMENT TOOLS IN THE ASPECT OF THE ASSESSMENT OF THE EFFECTIVENESS OF THE ENTERPRISE PRODUCTION PROCESS IN THE HYDRAULIC INDUSTRY

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Purpose: The purpose of including the following analysis was the problem diagnosed in a manufacturing company with hydraulic technology in the aspect of the growing number of hydraulic connected complaints. Therefore, a decision was made to analyze in detail the problem encountered with the available methods and tools.
Design/methodology/approach: The study presents a literature approach to issues related to the effectiveness of the production process and the characteristics of the principles, methods, tools and techniques of quality management, as well as the practical application of the 5 WHY tool, based on a production enterprise from the hydraulic industry.
Findings: The analysis carried out noticed problem using the Five Whys tool on the basis of data from a manufacturing enterprise from the hydraulic industry, as well as the created summaries of reasons for both quantitative and qualitative complaints in 2016 and 2017 enabled the identification of the main source of the diagnosed problem in the form of too many corroded hydraulic components in 2017 and the formulating of necessary recommendations to eliminate the above mentioned disadvantages of finished products for the enterprise.
Practical implications: The introduced changes in the company from the hydraulic industry will significantly facilitate and improve the identification of defective products that should ultimately not reach the enterprise's customers.
Originality/value: Formulating practical conclusions on using quality management tools in the aspect of the assessment of the effectiveness of the enterprise production process in the hydraulic industry.

Keywords: production process, quality management tools, process efficiency.

Category of the paper: Research paper, Case study.

1. Introduction

The modern economy faces numerous important problems, one of which is constantly growing level of competitiveness of enterprises regarding products, in terms of satisfying growing expectations of customers, coming from the market. Each production organization is focused on improving the quality of products and services offered, while ensuring a competitive market price. The main purpose of these activities is to increase brand recognition, gain the trust of contractors, which will clearly translate into the level of profit generated by the enterprise. Thus, one of the most difficult tasks the management team of production enterprises has to face today is to increase production efficiency. In literature, there are a lot of methods, tools and techniques that allow for the increase in the efficiency of organization's work and, above all, to improve the production process. When choosing the right method or tool, you should start by thoroughly identifying the problem until you find the root cause. Then, you should consider whether the chosen method or tool will solve the identified problem and allow you to develop a concept of changes that will be possible to implement in the life of the enterprise. After analyzing the above, it is possible to decide on the use of a selected method or quality management tool to improve the efficiency of the production process. That is because the production constitutes potential source of enterprise's competitive advantage on the market. However, it should be noted, that its efficiency can be improved not only by incurring additional financial expenditures, but also by introducing small changes, not related to additional investments (Słowiński, 2009).

The purpose of the article is to present the practical application of the selected quality management tool that has solved the problem identified in the enterprise from the hydraulic industry. The first part presents literature approach to the production process and the principles, methods, tools and techniques of quality management, while the next part presents the use of the Five Whys tool, based on data collected in an enterprise from the hydraulic industry, and the concept of proposed solutions in relation to the current state was created.

2. Operation and assessment of process efficiency in manufacturing enterprises

2.1. Characteristics of the production process in the enterprise

The production process is defined as an ordered sequence of planned activities that includes all stages of processing feedstock, materials, intermediate and semi-manufactured products into finished products. Starting from the collection of input material for the production process, through subsequent technological, control and transport operations, to the finished product and

its delivery to the customer. During the implementation of the production process, financial, information, human and IT resources were applied. The production process is defined as the transformation of the obtained input data into output data (Brzeziński, 2000).

The main functions of the production processes are:

- primary production processes – their objective is to produce the finished product and, at a later stage, sell it, which becomes the main source of revenue for the production enterprise,
- ancillary production processes – characteristic of them is the implementation of specific tasks, as a result of which a finished product is created, but it remains inside the enterprise, and is not sold outside, as can be seen in the case of primary production,
- service processes – support ancillary production in the simplest possible way, using tools and methods. The objective is to meet the individual needs of the production enterprise,
- utilization processes – they are used for the reuse of non-compliant products and production waste, which can finally be sold again (Hanusz, 1971).

2.2. Efficiency of the production process and methods for its measurement in a production enterprise

Efficiency is a difficult concept to define, because it is often confused with the issue of productivity, as well as effectiveness. This is an incorrect interpretation, due to the fact that efficiency should be understood as the most effective use of resources that are available in the important process of satisfying human needs. From an economic point of view, efficiency is presented as the ratio of effects achieved to expenditure incurred (Skrzypek, 200).

Efficiency is usually presented as a percentage, although depending on the needs, expectations and specifications of the enterprise it is considered in various criteria. The literature approach to efficiency was usually associated with the financial results of the organization. However, at present, efficiency is often used as a criterion for describing the current state of the enterprise's functioning, as well as opportunities and threats to the organization in the future.

Methods for measuring the efficiency of a production process are not usually just about the production process itself. They are directly related to the entire research facility, which, in this case, is an enterprise from the hydraulic industry. When choosing methods to measure the efficiency of a process, you should start by assessing the organizational unit at the strategic level, and thus you need to remember about the most commonly used techniques for the strategic efficiency assessment, such as (Ossowski, 2011):

- study sheet of strategic potential,
- analysis of key success factors,
- analysis of value chain,

- portfolio methods,
- life cycle of product and technology.

Bearing in mind the high complexity and integrity of processes taking place in manufacturing enterprises, the analysis of the efficiency of production processes should include:

- assessment of economic efficiency indicators of the production process,
- analysis of the effects of the production company,
- assessment of business efficiency indicators,
- analysis of production quality efficiency indicators,
- assessment of the technical level of the enterprise and systems supporting production efficiency.

Then, having a complete set of data and information on the researched production unit, it is possible to conduct a comprehensive analysis of the efficiency of production processes in the enterprise, which will give a reliable picture of the company's situation, along with areas identified for improvement using available methods and quality management tools (Koliński, 2004).

2.3. Methods and tools for quality management in manufacturing enterprises

According to the literature, it is possible to divide Quality Management Instruments into four groups, i.e. principles, methods, tools and techniques. The above division results from the range of an activity, characteristic for each group. The principles of quality management do not depict ready schemes of solutions and patterns, they only show a certain point of view of the organizational unit. They give a chance for a directional course of thinking and acting, and thus support the motivation of employees to constantly improve and achieve their intended goals (Wolniak, and Skotnicka, 2008). Quality management methods are based on planned, repetitive schemes of conduct during the implementation of entrusted tasks. They include specific steps that occur one after another, according to the usual scheme, without the possibility of making changes. Quality management tools are used to collect and then process data that lead to finding errors and defects in supervised production processes. Techniques, however, are components of the tools, methods and principles described above, whose primary goal is to achieve the intended quality objectives. Detailed definitions of principles, methods, tools and techniques are presented in Table 1 (Sęp, and Pacyna, 2011).

Table 1.
Principles, methods, tools and techniques of quality management

Concept	Definition
Principle	- presents the point of view of the organizational unit and its employees to problems related to quality, - shows, in an easy and transparent manner, the tasks and objectives set out in the quality policy of each enterprise.
Method	- a procedure based on scientific foundation for performing specific quality assurance activities, - scientific research on elements of phenomena and things, - used in an array of fields, process fragments, - consistently used procedure or implementation aimed at achieving the intended objective through the implementation of a series of tasks in the field of quality assurance.
Tool	- used to collect and use data, - used in the scope of technique or method – a simple element, - used for processes within quality management or quality assurance, - processes and presents information collected during research.
Technique	- recipe, - procedure, - components of methods, - a specific way of performing given works and activities and the use of tools and instruments - mastered and trained ability to perform given activities, - an algorithm procedure that deals with a narrow part of the problem encountered.

Note. Bendkowski J., and Matusek M. (2013). Logistyka produkcji - część II Narzędzia, metody, systemy. Gliwice: Wydawnictwo Politechniki Śląskiej.

A very important observation regarding the principles, methods, tools and quality management techniques is that all four are interdependent and the interactions occurring between them cause the collection and processing of specific data for continuous improvement. Respective examples of principles, methods, tools and techniques are presented in Table 2. (Frąś, and Siwkowski, 2011).

Table 2.
Examples of principles, methods, tools and techniques of quality management

Principles	Methods	Tools	Techniques
- 8 principles of quality management, - Kaizen, - Poka-yoke, - 14 principles of Deminga,	- FMEA, - QFD, - SPC, - DOE – planning experiments, - 8D report, - 5S,	- Five Whys, - Six Sigma, - Ishikawa diagram, - Pareto-Lorenz diagram, - Flow diagram, - Histogram, - Shewart's control cards, - Brainstorming, - New quality management tools,	- Record, - Measurement, - Organoleptic assessment, - Research sheets.

Note. Mazur A., and Gołaś H. (2010). Zasady, metody i techniki wykorzystywane w zarządzaniu jakością. Poznań: Wydawnictwo Politechniki Poznańskiej.

In the literature on the principles, methods, tools and techniques of quality management, you can find various classifications and divisions that are used to identify errors in the process and, in the next stage, to solve difficulties and problems at all stages of the process of creating the finished product, from design to finishing on quality control of the final product. Table 3 presents a detailed breakdown of quality management instruments (Wawak, 2002).

At present, the literature approach contains a very wide selection of methods, as well as tools and techniques of quality management, the application of which depends on the problem that has been identified to be solved with their help. It is very important to scrupulously recognize the defect, error or problem that arises, initially carefully analyze the structure and finally adjust the scope of the selected method, tool or technique to the needs of a given production enterprise (Mazur, and Gołaś, 2010).

Table 3.
Division of quality management instruments by types, methods and tools

Instrument	Instrument type
Methods	**Design methods**
	- FMEA, - QFD, - DOE.
	Teamwork methods
	- Brainstorming, - Quality wheels.
	Inspection and control methods
	- SKO – statistical receipt control, - SKP – statistical process control, - SPC – statistical quality control.
	Other methods
	- Poka-yoke, - SERVQUAL.
Tools	**Old quality management tools**
	- Ishikawa diagram – cause and effect diagram, - Pareto diagram – Pareto-Lorenz diagram or ABC analysis, - Histogram, - Block diagram, - Control sheet, - Shewhart control cards, - Correlation chart, - Process map.
	New quality management tools
	- Affinity diagram, - Matrix diagram, - Interrelationship diagram, - Tree / Systematic diagram, - Matrix data analysis, - Planning process of decision-making diagram, - Arrow network diagram.

Note. Mazur A., and Gołaś H. (2010). Zasady, metody i techniki wykorzystywane w zarządzaniu jakością. Poznań: Wydawnictwo Politechniki Poznańskiej.

An important element of efficient management is the assessment of the efficiency of the production process, which should be subjected to detailed and comprehensive analysis. It should be noted that the issue of production process efficiency concerns not only economic aspects, but also the designation and assessment of its measures. And only a full analysis of the efficiency of the production process will make it possible to recognize the situation in which a given production enterprise is in. The literature on the subject does not currently propose a universal instrument that will allow for a multi-faceted, detailed analysis of the efficiency of the production process in operational terms, and research conducted in this direction confirms

the difficulty described above. Table 4 presents the methods, techniques and measures for assessing the efficiency of the production process (Wolniak, and Skotnicka, 2010).

The assessment of the efficiency of the production process is carried out using methods that allow for an overall assessment, i.e. taking into account both the economic, technical, social and ecological aspects. Therefore, when choosing methods, tools and quality management techniques you should be guided by universality, as well as wide range and comprehensiveness of application (Sęp, and Pacyna, 2011).

Table 4.
Methods, techniques and measures for assessing the efficiency of the production process

Efficiency	Methods, techniques and measures for assessing the efficiency of the production process	
Operational	**Process**	Productivity indicators
		Performance Analysis and Degree of Use of Positions
		Activity-based Costing
		Spatial efficiency of production organization
		Economic Assessment of Production Structure
		Value Stream Map (VSM)
	Technical	Dynamic Control Plan (DCP)
		Five Whys
		8D
		Statistical Process Control (SPC)
		Measurement System Analysis (MSA)

Note. Trojanowska J., and Koliński A. (2011). Budowa Maszyn i Zarządzanie Produkcją. Strategia efektywnego zarządzania przedsiębiorstwem poprzez adaptacyjne sterowanie produkcją. Poznań: Wydawnictwo Politechniki Poznańskiej, pp. 225-240.

3. Characteristics and application of the selected quality management tool in a company from the hydraulic industry – case study

3.1. Characteristics of the Five Whys tool

The Five Whys tool is used to identify and search for causes and sources of problems. This is a simple, schematic analysis that does not require additional preparation or specialized training. Only comprehensive knowledge of the identified problem, with which you need to deal with, is necessary, and the area, in which it was found. This tool is represented by a tree diagram, thus showing the direct causes of the problem. Five Whys tool involves asking five "WHY" questions, which leads to the identification of the cause of errors found, or resulting disruptions, and in the next stage to identify and introduce specific solutions to the problem. It is not obligatory to ask five questions exactly, often only four are enough to diagnose the cause of the error, but sometimes it is necessary to ask more questions to get to know the source of the problem (Łuczak, Matuszek-Flejszman, 2007). Figure 1 presents the diagram of the procedure when using the Five Whys tool (Mazur, and Gołaś, 2010).

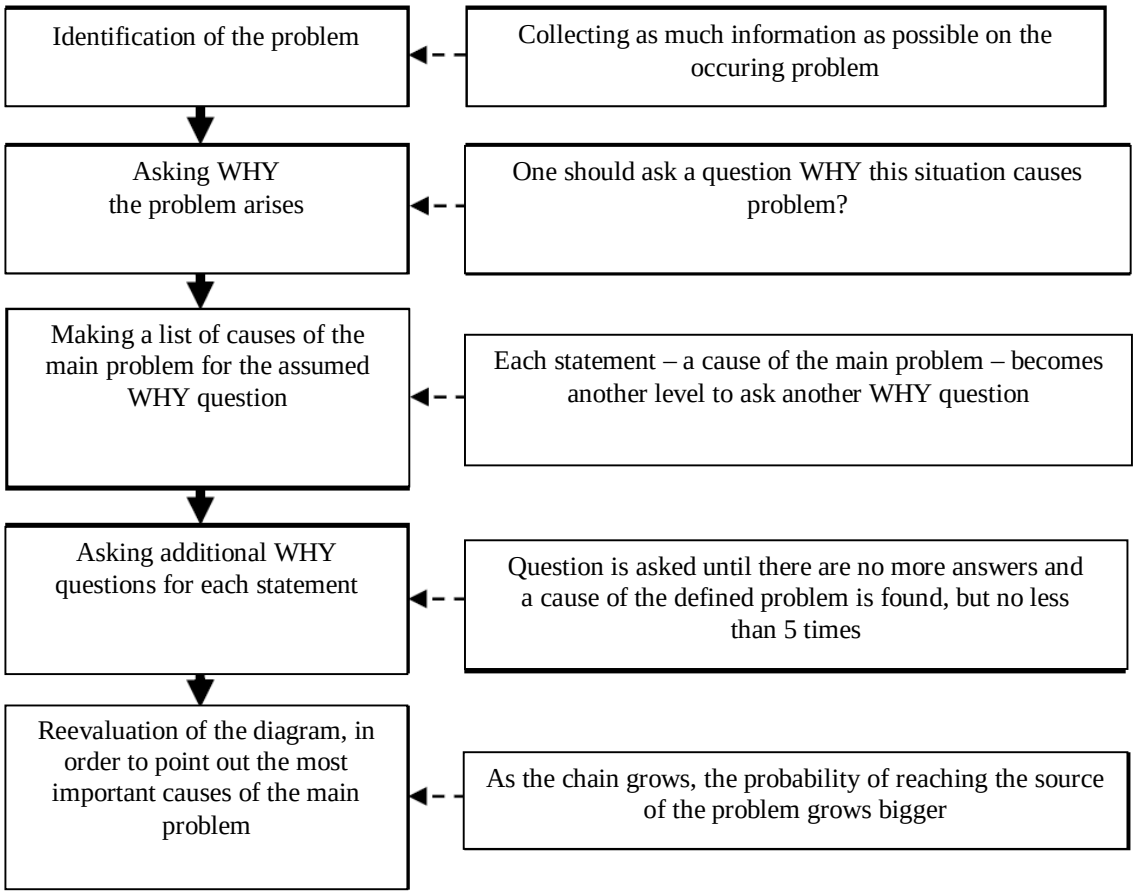

Figure 1. Diagram of the Five Whys procedure. Adapted from: Mazur A., and Gołaś H. (2010). Zasady, metody i techniki wykorzystywane w zarządzaniu jakością. Poznań: Wydawnictwo Politechniki Poznańskiej.

Five Whys shows the source of the identified problem in a very transparent and simple way, which makes it very easy to use. The tool enables problem-free and quick elimination of the source of the problem. Therefore, in practice, it is often used because of its schematic form and simplicity, as well as the opportunity to thoroughly understand the structure of the problem. The analysis does not require knowledge of complex statistical formulas and methods, thanks to which the user is not obliged to have specialized training and additional competences. It is very important that this tool is very quick to use, which is decisive and crucial in many situations at the time of use. It should be remembered, however, that in the process of searching for answers to specific questions, you cannot search for faults in the employee or their work. Usually the source of the problem is located in the system, adapted work method or organization of the production company. Therefore, it is very important to reject the possibility of an error on the employee's side in the initial phase of identifying the source of the problem (Osiadacz, 2011).

3.2. Application of the Five Whys tool on the example of an enterprise from the hydraulic industry

Due to a growing number of complaints about the products of the enterprise producing steel hydraulic fittings, the Company's Management Board decided to carry out a detailed analysis of complaints in 2016 and 2017. Based on the collected data, it was possible for the author to prepare the below summaries, together with indicators presenting a clear increase in the value of both qualitative and quantitative complaints. This indicator shows the percentage share of defective hydraulic fittings in relation to the total production of fittings in 2016 and 2017.

Year 2016

$$\frac{Number\ of\ finished\ products\ [items]}{Number\ of\ complained\ products\ [\%]}\ x\ 100\% = \frac{66153000}{1980}\ x\ 100\% = 0{,}0029\ \%$$

In 2016, an enterprise from the hydraulic industry received 1,980 complaints, and their reasons are detailed in Table 5.

Table 5.
Reasons for complaint in 2016

No.	Reasons for complaint	Number of entries [items]	Number of entries [%]
Qualitative complaints			
1.	Component mechanical damage.	245	12.37
2.	Uneven color in details – discoloration.	271	13.69
3.	Wrong diameter of the fittings.	199	10.05
4.	Incorrect length, width, thread type.	278	14.04
5.	Incorrect dimensions of length and/or wall width of the fittings	169	8.53
6.	Corrosion of fittings.	308	15.56
7.	Delayed delivery time.	189	9.55
Quantitative complaints			
8.	**Incomplete order.**	**321**	**16.21**

Note. Own study based on data from the enterprise.

In 2016, the reason for complaints reported by customers of the manufacturing enterprise turned out to be the incompleteness of the order, qualified for the category of quantitative complaints. The aforementioned type of complaint mainly concerned too few items in the packaging of orders placed. After identifying the problem and to reduce the complaint in the above category, an additional, random control of packaged orders was introduced. This solution has significantly reduced the category complaint regarding incompleteness of orders, and this can be seen in Table 6.

Year 2017

$$\frac{Number\ of\ finished\ products\ [items]}{Number\ of\ complained\ products\ [\%]}\ x\ 100\% = \frac{67180000}{2320}\ x\ 100\% = 0{,}0035\ \%$$

In 2017, the company received 2,320 complaints, in relation to 67,180,000 items produced, which allowed the calculation of the complaint rate at 0.0035%, as illustrated by the above equation. It should be noted, that in 2017, the production of hydraulic fittings was significantly increased, as compared to 2016, while there is also a noticeable increase in the rate of advertised products in relation to the total number of finished products, which indicates a problem in the enterprise, regarding the complaint category, which is corrosion of fittings. Identified reasons for complaints in 2017 are presented in Table 6, where you can see a reduction in the percentage of incomplete order categories from 16.21% to 10.77%.

Table 6.
Reasons for complaint in 2017.

No.	Reasons for complaint	Number of entries	Number of entries [%]
Qualitative complaints			
1.	Component mechanical damage.	289	12.46%
2.	Uneven color in details – discoloration.	321	13.84%
3.	Wrong diameter of the fittings.	119	5.13%
4.	Incorrect length, width, thread type.	105	4.53%
5.	Incorrect dimensions of length and/or wall width of the fittings	217	9.35%
6.	**Corrosion of fittings.**	**732**	**31.55%**
7.	Delayed delivery time.	287	12.37%
Quantitative complaints			
8.	Incomplete order.	250	10.77%

Note. Own study based on data from the enterprise.

The table above presents the identified reasons for qualitative and quantitative complaints in 2017. Based on the above data, it can be seen that the largest percentage of complaints relates to corrosion of fittings, i.e. 31.55%. Due to this, a comprehensive analysis of the source of the problem is necessary. Therefore, in order to diagnose the reason for such a high percentage of complaints regarding the corrosion of fittings, the decision was made to carry out the analysis using the Five Whys quality management tool presented in Figure 2.

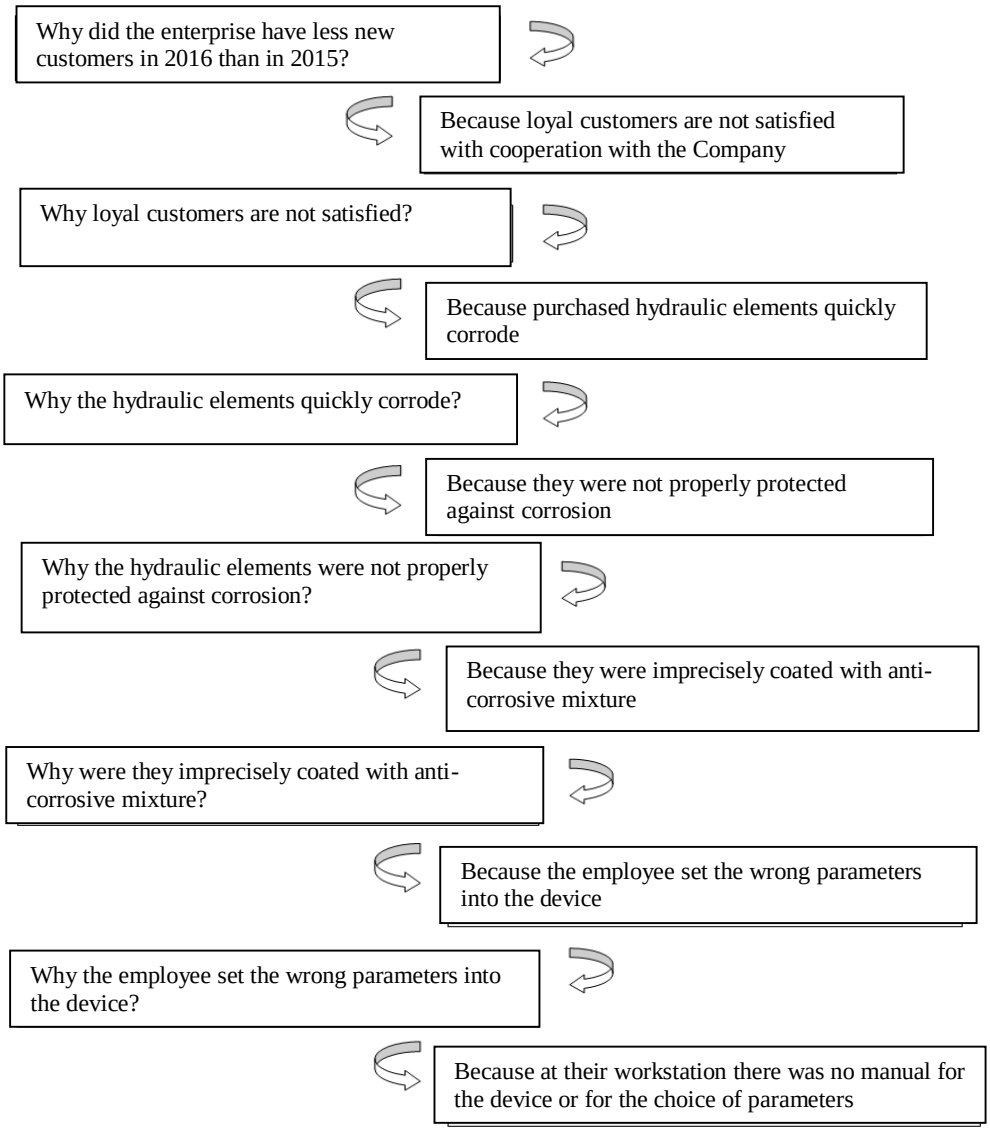

Figure 2. Analysis carried out using the Five Whys method. Adapted from: own study.

The Five Whys analysis, which was carried out in an enterprise from the hydraulic industry, allowed the development of the following conclusions:

- The source of corrosion of the fittings turned out to be imprecise coating of the individual components with an anti-corrosive mixture. The reason for this was the wrong entry of parameters into the device by an employee.
- The employee incorrectly entered the parameters into the machine, due to the fact that their workstation did not contain a manual for the device, nor a production card for a specific batch of hydraulic components with all the specifications of the production of a given series of fittings during their work shift.

Bearing in mind the cause identified by means of the Five Whys tool, which resulted in corrosion of hydraulic fittings, the author of the article decided to formulate a number of specific suggestions for recommendations for the manufacturing enterprise from the hydraulic industry, which will allow a significant reduction in the percentage of complaints related to corrosion of hydraulic components, which are presented in Table 7.

Table 7.
Suggestions for enterprise recommendations

No.	Current state	Proposed solutions
1.	No systematic control of workstations in the manufacturing enterprise.	It is proposed to check each workstation before the start of subsequent work shifts, carried out by the shift manager, and then to draw up a business note on the given product's production card.
2.	No 100% inspections of finished products in the enterprise.	Additional inspections of finished products at the stage of packing the order to the customer.
3.	Lack of employee self-control.	Additional quarterly bonuses for employees for obtaining the smallest percentage of non-compliant products.
4.	Lack of supervision by top management over the observation of implemented rules by middle-level employees.	Essential comprehensive control of documentation, production cards and work station instructions, tools, all equipment and workstations themselves, carried out by top management.

Note. Own study.

The solutions proposed above will significantly reduce the percentage of quality complaints regarding the corrosion of individual hydraulic components, which will effectively translate to a reduction in the ratio of products that do not meet customer requirements, undergoing the complaint process. The introduced changes will significantly facilitate and improve the identification of defective products that should ultimately not reach the enterprise's customers. This will reduce the cost of repairing the components or their complete replacement with new ones, as well as reducing the number of unsatisfied customers, which directly translates to the achievement of a lower value of defective product index and increase in the trust of contractors in the company. The growing satisfaction of current company customers with the quality of products and services, as well as the lack of the need to make complaints about the purchased hydraulic components, will lead to increased brand recognition of the company on the market of both domestic and international products of the enterprise from the hydraulic industry.

4. Conclusions

The rapid changeability of the market economy and its continuous development forces producers to seek and invest in more and more innovative and new methods and tools increasing the efficiency of production processes, and thus more effective in meeting the needs of consumers constantly flowing from the market. Continuous improvement of processes, work organization and resources is a prerequisite for the effective and efficient functioning of a production enterprise. It should be noted that not only technological and material resources are extremely important, but, above all, human resources, which have a decisive impact on the strategic operation of the production enterprise. The human factor in the enterprise has a huge impact on the effectiveness and efficiency of services rendered and products offered. The quality of the proposed finished products and services, both on the Polish and foreign market, depends on the appropriate allocation of resources financed with the latest technologies

enabling the implementation of production processes, the use of innovative control methods while minimizing the expenditure incurred, which will significantly reduce or completely eliminate defects and product manufacturing errors.

Nowadays, there are many methods, tools and techniques of quality management on the market that will significantly increase production efficiency. An important aspect when choosing a specific instrument is to familiarize yourself thoroughly with the identified problem in the enterprise, as well as with the reason that caused it. In addition, it is important that the selected tool is simple and schematic in use, so that the employee responsible for its use does not have to acquire additional, often time-consuming competences, as well as training in this field. Because often a very important criterion in the selection of a method or tool for improving the process or assessing its efficiency is the complexity and duration of its application.

The purpose of the article was to present a literature approach on the methods, tools and techniques used to improve the efficiency of processes in manufacturing enterprises on the example of the hydraulic industry. The set of principles, methods and tools presented in the article, used to assess the efficiency of production processes, contains only examples, because, in the literature on this subject, you can find many other, less frequently used instruments. The analysis carried out using the Five Whys tool on the basis of data from a manufacturing enterprise from the hydraulic industry, as well as the created summaries of reasons for both quantitative and qualitative complaints in 2016 and 2017 enabled the identification of the main source of the diagnosed problem in the form of too many corroded hydraulic components in 2017 and the formulating of necessary recommendations to eliminate the above mentioned disadvantages of finished products for the enterprise.

In the event of a problem that was identified in one of the companies in the hydraulic industry, the Company's Management Board decided to conduct a detailed analysis. For this purpose, indicator analysis was used, as well as the 5 WHY tool. This tool is very simple and uncomplicated to use, but it gives a full picture of the problem diagnosed. Due to the fact that the company's problem was found in one of the production halls, it was necessary for production employees to be involved in the process of eliminating irregularities, and thus to have knowledge of what tools and methods are used, as well as how to use them in practice. Therefore, it was selected and decided to use the potentially simple WHY 5 tool that allowed to deal with the identified problem.

It should be noted that the methods, tools and techniques for assessing the efficiency of the production process must be strongly focused on achieving both strategic and financial objectives that will significantly improve the enterprise's competitiveness on the market.

Acknowledgements

This paper was financed from the resources of the Silesian University of Technology, project no. BK-235/ROZ-1/2020 (13/010/BK_20/0042).

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