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IMPROVEMENT OF MAINTENANCE PROCESS IN A COAL MINE – CASE STUDY

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Purpose: identification of possibilities of using quality management methods and tools to improve maintenance processes.
Design/methodology/approach: the tools used were adjusted to the results of cognitive interview and maturity analysis of maintenance process carried out among representatives of various levels of the organization's management, based on an original tool.
Findings: it was found that the level of maturity of the process is in the chaotic phase, despite the fact that the company implemented integrated management systems, quality management methods and tools are not systematically used in the process; it seems, however, the needs in this area are very large.
Research limitations/implications: the study was conducted on the basis of only one process, in one workplace; only on the basis of own observations it can be concluded that other processes in this plant, as well as similar ones, will show similar deficiencies, which should, however, be subjected to a deeper analysis.
Practical implications: it can be assumed that the research results presented in this paper, as well as the proposed practical solutions, may support not only the process under study, but also completely different processes; the study seems to indicate the need of educating the managers in the field of practical skills for improving the processes in the organizations.
Originality/value: the study proposes the use of an original tool for measuring process maturity as an entrance to further steps, it also presents the possibility of using tools, the process of their implementation in an actual process, as well as barriers encountered.

Keywords: process maturity, methods and tools of quality management, process improvement, maintenance.

Category of the paper: research paper, case study.

1. Introduction

It would not be very exploratory to say that the maintenance processes (MP) in large companies are one of the most crucial elements influencing their effectiveness. It seems, however, that there is still an insufficient support for these processes, an understanding of their actual meaning, as well as provision of adequate resources, including knowledge, competences and skills to those managing the maintenance processes. For several years, there have been numerous studies that point out that production plants currently devote a lot of attention to their MP (Zasadzień, 2016; Jasiulewicz-Kaczmarek, 2013; Gajdzik, 2010). However, one should consider what is the attention most often really paid to – investing in the process or looking for the guilty party – if the production does not go according to the plan. Hard coal mines are specific workplaces, according to the author, in many cases with an organizational culture remaining in the previous system and reactive to market needs. However, they provide great potential for the implementation of the quality management tools, because, despite of the implementation of the integrated management systems, the level of using the tools is low, and usually comes down to breaking open doors by process managers. The generation gap causes the mines to suffer from a lack of knowledge and competences among employees, plants collect more and more data that needs to be processed, and the turmoil around the environmental and economic aspects of coal mining makes many people's eyes turn to the mines. Therefore, it seems even more vital to take care for the maturity of the processes, which is manifested, generally speaking, in the degree of "control" (the scope in which the processes are defined, managed, flexible, measured and effective) over the processes taking place in the company (Grajewski, 2007), should be the center of the attention of the coal mining companies. Can a maintenance process maturity assessment help to plan effective and efficient methods and tools for process improvement? Based on the author's previous experience with the study of the maturity of the organization, it could be assumed that it would be an effective tool and, consequently, would allow to diagnose the strengths and weaknesses of the company, as well as to propose tools that could be used, both for organizational and substantive reasons. Therefore, the study was undertaken. Since it was conducted in the idiographic trend on the basis of one case, the formulation of the above research problems seemed to be sufficient to achieve the assumed goal.

2. Methods

The study was divided into two part – introductory – a cognitive interview with the owner of the process, and a main part. The participants in the main part of the study were 53 managers from 4 levels of maintenance management in the mine being under study (level 4 – marked as the lowest level, while level 1 as the highest and represented by one person – the owner of the maintenance process in the examined plant). The most numerous group were level 3 managers ($\Sigma = 32$), then level 2 managers ($\Sigma = 14$) and level 4 managers ($\Sigma = 6$). Due to the specificity of the mining industry, no women took part in the study.

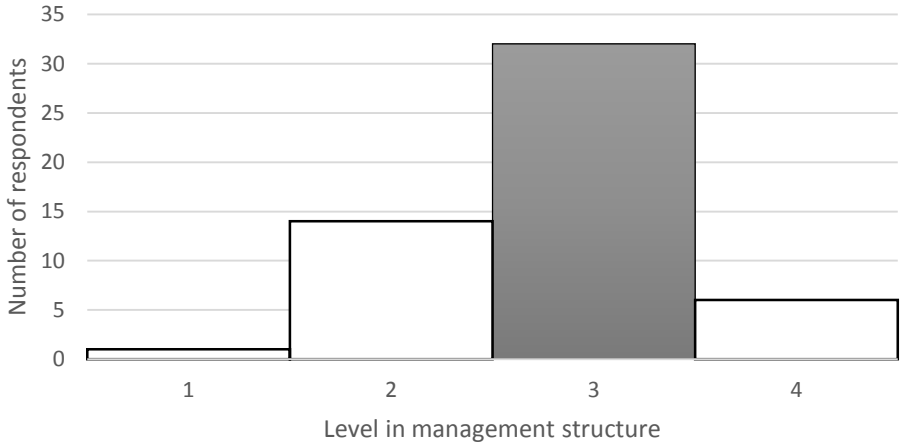

Figure 1. The number of respondents depending on the level of process management.

The researcher was interested in the level of maturity of the maintenance process, according to the managers at various levels. This was to identify strengths and weaknesses in order to propose methods and tools for improving quality management in the examined process.

The study used the proprietary process maturity measurement questionnaire, which consisted of 49 statements divided into 7 areas – customer orientation, leadership, people involvement, process approach, improvement, decision making based on facts and relationship management. The Likert scale in the 5-point variant was used as the answer model, according to the pattern below:

1 – I strongly disagree/the statement is completely inaccurate (M-1);

2 – I disagree/the statement is rather inaccurate (M-2);

3 – I partially agree/the statement is half correct (M-3);

4 – I agree/the statement is rather accurate (M-4);

5 – I strongly agree/the statement is completely accurate (M-5).

The lower the examined person assessed a given statement, the lower the grade on the scale was marked.

Table 1.
Maturity level scale

Level	Description
M-1	**For each principle, definitely no or not true (0-19% compliance).** There is no objective evidence for the implementation of the measures. Lack of systematic action in the field of: 1) customer focus of the MP 2) enterprise leadership focused on managing the MP 3) involving people in the implementation of the MP 4) processes implemented to ensure the appropriate level of achieved results 5) ways to improve the MP 6) making decisions about the MP on the basis of facts 7) managing relations with parties interested in the MP
M-2	**For each principle, no or false for most activities (20-39% compliance).** There is little objective evidence for the implementation of the measures No systematic action in the above-mentioned range
M-3	**For each of the principles, no or false for some activities (40-59% of requirements fulfillment).** There is objective evidence that the measures have been implemented Systematic operation of selected activities, mainly related to profits
M-4	**For each principle, yes or true for most activities (60-79% compliance).** There is objective evidence that measures have been implemented for almost every activity Systematic operation in most activities related to the maintenance process
M-5	**For each principle, definitely yes or true for most or all of the activities (80-100% compliance).** There is objective evidence that measures have been implemented for all activities Systematic action in all activities related to MP

As a similar tool was previously used, but to study food safety management processes, this time the questionnaire was not tested. It was only consulted with a person familiar with the maintenance process, in order to eliminate such errors as inadequate language of the tool, incorrect knowledge assumption, suggestive statements, blurred concepts, etc.

Cronbach's Alpha was used to assess the reliability of the questionnaire, or the repeatability of the study, for example a situation in which the research carried out with the same tool gives the same result each time. Cronbach's alpha for the total of 49 test items included in the questionnaire was 0.893[1], which means that the questions in the maturity measuring tool are internally correlated – they measure the same construct.

Due to the specifics of the sample – a large group of people working on various shifts and the choice of the questionnaire as a research tool, it was decided to use the CAWI technique. Sending the research tool was always preceded by a telephone or personal conversation with the examined person about the possibility of carrying out the research. This part was carried out by the owner of the maintenance process in the surveyed company. Diagnostic questionnaires were sent to the e-mail address provided by the examined person. The respondents filled in the spreadsheet on their own computer and sent it back via the "send" option. The main introduction of the participants of the study was the cover letter attached to the tool, which included the following content:

[1] On a scale from 0 to 1, the closer to 1, the higher the consistency of the test items.

1) information about the person conducting the examination and the person supervising it;
2) the purpose of the study;
3) information about anonymity and voluntariness;
4) instruction.

The study was conducted in January 2020. The subjects had 7 days to complete the questionnaire. The adoption of such a time frame gave the opportunity to receive fully valuable questionnaires, and on the other hand, significantly accelerated the obtaining of results, which was important for the process owner. Adopting a longer period could cause the respondents to lose their motivation to complete the questionnaire or, for example, forget to complete it. Additionally, to prevent the above, 5 days after receiving the questionnaire, a reminder e-mail was sent. All of the people who declared participation in the study completed the questionnaire. It should be noted that completing the sheet was voluntary. Although the survey was anonymous for the person conducting the survey, due to the need to monitor the filling of the sheets, the e-mails were collected, but they were only used by the process owner to verify which of the people declaring participation had completed the sheet – both the researcher and the process owner did not compare the content of the questionnaires with those who filled it in.

The purposeful selection of the population itself was dictated by the specifics of the study and the entire project. The study was not a sample of the population of the managers of various levels of the analyzed process, but all of them, it was to enable the identification of special variables influencing the maintenance process, which would be invisible in the study on the sample. The applied research technique, however, has certain drawbacks, which include, first of all, the inability to control whether the person completing the questionnaire devotes himself to it. A control question was used in the study to minimize this problem. Due to the advantages of the technique, taking into account the specificity of the study, for example, the relative ease of reaching all respondents and the relative speed of the study, such a solution was considered the best for this type of project.

Quite complex questionnaires (as in this case) may cause an excessive burden on the respondent. This may lead to the inconsistency with the facts or to the so-called satisficing, that is, giving an answer that is "a satisfactory choice", therefore good enough for the respondent, but not necessarily consistent with the actual state. A preventive measure introduced for this threat was to conduct a cognitive interview with the owner of the maintenance process and to observe the process.

3. Results

3.1. Introductory information from the study

As mentioned, the study was conducted in stages, its general outline is presented in the study scheme presented in Figure 2. As also mentioned above, in order to avoid problems with the reliability of the study, in the first phase, an cognitive interview was conducted with the owner of the maintenance process, aimed at drawing attention to the areas in need of improvement. During the interview, the process was also confronted with the model of Crespo Márquez et al. (2009), presented at Figure 4, and areas for improvement were indicated. Then, a study was conducted using the MP process maturity assessment questionnaire, which technical details were described above. On the basis of the study, an analysis and evaluation were made, and conclusions were drawn regarding the maturity of the described process. An action plan was developed and a risk analysis for the planned activities was carried out, which was not included in this study due to its wide scope, making it impossible to be fully and clearly described here.

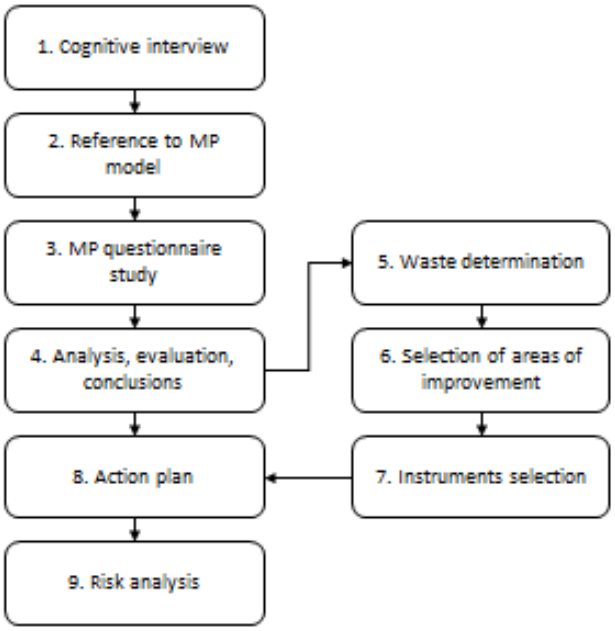

Figure 2. A simplified diagram of the tests performed at the XYZ coal mine.

For the sake of clarity of this description, the tools will be presented in relation to the identified area of improvement, and not collectively in the tool selection point, therefore regardless of whether the need to implement the tool resulted from the introductory part, the main part of the study, or both.

The cognitive interview[2] with the process owner provided, among others, information on difficulties in carrying out tasks resulting from insufficient employee competences or the need to spend time solving problems that should be dealt with by employees of lower levels or other departments. One of the basic themes that emerged from the analysis was also the waste of time in the process. In order to identify the actual duration of activities carried out in practice, it was proposed to implement the Productivity Calculator at the workplace of the owner of the maintenance process (Figure 3). Several main categories were taken into account (apart from those shown in Figure 3, additionally – planned activities and waste[3]) and to each of them subcategories identified by the process owner were assigned. Twelve units of measurement (twelve hours) were planned. Within each of them, time was entered in minutes for a given category of activity.

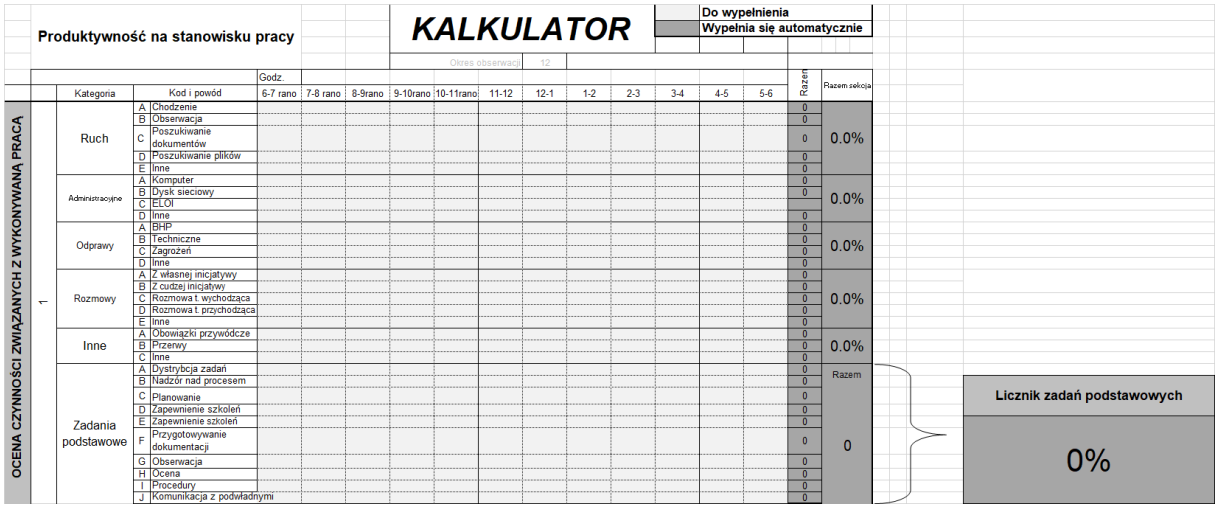

Figure 3. Part of the Workplace Productivity Calculator.

Data was collected for one month and the results were averaged. The measurement showed that the average time devoted to basic tasks was 23.8 pct. of working time, which was the highest value, followed by administrative activities with an average rate of 19.1 pct., the least, because only 1.0 pct. Spent on "other". Waste, on the other hand, was determined at the level of 8.3 pct. and the most important turned out to be the (unused) skills. After the analysis, the scopes of work activities of some employees were changed, which partially solved the problem, another tool for improvement in this area were the competence matrices described below. Interestingly, after the direct supervisor of the process owner returned to work, the waste increased to 20.4 pct. and the highest rate was related to overprocessing. On an hourly basis, it turns out that waste takes one day a month. In similar studies (Zasadzień, 2016), which also measured working time, but of maintenance workers with an unknown position and in a slightly

[2] The interview was conducted using the paradigm proposed by Saldaña (2009). Information obtained from the process owner was encoded using three types of codes: descriptive, analytical and in vivo.

[3] 11 categories of waste were referred to: transportation, inventory, motion, waiting, overprocessing, overproduction, defects, skills, inappropriate use of a computer/telephone, lack of employee involvement, inappropriate indicators.

more general way, it was calculated that ineffective working time is on average 14.6 pct., which would be the average time after adding the before and after the return of the superior of the process owner. An oral request was made to shorten the wasteful activities and to carry some of them out electronically. Unfortunately, even despite documenting the losses in the process, it was not possible to convince the supervisor to change the form of carrying out some of the non-value adding activities (NVA).

As mentioned above, during the interview with the process owner, the studied area was confronted with the maintenance model of Crespo Márquez et al. (2009) (Figure 4). The model consists of eight phases, first three of which relate to the effectiveness of the implemented process, the next two to its efficiency, phases six and seven relate to the evaluation of the maintenance process, and the last phase – to continuous improvement of the process.

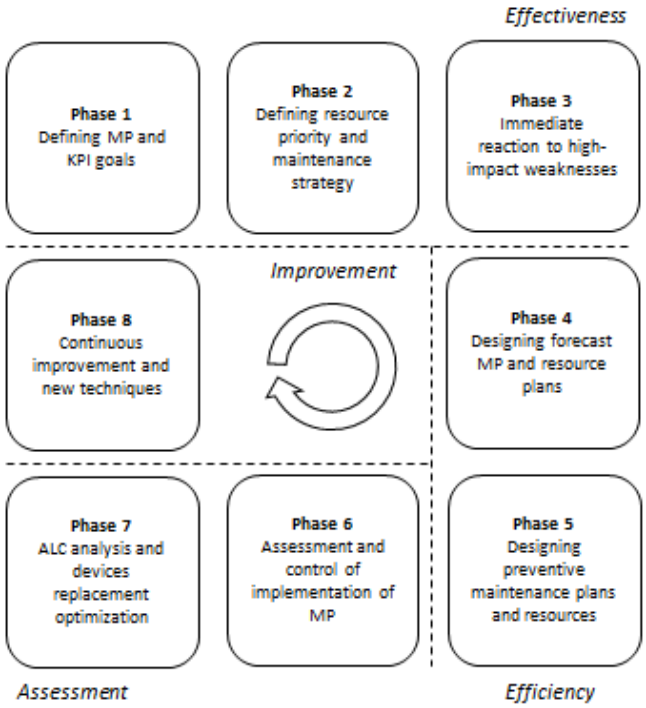

Figure 4. MP model. Adapted from Crespo Márquez et al., 2009.

As it turned out, the examined process does not meet the requirements of the first phase, because at the planning stage, neither the process goals nor the key performance indicators (KPI)[4] were defined. According to the words of the process owner, its management comes down to extinguishing fires, so it has a reactive dimension, which at the beginning could indicate the low maturity of the examined process. A critical to quality (CTQ) tree, related to the Voice of client (VoC) analysis and the Out of Control Action Plan (OPAC) were used as a process support tool in this area – both shown in Figures 5 and 6.

[4] Assuming, as defined in ISO 9000: 2015, that there is no efficiency without effectiveness, then at this stage the comparison of the as is process with the model can be completed.

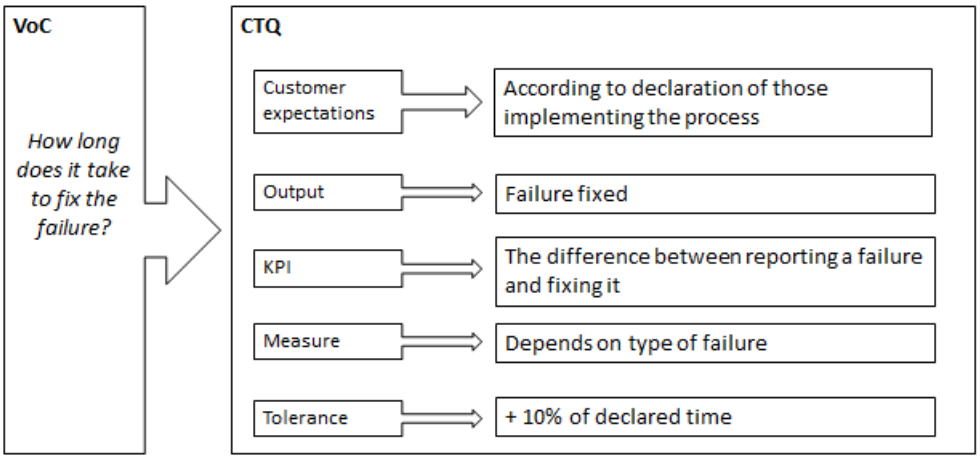

Figure 5. VoC-CTQ analysis example.

Since the organization does not carry out any proactive activities related to the assessment of customer needs, such as, for example, discussion groups, the "customer voice" was determined on the basis of the most frequently reported oral complaints related to the duration of failure removal, etc. In order to alleviate customer concerns, the focus was primarily on the efficient diagnosis of failures, as well as corrective actions. For this purpose, the OPAC and the Non-conformity Card were implemented (Figure 7).

Process step	Measures (input/output)	Value	Measurement method	Control method	Person responsible	Reaction
Receiving failure report	Output Completeness of information	100%	Complete answer to checklist questions	checklist	Shift supervisor	1. Train the person receiving the information on the data necessary to implement the actions 2. Record in data sheet
Organization of necessary resources	Output • resource organization time • resource completeness	≤15 min. 100%	Time measurement from end of conversation - application for sending a brigade	check sheet	Shift supervisor	Create a decision tree
Failure fixing	Input • actual completeness of resources • actual completeness of information Output • failure procedure time	100% 100% within limits	output/input measuring time of notification to confirmed fixing	Failure card Shutdown sheet	Shift supervisor Person of higher supervision	

Figure 6. An example of an implemented action plan.

The action plan refers to defining actions in the event of an acceptable state being exceeded – "what will we do if ...". It allows to effectively deal with deviations and ensure stability when the conditions change. It also gives a chance to detect impending problems before they become them (Eckes, 2016). In the analyzed organization, high-risk decisions are most often taken, in the case of the analyzed process it is largely associated with financial losses. The cost of the downtime, depending on the technological line, per hour is tens of thousands of zlotys, so it is important to minimize the downtime. In the action plans, a team of higher supervisors built a flow diagram, referred to the indicator and its desired value, the method of measurement and control was determined, and a person responsible for a given step in the process was assigned. The necessary actions were also designed to respond to the threat of failure to complete a given step in the process at the assumed level.

It is important to take into account not only the effects of problems, but also their causes. Even the best-planned activities related to a potential threat that may occur in the process are subject to error, for example due to the residual risk. Only determining the causes and corrective actions gives a chance to eliminate nonconformities in the future. A major problem in the analysed company was the lack of a formalized system for collecting information on non-compliances and their causes, therefore a Non-conformity Card was introduced, containing information on the situation, its causes, remedial and corrective actions. The Non-conformity Card is presented below (Figure 7) – due to the legibility of the record, the handwritten notes were transferred to the computer version and translated into English.

KARTA AWARII

Miejsce awarii	Data awarii	Czas awarii	Dozór	Elektryk	Nadsztygar
Longwall 106	01.02.2020	4.55-5.30	IK	BM	SK
Opis awarii (krótka i prawdziwa informacja)					
At 4.55 am an electrician was called because the combine was not working. The electrician ordered a mechanic with whom they checked if there was a water flow					
Przyczyna awarii (np.: woda w urządzeniu, mechaniczne uszkodzenie, źle zabezpieczone przewody, niewłaściwe użytkowanie, itp.)					
No water flow on the right side					
Sposób usunięcia awarii oraz problemy napotkane podczas jej usuwania (np.: brak rezerwowej części, brak doświadczenie elektromontera, itp.)					
The outflow was checked. Flow sensor defective					
Środki jakie należy podjąć w celu uniknięcia lub skrócenia czasu trwania awarii.					
Crew training. Providing a better quality medium. Accomplishing maintenance and cleaning of filters					
Uwagi dozoru wyższego - zawierające analizę przyczyn i działania korygujące					
No comments until the failure was removed					
			Podpis sztygara		Podpis nadsztygara
			.....		.....

Figure 7. Completed Non-conformity card.

The card is filled in by a supervisory person and verified by a higher supervisory body. As can be seen in Figure 7, the card was not filled in fully in accordance with the requirements, e.g. corrective actions should refer to a deeper analysis (e.g. with a 5-why), carried out in search of the root cause, which, however, was not identified on the card. As it seems, the card also lacks information on the verification of non-compliance after time, and the supervisory remarks contain information on the analysis of causes and corrective actions, which, in principle, to a limited extent, were already described above. The records are also imprecise, there are no dates, employees being responsible, but it was the first tool built on the basis of verbal information on what should be included in the card and since then the card has been modified and enriched with the required information and analyses, which are also introduced into the presented below maintenance process management worksheet (Figure 10).

On the basis of the Non-conformity Card, it is planned to perform an assessment of the root cause analysis. A three-phase analysis will be used for this purpose.

1. Generating ideas:
   a. method 635,
   b. Ishikawa diagram.
2. Narrowing down the ideas:
   a. prioritizing causes,
   b. Pareto-Lorenz analysis.
3. Selection:
   a. 5-why,
   b. regression analysis.

As these are completely new tools for the process participants and require training, despite their importance in the improvement process, the root cause analysis was not planned to be implemented in the first place. The team is training in its implementation.

3.2. Results of maturity study of maintenance process

On the basis of the conducted research, areas requiring improvement were identified by the maturity assessment questionnaire. The assessment of the maturity of each of the seven surveyed areas was based on the weakest point. Figure 8 shows the average score of all respondents with the lowest grade they awarded. This is important because when conducting research on such a large research group, it should be determined whether the lowest grade is adequate to the actual level of the process or results, for example, from specific personality traits of the researched person (e.g. excessively critical, malcontents, etc.), which may possibly be verified by the number of specific, for example lowest, indications of a specific person and compared with the average indications. Of course, low grades may also be the result of the assessor's greater knowledge of specific issues, experience, comparisons with other departments, if known, etc.

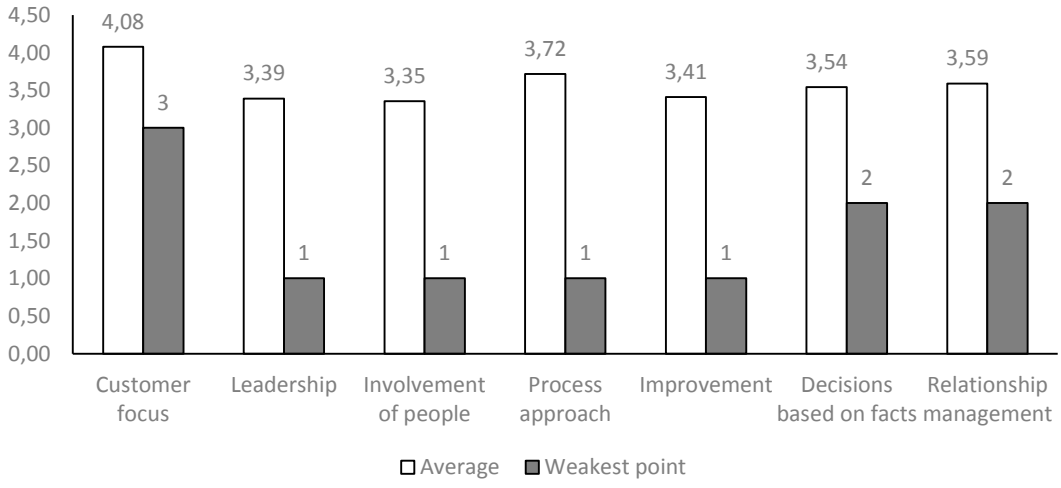

Figure 8. Results of the maintenance process maturity assessment.

Due to the fact that already in the first phase of the study – during an interview with the process owner – numerous areas for improvement were identified, it was decided that the implementation of the instruments would be justified in each of the areas. In the course of the improvement project, which is still pending, the focus was primarily on the areas with the lowest scores. When selecting the tools to be implemented, the so-called low-hanging fruit strategy was used, so such instruments were selected that would quickly show the effects of their implementation, and would also serve a large group of people. This was primarily to encourage the use of tools, which paradoxically, in the case of a process in which tools are not practically used, does not have to be easy at all, because it requires additional effort and overcoming the typical reluctance to change in the organization. In line with Adamiecki's counteracting principle, it was decided to implement the tools successively on the basis of the improvement plan (Table 2).

Table 2.
Example of areas and tools within the improvement plan

Improvement area	**Instrument**	**Implemented Y/N**
Customer focus		
I plan, design, develop, deliver maintenance processes and support production to meet customer requirements	CTQ, VoC	Y
Leadership		
TM creates and maintains common values, fairness and an ethical model of behavior at all levels of the organization	Organizational culture analysis – assessment using a modified organizational culture maturity assessment form	N
Involvement of people		
In my organization, employee satisfaction is assessed, the results are presented and appropriate action is taken	Semi-annual employee satisfaction assessment	N
Process approach		
The MP we carry out is well described (there are documents, we know what, when and how to do it, we have resources for it) and thanks to this we can achieve the main goal	Flow charts	Y
Improvement		
It is ensured that people are competent to support and implement improvement projects	Competency matrix	Y
Decisions based on facts		
KPIs are identified, measured and monitored as part of the MP (not just limited to achieving the output level)	MP management worksheet, Kanban board OEE indicator	Y N
Relationship management		
Performance is measured and the information derived from it is shared with relevant stakeholders (e.g. suppliers, partners, customers, employees, etc.) to support improvement	Presentation of indicators on the visual management board, e-mails to participants of other processes with current information on the effectiveness of the process	N

Due to the need for a transparent presentation of the issues, only a part of the improvement plan and examples of the instruments proposed as part of the improvement of individual areas were presented. For the same reason, only some of the implemented process improvement instruments[5] were presented below.

Another implemented tool was the competency matrix. It was a response to repeatedly communicated problems with the lack of appropriate competencies among employees, also identified as part of the maturity assessment of the "Improvement" area and having a large impact on other areas. The competency matrix is a tool for mapping the required and desired competencies[6] of a team. It is a grid that visualizes the required and available competencies in the team (Figure 9). First of all, it helps to assess the required competences. Secondly, the competency matrix provides insight into the competences available in the team and indicates the strengths and weaknesses of team members, which in turn gives an opportunity to use the strengths and eliminate weaknesses. In order to successfully implement the matrix, a team consisting of supervisory staff had to review the hard and soft competencies required to successfully complete the work.

MATRYCA KOMPETEN

ODDZIAŁ MEUD-1/2/3 Data: Kwiecień 2020		OPERACJA/PROCES/ UMIEJĘTNOŚĆ	Upowaznienia i uprawnienia do 1kV		Upowaznienia i uprawnienia do 1 kV i powyżej		Wykonywanie muf kablowych oraz naprawa przewodów 6 kV / 3,3 kV	Pomiary natężenia prądów błądzących	Pomiary natężenia oświetlenia	Pomiary SUPO	
Lp	PRACOWNIK		roboty przygotowawcze-ścianowe	Roboty pozaprzodkowe ścianowe	roboty przygotowawcze ścianowe	Roboty pozaprzodkowe ścianowe					RSK 6
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											

SKALA	OCENA	OPIS
	0	brak wiedzy/umiejętnosci/uprawnien
	1	uczy się
	2	pracuje ze specjalistą/ekspertem
	3	specjalista - pracuje samodzielnie
	4	ekspert/szkoli innych

+ DOZÓR	umiejętnośc rozwiazywania problemów
	praca pord presją
	zarządzanie zespolem

Figure 9. Competency matrix.

[5] Broadly understood as tools, methods and techniques that can be used to improve a process.

[6] There are hard and soft competencies. The hard ones include, above all, industry knowledge or the use of specialized computer programs. As part of soft competences, there are personality traits and social skills, such as: conscientiousness, leadership skills, the ability to work under time pressure, teamwork, communication skills, etc.

The competency matrix helps to increase the performance in many ways. This is beneficial not only for the team, but also for the individual, company and internal and external clients, so it also supports the areas of "Customer focus" or "Relationship management". Thanks to the competency matrix, the team obtained a quick overview of both the competences that are present and those that are missing. The missing ones can of course be found by employing people with appropriate competences, but in reality of the surveyed company it is extremely difficult. Therefore, a mentoring system was introduced that allows other employees to train and support people with missing competences. Another important factor is the effective internal training system at the disposal of the organization, as well as the training system with the help of external companies cooperating with the surveyed company. Thanks to the matrix, the team is more aware of its weaknesses and can be especially careful so that the missing competences do not affect the performance. The competency matrix also gave employees individual insight into their own competencies and what they bring to work and what they lack. The process was strengthened by obtaining an overview of available competences and areas for improvement. These are areas where the process can invest its research and development budget in order to function better. In addition, competency matrices can help redistribute internal talent to where it is most needed. Not only is it said that employees lack competences, but you can see exactly which ones and what can be done about it. Customers also benefit from the implementation of the proposed tool, because they have a chance to receive a higher-quality process and it does not matter whether they are internal or external customers.

Fact-based decision making is a systematic process that emphasizes collecting the right data, ensuring its quality, conducting non-judgmental analyzes to isolate insights, jointly weighing up the pros and cons of possible decisions, and selecting business decisions that are supported by analysis results instead of guesswork or just following ones hunch. In the process under study, as in the entire enterprise, many decisions were made in this informal way. In this area, the implementation of the instruments was relatively easy due to the high involvement of the process owner. The first tool that was ever created as part of the implementation of improvement instruments was the maintenance process management worsheet (Figure 10).

The worksheet is constantly being expanded with new and more advanced functions and for the process owner it is the basic instrument for making many decisions, not only regarding the proper workload, but also bonuses or settlements for tasks performed by directly subordinate employees. The tool contains information necessary for the objective management of subordinate employees, including the orders issued and the level of their implementation, along with employee comments. It contains information on absenteeism, training and supervision assessment which translates into the level of bonuses granted. The spreadsheet is an exact answer to the needs of the process owner, and its cost is low as it was created internally using a popular spreadsheet.

Figure 10. Menu of the MP management worksheet.

Another implemented instrument supporting decision-making based on facts was the Kanban board. This visual management tool is designed to help to visualize ones work, reduce work in progress and maximize efficiency. A simple three-column Kanban board was proposed, consisting of cards whose colors refer to individual employees directly reporting to the process owner and are pasted by them as the tasks and columns progress – "tasks", "in progress", "completed" (Figure 11). Since the employees of higher supervision perform many different activities, the part of them that relates directly to process improvement is included on the board. Kanban can be adapted to many environments, and the type of Kanban often determines whether the board is physical or digital. In this case, for easy tracking the progress of work by all participants of the improvement process and due to the importance of this process, the board was hung in the process owner's office in a place visible to all interested parties. One of the other advantages of a physical board is that it is "always on", easy to set up, easy to show to others, and is often a better way to communicate with specific teams. Additionally, any person entering the process owner's office may realize that there is also improvement as part of the process tasks, which may encourage other people to make a similar effort. Very often, process managers in mining enterprises have extensive knowledge of the practical side of task implementation, but little knowledge in terms of the extensive process management instruments.

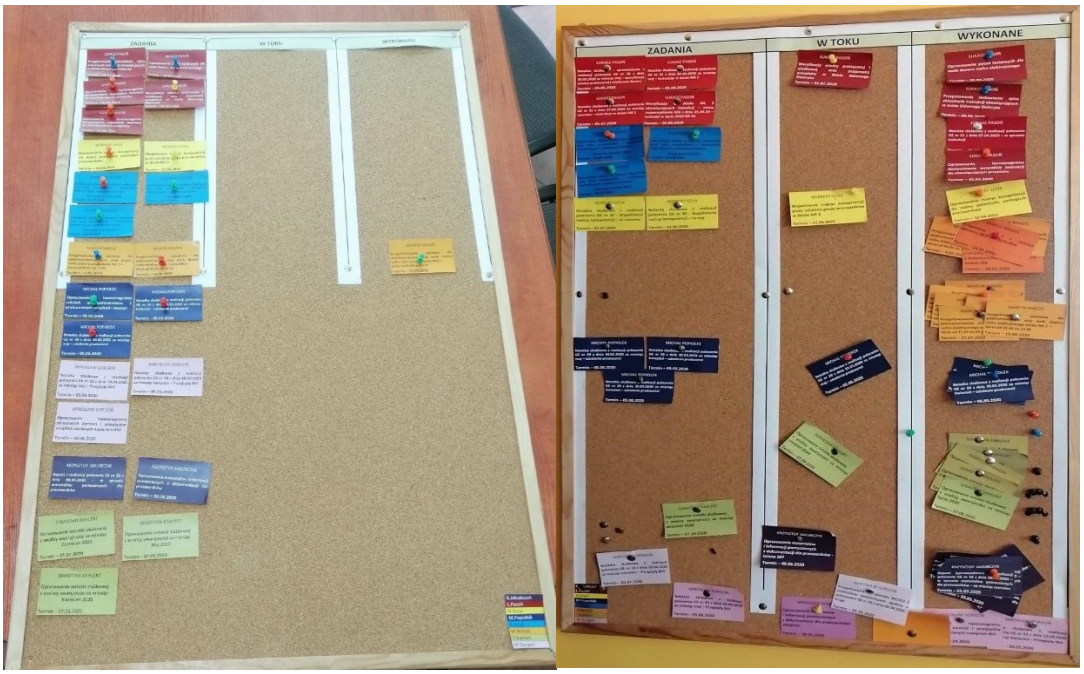

Figure 11. Kanban board while assigning tasks and carrying them out.

As Figure 11 shows, the board perfectly visualizes the workflow and tasks, and provides an overview of the workload. It is also a good tool for visualizing potential problems in the process. It is easy to see which and whose tasks are coming faster than they are leaving, work begins to pile up and the problem becomes visible to the entire team. This could be due to a temporary problem or a bottleneck in the process. Recognition of the problem and implementation of adequate measures gives a chance for the success of the entire maintenance process improvement project.

4. Discussion

The maturity level of the examined process was rated at 3.58 on average, which, according to the adopted criteria, should be classified as maturity level 3. This is consistent with other studies carried out in similar enterprises, although with different instruments (Łukasiński, 2016; Brzychczy, Kostka, 2018). However, when referring to the assessment according to the weakest point, the examined processes should be assessed at the first level of process maturity. As it seems, the discrepancy quite often results from the general nature of the research performed using the average, also the most frequently used five-point scale seems to be too general. Quite often, the assessment of maturity is carried out by individual people dealing with management systems in the organization and assessing the process or organization from their own perspective, therefore there is no objectivity, as evidenced by the own research quoted below. Nevertheless, it is of key importance to ensure data integrity through accurate and appropriate analysis of the data obtained. Inappropriate analysis, whether statistical or not,

distorts scientific findings, misleads the reader and may negatively affect the public perception of research at all (Shepard 2002).

It seems that the implementation of improvement instruments in a mining company is not only possible, but even necessary. This is related, among others, to the large and constantly growing amount of data that should be analyzed and assessed in mining companies. Not without significance is the lack of these instruments, often resulting from the unacquaintance of the instruments, despite the fact that most, if not all, mining companies have integrated management systems, including a quality management system that requires the use of various types of improvement instruments. Especially the latter confirms that without equipping the people managing individual processes, as well as the entire system, with knowledge about modern concepts of process management or, more broadly, of a company, which in some industries or even sectors are mostly Lean Management and Lean Manufacturing, it will not be possible to improve processes.

However, the requirement for introducing changes is taking into account Adamiecki's counteracting principles. Other authors also point to the possibility and necessity of implementing improvement tools, as well as the need for their gradual and rational implementation in mining companies (Jasiński, Jasińska, Janik, 2017; Migza, Bogacz, 2015; Rozmus, 2011). The aforementioned Adamiecki's principle says that the system to which changes are made will tend to return to its original state. This is related to the emotional block in the face of changes, which the members of a company build within themselves in fear that the upcoming change will somehow worsen their current situation (Centkowska, 2015; Eckes, 2016). It is still visible in the surveyed company.

The implemented project indicates a large area to be developed for people dealing with both the theory and practice of process improvement in the mining sector, especially in relation to hard coal mines. It is also related to the organizational culture of these enterprises. As it seems, it remained in the realities of the previous economic system and therefore blocks many improvement activities, which is also supported by the atmosphere around the industry itself, as well as the current market situation, which is definitely not conducive to changes and forces the adoption of rather directive attitudes towards management (Rakowska, 2011; Huczek, 2015). An interesting issue for further research would be the analysis of the organizational culture of mining companies and its impact on the possibility of implementing modern management methods, techniques and tools.

When implementing improvement tools, it is also important to select them in such a way to adequately match them to the examined process, including the competences or personalities of the employees who would use them. As the instrumentation is very rich, it is rarely possible to implement it without cooperation with a person with extensive knowledge of methods, techniques and tools for improvement. During the implementation of the project, it took a lot of time to present the instruments, which also entailed the need for the owner of the process and the supervisors to reach for the literature on the subject. The selected instruments resulted from

the real needs of people involved in the improvement, which may be of great importance for the sustainability of the improvement project. The research stage – "as is" – and the selection of the appropriate assessment tool are also important. In the case of the implemented project, a proprietary tool was used, which also requires knowledge in the field of tool construction and their evaluation. Even if process managers use ready-made questionnaires, they must have knowledge about their existence, which could be derived from people dealing with management systems in the company, but, as already mentioned, they are rarely actually useful in this area. Own research carried out among 60 employees of various plants with implemented management systems, mainly (66.7 pct.) the quality management system according to ISO 9001, showed that all respondents expect people who carry out tasks within this process to have a more practical approach to the system. Cooperation in the field of quality improvement is expected by 83.3 pct. and 50 pct. of the respondents would like less checking and more improvement, help in the application of tools and introduction of tools based on the needs identified, e.g. during audits. At the same time, one third of the respondents also stated that people who implement and maintain processes related to management systems do not contribute to the organization. Taking into account the already mentioned fact that there is an integrated management system in the examined company, it can be concluded that the ones in charge of it could be described in a similar way, and the process implemented by them could be described as ineffective. It seems interesting to investigate the reasons for such a situation and the possibilities of changing it. Does it result from the lack of proper preparation of people dealing with management systems in the company, a lack of understanding of the ideas of these systems or treating them as a necessary evil related to the image, and not a source of improvement?

As it seems, this study confirms that the assessment of the maturity of the maintenance process can help in planning effective and efficient methods and tools for improving this process, because it was possible to diagnose the strengths, weaknesses of the company, and to propose applicable and content-related instruments.

5. Summary

Maturity assessment studies are useful as an input to the improvement process. While maturity models and related assessment methods do not directly address business outcomes and benefits, it is possible to move from one maturity level to the next without having to demonstrate progress. However, they allow to identify the strengths and weaknesses of the company and plan appropriate actions. However, these types of projects are time-consuming, require extensive knowledge in the field of improvement, and the implementation of a management system does not guarantee that the company will use improvement instruments

on a large scale. A great problem is the employees' resistance to changes, unfamiliarity with improvement instruments or organizational culture that inhibits improvement activities. In the improvement project described in this study, instruments corresponding to the participants of the process with their scope, level of complexity and, above all, adequate to the identified area of improvement were used. The project started in 2019 and how many such ventures has become an integral part of the process under study. At this point, it is a kind of perpetual motion machine, because it is based on the low-hanging fruit strategy and as long as it is possible to use the strategy mechanisms, one can count that the improvement process will not stop. However, it should be noted that at some point it will become necessary to reach for more advanced and innovative improvement projects. Otherwise, it can be expected that the entire improvement process will stop, even though continuous improvement is a prerequisite for supporting quality management in ISO 9001 certification. It does not appear to be an over-interpretation that highly efficient processes and flexible structures are the most important competitiveness factors for an organization. Successful organizations regularly test all processes and procedures. They challenge the status quo, actively search for ineffective activities, and develop unique solutions for more efficient operational processes.

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