Six Sigma methodology as a road to intelligent maintenance

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Abstract
An enterprise which is managed in a modern way should be based on the concept of knowledge management. It is particularly important in the case of processes related to facility maintenance, where the efficiency and effectiveness of work is directly connected with the employees’ knowledge. Improvement of processes involved in facility maintenance has a real influence on the productivity of a manufacturing enterprise. High accessibility of technical equipment and its correct functioning influence not only production efficiency but also the quality of products and the safety of operators. The article is a description of an attempt to implement one of quality engineering methods for improving the facility maintenance process. The author decided to use the 8D method to shorten the duration of downtimes caused by breakdowns. Owing to the conducted analysis and the implementation of the improvement and preventive actions, we were able to shorten the duration of a downtime of a machine having a crucial importance for the company. Investigations and implementation were conducted in one of Silesian production plants.

Keywords
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1. Introduction

1.1. Facility maintenance

A proper operational policy should limit the probability of breakdowns. Despite minimizing the risk, it is impossible to guard against breakdowns of machinery park elements. A breakdown of a machine taking part in the production process can cause the impossibility to continue the production, decreased efficiency, that is delays in production, threat to the operating staff or danger to the natural environment, an increased risk of failure to meet the delivery deadlines or worsened quality of the products (PINTELON L., SRINIVAS K.P. 2006). A breakdown is a sudden and, most frequently, an unexpected phenomenon, so the process of breakdown removal is complex – it involves the necessity to act quickly and reorganize the production plans.

The duration of a downtime caused by a breakdown can be influenced by elements the duration of which depends on facility maintenance organization and management (administration delay, the time of waiting for the staff and spare parts), i.e. the so-called support capacity as well as on the duration of particular technical actions, e.g. diagnostics and repair, i.e. the easiness of maintenance (CARREL A. 2000). Maintenance easiness depends first of all on the qualifications, knowledge and competence of the employees, construction of the facility, its technical condition and location. The shortening of a downtime caused by a breakdown will therefore involve shortening the time of a passive and/or active breakdown removal process. Improving the facility maintenance process in this aspect is possible owing to the use of tools and methods applied in quality management.

1.2. The 8D method

Continuous improvement should be included in the strategy of every modern enterprise which wants to meet the requirements imposed by the demanding, competitive market.

Among an array of tools and methods used to improve production processes, one can distinguish the ones which help to identify problems, find the causes and sources of irregularities as well as the ones that support the process of developing and implementing the improvement and preventive actions. The first group includes popular tools, such as the Pareto chart (ABC), check sheet, Ishikawa diagram (4M, 5M, 6M), 5 Why (5W2H), the interrelationship diagram etc. (ISHIKAWA K., 1986, TAGUE N.R. 2005, MIDOR K. 2014, ANDRÁSSYOVÁ Z. ET AL. 2013, GAJDZIK B., SITKO J. 2016). Tools which support the undertaking of improvement and preventive actions include first of all: FMEA (PFMEA, CFMEA), 8 Disciplines (8D), Drill Deep and Wide (DDW) as well as DMAIC
The 8D method was applied to solve a problem related to an excessively long downtime caused by improper work of extruder head heaters. Incorrect functioning can be manifested in the lack of head heating or improper distribution of temperatures on its circumference.

1D – Working group
To solve the problem, a working group was established, consisting of facility maintenance manager and team leaders, production manager and a team leader of the pipe production department. The person approving the team’s activities (leader) was the technical director.

2D – Description of the problem
The analysed problem concerns the excessively long downtime caused by a breakdown described in the system as „incorrect temperature of extruder head“. This breakdown is reported by the extruder operator based on the observation of the appearance of the extruded pipe’s surface.

3D – Immediate action
In the case of this problem, immediate actions to solve the problem were temporarily given up. This part of the method is not applicable to the maintenance process improvement.

4D – Cause of the problem
The causes of the problem were identified by means of the modified 5M method. The basic elements of the diagram, i.e.: man, machine, material, method and management were replaced by elements which better characterized the process subjected to analysis, namely: availability of spare parts, machine operator’s mistake, flow of information between employees, availability of facility maintenance employees, availability of consumables, availability of tools necessary for breakdown removal, work of facility maintenance employees.

By means of so conducted analysis (Fig. 2) the two main causes of the problem were identified. The direct reason is a mistake made by the extruder operator, who in the process of head retooling (e.g. due to a change of the pipe diameter) connects the heaters’ plugs and the corresponding thermocouples’ plugs in a wrong way. As a result, the thermocouple measures temperature in another place than the heater it controls. This leads to incorrect distribution of temperature on the extruder head circumference. The direct cause is the behaviour of FM employees when diagnosing a breakdown. The employee called to remove a breakdown in the first place diagnoses damage to the head heating system elements: heaters, thermocouples, wires and connections. As the last step, having checked the functioning of all the devices, the FM employee analyses the correctness of connections.
5D – Determining the corrective actions

Improvement actions included developing a system of markings for the connections of heaters and thermocouples by means of labels resistant to dirt and damage, which has been presented in Fig. 3.

The solution effectively reduces the probability of making a mistake when connecting the head heaters and thermocouples to the control system and, at the same time, does not generate additional costs involved in its implementation.

6D – Prevention of another occurrence

The proposed improvement action the implementation of which would prevent the occurrence of the problem in the future was a checklist for the procedure of extruder head retooling, which is completed by the operator upon completion of extruder retooling. The checklist contains a list of all the elements in the extruder line (or their settings) that may change after retooling, which the operator should check before start-up. The checklist is presented in Fig. 4.

7D – Implementation of corrective and preventive actions

In this step of the 8D method actions aimed at preventing problems in the future have been proposed. The actions concern both the production and facility maintenance departments. For the extruder line it is updating of the extruder retooling procedures.

The update applies to the duty of completing the checklist after the line retooling and a description of the system of markings for head heaters’ connections. In the case of facility maintenance department, changes in the procedure of training new employees have been made. The essence of the change in the procedure was introducing the rule that a breakdown cause diagnosis should start with examining the most frequent potential causes. This change resulted in developing a sheet of the most frequent breakdowns and their causes, which is available to facility maintenance employees and updated once a month based on the data collected in CMMS system.
8D – Report on completion of actions

After developing and implementing all the corrective, improvement and preventive actions, the team prepared a report on the undertaken actions based on the 8D method in a form of the sheet presented in Fig. 5.

The form contains all the most important information on the team’s work. It describes the effects of implementing all the analysis stages.

After all the improvement and preventive actions were undertaken in a period of 6 months, one error in the connection of head heaters was recorded, the duration of two downtimes caused by improper temperature of the head heaters was 0.56 h. In the corresponding period preceding the actions, the average breakdown removal time was 0.98 h, and there were 5 downtimes.

3. Summary

Application of the 8D method allowed identifying the root causes of the problem subjected to analysis, which were as follows:

- errors in heaters’ connections,
- long diagnostics of breakdowns.

Improvement and preventive actions were formulated and implemented as follows:

- introduction of markings for the heater-thermocouple wires,
- implementation of a checklist in the head retooling procedure,
- changes in the breakdown diagnostics manual,
- changes in the employee training procedures.

An additional element influencing the removal of the remaining breakdowns was developing a base of knowledge about the most frequent breakdowns and the ways of their diagnosis. The base, in line with the concept of an intelligent enterprise, is regularly updated and extended, which is an important contribution to the element of learning and exchange of information between employees.

Application of the 8D method for improving the process of breakdown removal allowed obtaining tangible benefits, such as shortening the duration of downtimes, a reduced number of mistakes made by operators and a streamlined system of breakdown diagnosis.

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References

1. ANDRÁSSYOVÁ Z., ŽARNOVSKÝ J., ÁLLO Š., HRUBEC J. 2013. Seven new quality management tools. Advanced Materials Research. Vol. 801.
2. CARREL A. 2000. Design for Reliability, Maintainability and Supportability. In: Reliability, Maintenance and Logistic Support – A Life Cycle Approach. Dinesh K. U., Crocker J., Knezevic J., El–Haram M. (eds.). Springer Science+Business Media.
3. DOBROSZ K., MATYSIAK A. 1994. Tworzywa sztuczne. Materiałoznawstwo i przetwórstwo. WSiP.
4. GAIDZIK B., SITKO J. 2016. Steel mill products analysis using qualities methods. Metalurgija. Vol. 55, issue 4, pp. 807-810.
5. ISHIKAWA K. 1986. Guide to Quality Control. Asian Productivity Organization.
6. JAGUSIAK-KOCK M. 2017. PDCA cycle as a part of continuous improvement in the production company - a case study. Production Engineering Archives. No 14, pp. 19-22.
7. KRAJNC M. 2012. With 8D method to excellent quality. Journal of Universal Excellence. No. 3, pp. 118–129.
8. MIDOR K. 2014. An analysis of the causes of product defects using quality management tools. Management Systems in Production Engineering. No. 4.
9. PALUCHA K. 2012. World Class Manufacturing model in production management. International Scientific Journal. Vol. 58, issue 2, pp. 227-234.
10. PINTELON L., SRINIVAS K. P. 2006, Evaluating the Effectiveness of Maintenance Strategies. Journal of Quality in Maintenance. Vol. 12, no. 1, pp. 7-20.
11. SOKOVIC M., PAVLETIC D., KERN PIPAN K. 2010. Quality Improvement Methodologies – PDCA Cycle, RADAIR Matrix, DMAIC and DFSS. Journal of Achievements in Materials and Manufacturing Engineering. Vol 43, issue 1, pp. 476-483.
12. TAGUE N. R. 2005. The Quality Toolbox. ASQ Quality Press.
13. WOŁNIAK R., SKOTNICKA–ZASADZIEŃ B. 2011. Metody i narzędzia zarządzania jakością. Teoria i praktyka. Wydawnictwo Politechniki Śląskiej.