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THE A3 REPORT AS A PROBLEM-SOLVING TOOL IN A MANUFACTURING ENTERPRISE – CASE STUDY

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Purpose: This article aims to analyze a problem occurring in the pipe production process and then solve it using the A3 report. The analysis was conducted using a production plant in Poland, where non-compliance was identified as gel lumps on the inner surface of pipes, affecting the quality, durability, and safety of use of finished products. Solving the problem using the A3 report methodology enabled understanding of the problem, analysis of its root causes, and development of an action plan, while engaging the team in the improvement process.
Design/methodology/approach: The A3 report was used for the analysis as a tool to support problem-solving in the production environment. According to the A3 report methodology, the problem-solving process included seven stages: defining the problem, analyzing current conditions, defining the action objective, identifying the root cause, defining countermeasures, developing an implementation plan, and defining further actions (monitoring results and drawing conclusions).
Findings: Using the A3 report allowed the identification of the root cause of the problem being analyzed, and taking preventative measures and standardizing the process effectively resolved the problem and prevented its recurrence. The results obtained were also passed on to other company plants as source material.
Research limitations/implications: The analysis focused on a single issue in the company's pipe production process, which limits the ability to compare the results regarding the effectiveness of the A3 report as a problem-solving tool at this plant. Furthermore, the effectiveness of the implemented actions was observed over a limited time period. The results obtained may also depend to some extent on the competence and commitment of the team conducting the analysis, which constitutes a further direction for research in this area.
Originality/value: This article is a case study and presents the practical application of the A3 report in the process of solving a specific problem at a manufacturing company in Poland. The work serves as source material for the company where the analysis was conducted and can also be a source of knowledge for other companies undertaking similar activities. Furthermore, the conducted research can serve as a reference point for further research and comparative analyses in industrial practice.
Keywords: the A3 report, Problem-Solving, PDCA, continuous improvement, Lean Manufacturing.
Category of the paper: research paper, case study.

1. Introduction

Every company, regardless of industry, faces a variety of problems that require corrective action. How a company approaches problem-solving often determines its operational efficiency, competitiveness, and ability to grow. More and more companies are therefore turning to proven, systematic methods and tools that not only help solve specific problems but also support long-term process improvement. One such tool is the A3 report – a practice pioneered at Toyota plants that records the problem, analysis, corrective actions, and action plan on a single sheet of A3 paper. This allows every employee dealing with a problem to see it from the same perspective. At Toyota plants, A3 reports have evolved into a standard method for developing summaries of problem-solving activities, reporting the current status of activities, and planning (Lean Lexicon, 2018; Shock, 2018).

The A3 report is based on the PDCA cycle (Bassuk, Washington, 2013), developed by Deming in 1950, which supports problem analysis and has a wide application (Singh, Ghandi, 2024). The A3 report is not just a form; it's a way of thinking and acting. It allows for understanding the problem, analyzing its causes, and developing a coherent action plan. The report also serves as a communication element, and its greatest advantage is its clarity and logical structure. This allows for presenting the situation to all employees, engaging the appropriate people, and collaboratively developing a solution. This tool therefore fosters a culture of continuous improvement, teamwork, and employee competency development, which in the long run benefits the entire organization (Liker, Meier, 2011; Siwiec et al., 2017).

The study aimed to analyze non-compliance in the production process for pipes at a Polish enterprise. The problem concerned gel lumps on the inner surface of the pipes, which affected the quality, durability, and safety of the finished product. The A3 report was used for the analysis as a tool to support problem-solving in the production environment. The conducted research demonstrates how the use of the A3 report affects the effectiveness of problem identification, cause-finding, and implementing sustainable solutions. This article is a case study that presents the practical application of the A3 report to solve a specific problem at the analyzed company. This work serves as a source material for the company where the analysis was conducted and can also be a source of knowledge for other companies undertaking similar activities. Furthermore, the conducted research can serve as a reference point for further research and comparative analyses in industrial practice.

2. The role of the A3 report in problem solving and continuous improvement

Companies use a variety of methods and tools to ensure the high quality of their products and meet the growing demands of customers. Using appropriately selected methods and tools can be an effective way to resolve emerging problems and prevent their recurrence. Such actions enable the continuous pursuit of excellence, which is crucial for every company (Siwiec et al., 2017).

According to the literature (Hamrol, 2008), improvement is understood as "action undertaken to obtain additional benefits for the organization and its customers". Improvement, which involves incremental improvements to products and processes, can be viewed as a form of problem-solving. Effective problem-solving requires knowledge of the process or product, a set of appropriate methods and tools, and the ability to use them. It is emphasized that the ability to recognize problems is crucial.

The principle of continuous improvement (known as Kaizen in Japan) is an extension of Deming's fifth principle, which advocates a continuous search for the causes of problems to improve all elements of the production system and the actions undertaken. The PDCA (Plan-Do-Check-Act) cycle is linked to the principle of continuous improvement, according to which developing a detailed action plan is the basis for implementing it (Hamrol, Mantura, 2002; Liker, Meier, 2011; Rangel-Sánchez et al., 2024). Good planning enables effective problem-solving, leading to defect-free production and eliminating waste. Problem-solving according to the PDCA cycle is a key element of Lean Thinking (Liker, Franz, 2016). This approach, pioneered by the Toyota Production System, enables companies to achieve more with less by eliminating waste and non-value-added activities, thereby delivering better customer value (Womack, Jones, 1996; Argiyantari et al., 2021; Vijverberg et al., 2023). Consequently, many manufacturing companies worldwide are using TPS-based solutions in Lean Manufacturing to address problems and pursue excellence (Al-Qayoudhi, 2022; Utami et al., 2023; Małysa et al., 2024).

The literature (Smalley, 2018) distinguishes four types (methods) of problem-solving:

1. Removal of faults– reactive problem-solving based on rapid response and reacting only to directly visible symptoms.
2. Eliminating deviations from standards – structured problem-solving involving problem definition, goal setting, root cause analysis, implementing countermeasures, control, setting standards, and planning future actions. This aims to prevent recurrence by eliminating the root cause.

3. Achieving a new target state – continuous improvement (Kaizen) that goes beyond current performance standards; it aims to eliminate waste systematically and may use existing methods in new ways to achieve greater value closer to the target state.
4. Innovation – innovative problem-solving based on creativity and the ability to seize opportunities; it sets new standards leading to radical improvements.

Companies whose production systems are based on Lean Manufacturing concepts solve problems using Types 2 and 3, with the explicit goal of this approach being learning. It is believed (Smalley, 2018) that the most effective tool for solving Types 2 and 3 problems is the A3 report, which aligns with the PDCA cycle.

An A3 report systematically documents a problem, its causes, corrective actions, and their effectiveness (Santos Fihlo, Simao, 2022). The A3 report methodology is based on the need to gather information directly from the source of the problem (Gemba). All information needed to solve a given problem is placed on an A3 sheet in a predetermined format. It's important to note, however, that an A3 report is more of a way of thinking (so-called A3 Thinking) than a standard document format, and therefore should be flexible and adaptable to the current problem within a given organization (Shook, 2018; Rini, 2021; Burka, 2022).

The A3 report includes the following elements:(Shook, 2018; Koskela et al., 2020; Rini, 2021):

1. Situation description/background – a precise definition of the problem that has been observed. The goal is to clearly present the situation requiring a solution, without making interpretations, assessments, or formulating hypotheses. The key is to focus on the facts, and potential causes or solutions should not be suggested yet. This approach allows for objective analysis and provides a foundation for further action.
2. Current conditions – The goal of this phase is to develop the most accurate description of the actual state of affairs possible, using quantitative and qualitative data (process observations, measurements, photographs, charts, etc.).
3. Goals/metrics – at this stage, the goal of the improvement activities should be precisely formulated (the goal may be to eliminate an undesirable phenomenon or improve process parameters). The goal must be measurable, realistic, and closely related to the defined problem.
4. Analyzing and identifying the root cause of the problem is the most important step in the report. This process requires detailed analysis and often a multi-step investigation into the source of the problem. Using appropriate tools to support cause-and-effect analysis, such as 5 Whys, Ishikawa diagram, or Pareto diagram, is crucial. Correctly identifying the root cause is fundamental to the effectiveness of the planned corrective actions.
5. Proposed countermeasures – describe the proposed actions to eliminate the causes of the problem and achieve the intended results.

6. Action plan – the plan should include information on the scope of activities, responsible individuals, resources needed for implementation, a timeline, and indicators that will be used to assess the effectiveness of the activities.
7. Further actions – define how progress will be monitored. Key elements include regular reviews, audits, indicator analysis, and the identification of further improvement opportunities. This ensures that achieved results can be sustained and improved.

The literature analysis indicates that the A3 report is widely applied across various industrial sectors, including plastics manufacturing (Rini, 2021), the automotive industry (Grobelna, Wasilewska, 2023; Santos Filho, Simao, 2022; Lenort et al., 2017; Schwagerman, Ulmer, 2013), and the chemical industry (Kurnia et al., 2021). Studies confirm that the A3 report is an effective problem-solving tool (Grobelna, Wasilewska, 2023), and its application contributes to defect reduction, quality improvement, and process standardization (Rini, 2021). The use of the A3 report also helps reduce operational costs (Kurnia et al., 2021) and improve operational efficiency (Santos Filho and Simao, 2022). Furthermore, the A3 report supports SMED projects (Santos Filho, Simao, 2022) and facilitates the implementation of green innovations in the transportation of an industrial enterprise (Lenort et al., 2017). A3 reports serve not only as a problem-solving tool but also as a structured process for developing employees' problem-solving capabilities, thereby fostering a culture of continuous improvement (Schwagerman, Ulmer, 2013; Shook, 2018). Despite its many benefits, the use of A3 reports can present challenges and limitations that can impact their effectiveness in organizational practice, such as employee resistance to systematically documenting processes and issues, treating the report solely as a formal obligation, the time-consuming nature of the process, and a low level of continuous improvement culture.

3. Research methodology

The study was conducted at a company manufacturing plastic products. The analysis involved pipes made of a polyester resin composite. Each delivery of materials is subject to mandatory sampling and laboratory testing. Additives (including hardener and paint) are stored in designated areas and are also subject to a quality control system. After the production process is completed, the products undergo quantity inspection, visual inspection (to report any defects), verification in the internal IT system, labeling, and a final laboratory inspection.

During a visual inspection of the product, a non-compliance was identified, which posed a significant problem affecting the product's quality, durability, and safety of use. Therefore, steps were taken to identify the potential causes of the non-compliance and eliminate them.

The work aimed to analyze and solve the problem of non-compliance, specifically gel lumps forming inside pipes, using the A3 report. To achieve this goal, a seven-step research methodology was adopted, in accordance with the structure of the A3 report, namely:

1. Problem description.
2. Description of current conditions.
3. Defining the action objective.
4. Analysis and identification of root causes.
5. Defining countermeasures.
6. Development of an action plan.
7. Description of further actions.

The problem-solving process involved a team of employees, including the production manager, shift leader, technologist, maintenance department, operators, and continuous improvement specialist. The process of analyzing and resolving the problem took three months. The implemented solutions effectively eliminated the problem, but their effectiveness was observed only over a limited time horizon.

Only selected data related to the problem analysis is published in this article due to confidentiality concerns, particularly regarding measurement results.

4. Results and discussion

4.1. Problem description

During a visual inspection at the production facility, a product non-conformance was detected. Gel lumps were observed inside the manufactured pipes (Figure 1). This issue was considered significant due to its potential impact on the durability, structural integrity, and safety of the finished product, as well as on the production process and customer complaints. As a result of gel lump formation, the material loses its homogeneity and may not meet quality standards. In some cases, this can lead to micro-cracks, reduced pressure resistance, and, in the long term, product failure during operation.

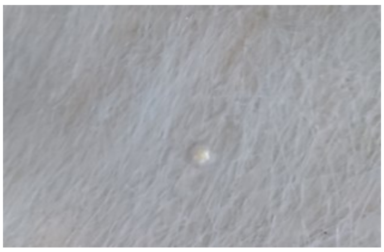


Figure 1. Gel lumps on the surface of the material.

Source: Materials provided by the company.

This problem required immediate action, i.e., identifying the source and implementing corrective actions to prevent its recurrence and ensure full compliance of the production process with quality requirements.

4.2. Current conditions

In the pipe production process, one of the ingredients is sand, which is mixed with resin, a hardener, and a reaction accelerator (cobalt). This mixture is then fed into a rotating drum, where the pipe's shape is formed. The desired result is a uniform and smooth inner layer free of defects.

The issue being analyzed involved the production of type A pipes, where gel lumps appeared on the inside of the pipes. Initially, the problem did not affect type B pipes, which were produced in parallel, but over time, lumps began to appear on them as well. Visual irregularities were reported on type A pipes, prompting a series of laboratory tests. The gel time of the hardener was checked using a gelometer:

– the gel time of the hardener taken from the tank was 20:13 min,
– the gel time of the fresh reference sample was 19:45 min.

Despite the slight difference in gel time, a significant visual difference was noticed – the hardener from the tank had an orange tint, while the fresh hardener was colorless.

Based on the analysis of laboratory data, it was determined that the formation of lumps could be influenced by:

– a decrease in viscosity – this makes the resin more fluid and more difficult to control during the molding process,
– a prolonged reaction time – this can cause incomplete or delayed curing of the mixture in the rotating drum.

4.3. Defining the action objective

The goal of the remedial actions was to restore stability to the production process for Type A and Type B pipes by eliminating gel lumps on the inner surface of the pipes. Achieving this goal should result in:

– ensuring a uniform material structure inside the pipe in accordance with technical and visual requirements,
– maintaining full control over the gel time and viscosity of the resin and hardener components,
– minimizing process parameter variability resulting from raw material properties and environmental conditions,
– securing the process against similar problems recurring in the future.

The achievement of the goal of eliminating the problem of inconsistencies on the pipe surface should be verified using the following metrics:

- 0% of pipes with gel lumps for a minimum of 4 weeks of production (applies to type A and B pipes),
- stable gel time values in tests (deviation ≤ ±0.15 min from the standard),
- constant resin viscosity within the accepted control range,
- positive visual and quality assessment of all produced pipes.

4.4. Analysis and identification of the causes of the problem

For the analyzed nonconformity, the Ishikawa diagram was developed to identify potential root causes of the problem. Due to the complexity of the process and the numerous possible variables, a detailed verification was conducted in six areas: material, machine, method, human, environment, and measurement (Figure 2). Brainstorming within the team identified the most likely causes: incorrect temperature, incorrect materials, operator error, incorrect recipe, incorrect measurements, and faulty machinery.

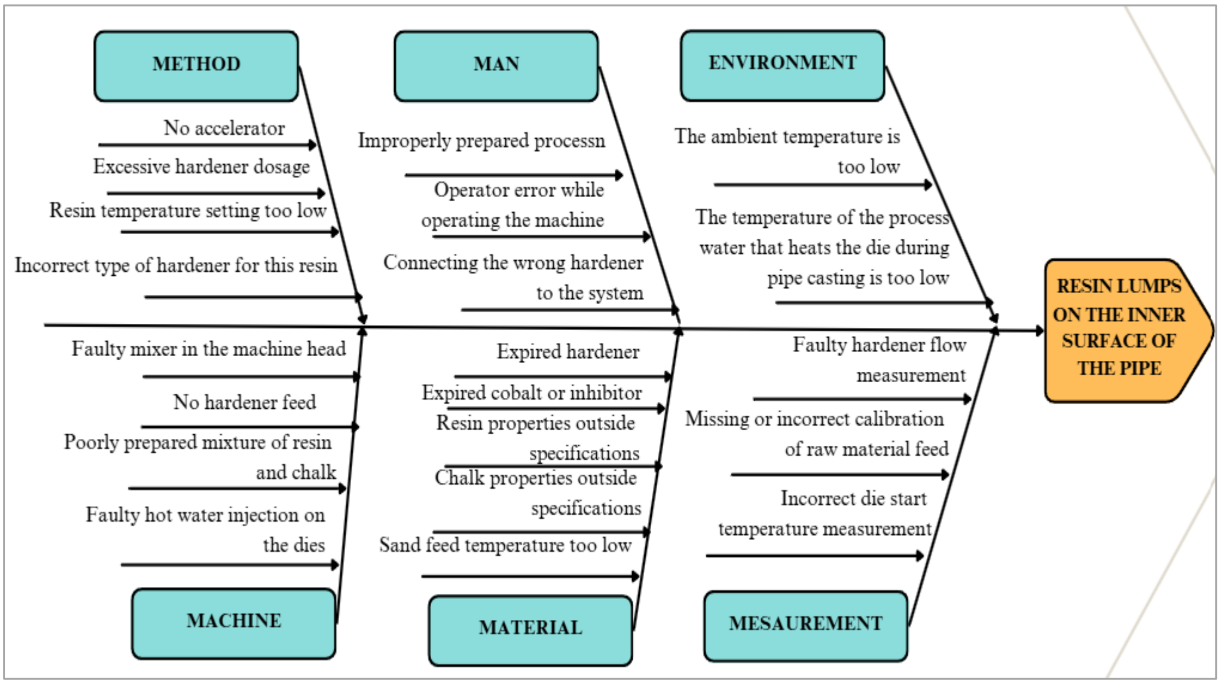


Figure 2. Ishikawa diagram for the analyzed problem.

Source: Own elaboration.

One possible cause was an error in the production recipe. However, it was verified that the recipes used had been unchanged for a long time, and the defect occurred suddenly, without any interference with the technological parameters. The verification showed their compliance with applicable guidelines and calculations.

The next aspect analyzed was the condition of the hot-water spray nozzles, which heat the matrix and initiate the reaction. The nozzles were checked for obstructions and proper adjustment. The inspection revealed no blockages, and the spray angle and direction were set correctly.

Next, a check was conducted to determine whether there may have been a lack of hardener delivery. The condition of the pump tubing and the alarm system was verified. No leaks or malfunctions were detected in the pumps – all were fully operational, and the system did not generate any alarms regarding lack of flow.

At the same time, the correct dosing of cobalt into the resin was checked. The inspection results showed that the doses were delivered according to the set values (no irregularities were found in this range). A potential cause could be the incorrect operation of the "mixer" in the head. Therefore, it was disassembled and inspected for cured resin, clogging, or drive damage. The inspection revealed that the device was functional and clean.

The next step was to analyze the quality of the prepared resin-chalk mixture. The dosing of the ingredients in the tanks was checked – all raw materials were added according to the settings and within the accepted tolerances.

The resin temperature was also verified. The analysis showed that the resin temperature was within the process guidelines (40-45°C) and did not deviate from the standards.

The die temperature was also an important factor – too low a temperature could affect the curing reaction. Measurements were conducted independently using two methods: manually by the operator and using properly calibrated stationary pyrometers. Both systems indicated the correct starting temperature values. No abnormalities were observed in the ambient temperature; environmental conditions in the production hall were stable at approximately 20°C, within the nominal limits for the process.

Similarly, the hot process water temperature was maintained between 60 and 70°C. No issues with the heat exchangers or boiler operation were identified. Water flow and temperature were stable, ruling out this factor as contributing to the defect.

As part of the analysis of raw material supplies, it was checked whether recent chalk deliveries might have deviated from specifications. While minor deviations were found, they were not considered significant because they did not affect the quality of the resin being prepared. Similarly, resin deliveries were within specifications. No changes in viscosity, monomer content, or color were observed, confirming the stability of the base material.

Further analysis focused on the accuracy of the hardener flow measurement. The flow meters were calibrated, and the readings were consistent with the actual flow (no deviations were observed).

The raw material dosing calibration system also showed no errors. All values were within acceptable limits, and the system did not indicate any irregularities.

The use of expired hardener or chemical additives was also ruled out. Each batch had a current expiration date and had been connected for up to two weeks before the problems occurred. The system was also checked to ensure the wrong hardener had not been connected. The hardener tanks were clearly labeled, and a hardener reactivity test confirmed compliance. The difference in gelation time compared to the fresh sample was insignificant and did not indicate an error.

Additionally, the sand temperature was measured at approximately 17°C. This value is acceptable and should not negatively impact the curing reaction.

Finally, the compatibility of the hardener used with the given resin type was analyzed, especially when mixed with chalk. Reactivity tests were conducted with two hardeners. The tests revealed that one of the hardeners did not react properly with the resin mixed with chalk. The samples did not gel throughout the volume, and the reaction time was unnaturally prolonged. Therefore, it was necessary to switch to a different hardener. The root cause of the defects was identified.

4.5. Defining countermeasures

After determining the root cause of the gel lumps on the inner surface of the pipes (an incorrect reaction between the hardener and the resin and chalk mixture), steps were taken to eliminate the incompatibility and ensure process stability. These countermeasures were divided into temporary and permanent measures.

Temporary measures – in the first stage, it was decided to implement measures to immediately reduce the risk of further non-compliance until a permanent solution could be implemented. These measures allowed for a reduction in the number of defective products in the production process and minimized the risk of shipping non-compliant products:

- suspending production of type A and B pipes using the defective hardener until the cause is determined,
- conducting a series of laboratory tests using various types of hardeners to confirm reactivity in the chalk and resin mixture,
- identifying and separating the entire batch of pipes with the suspected defect from the finished goods warehouse,
- increasing visual inspection of each produced pipe in the output area, with the participation of the shift leader and technologists,
- manually recording mixing parameters and reaction times in trial batches to monitor changes.

Target actions – after confirming the incompatibility of the hardener with the mixture currently used, measures were implemented to permanently eliminate the cause of the problem and prevent its recurrence:

- a permanent change in the hardener used in the casting process of type A and B pipes; a different hardener was used, which, in laboratory tests, demonstrated full compatibility with the resin and chalk mixture, ensuring proper gelation throughout the entire sample volume and a stable reaction time,
- updated technological documentation and production recipes; the hardener labels in the recipes and process sheets for the affected product range were updated, specifying its type and dosage,
- training of operators and maintenance staff; staff were trained in recognizing the symptoms of abnormal gelation and in the hardener change and identification procedure,
- additional inspection of raw materials before connecting to the system; mandatory laboratory reactivity tests were introduced for each new hardener batch (before its use in production). For a new supplier, each batch will be subject to a trial inspection using resin and chalk,
- increasing the level of standardization – daily checklists were developed and introduced (Figure 3) with control of the correct connection of chemicals and checking the starting parameters of the process.

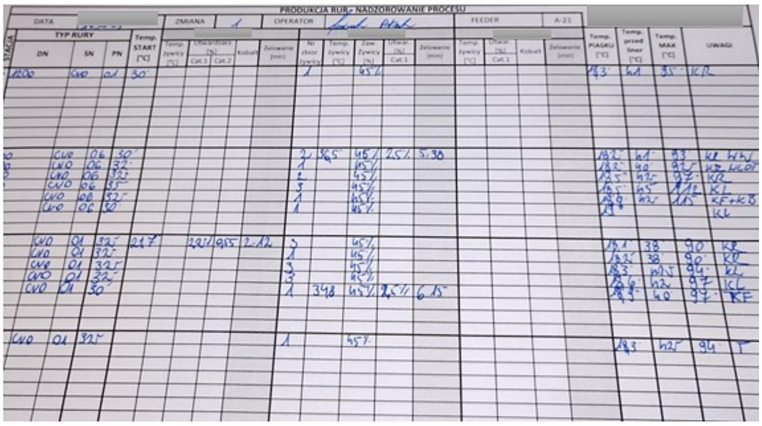


Figure 3. Fragment of the daily checklist.

Source: Own elaboration based on the company's data.

All the measures described were implemented to permanently improve process stability, eliminating the risk of human error and increasing product quality. The process was additionally monitored for the following two weeks to confirm the full effectiveness of the implemented measures.

4.6. Development of an action plan

Table 1 summarizes the actions taken to eliminate the problem. These actions were assigned to the employees responsible for their execution, and the required timeframe for their implementation was specified. The plan was intended to both eliminate the non-compliance that had occurred and prevent its recurrence.

Table 1.
The action plan

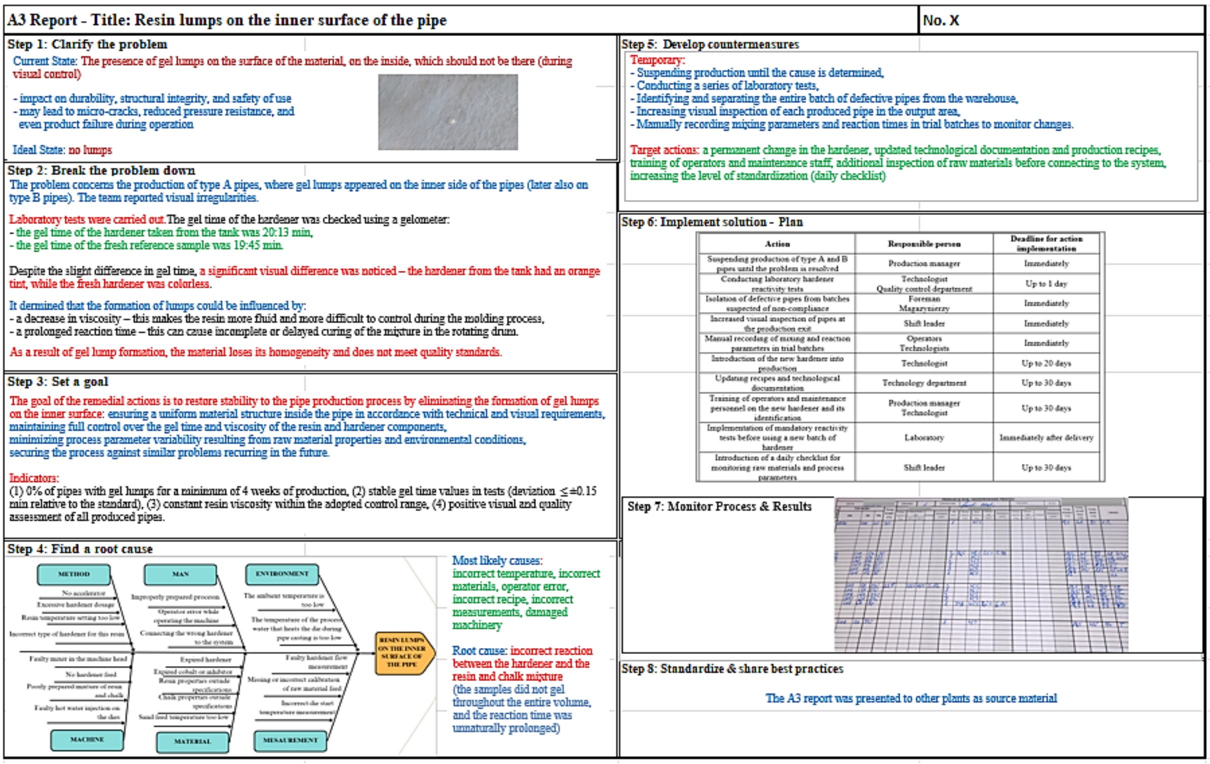
Action	Responsible person	Deadline for action implementation
Suspending production of type A and B pipes until the problem is resolved	Production manager	Immediately
Conducting laboratory hardener reactivity tests	Technologist Quality control department	Up to 1 day
Isolation of defective pipes from batches suspected of non-compliance	Foreman Warehouse workers	Immediately
Increased visual inspection of pipes at the production exit	Shift leader	Immediately
Manual recording of mixing and reaction parameters in trial batches	Operators Technologists	Immediately
Introduction of the new hardener into production	Technologist	Up to 20 days
Updating recipes and technological documentation	Technology department	Up to 30 days
Training of operators and maintenance personnel on the new hardener and its identification	Production manager Technologist	Up to 30 days
Implementation of mandatory reactivity tests before using a new batch of hardener	Laboratory	Immediately after delivery
Introduction of a daily checklist for monitoring raw materials and process parameters	Shift leader	Up to 30 days

Source: Own elaboration.

4.7. Further actions

To ensure the sustainability of the implemented solutions and prevent similar incompatibilities in the future, the following development activities are planned:

- creation of a central database of resin-chalk reactivity, enabling the rapid identification of risky combinations,
- implementation of periodic comparative tests of hardeners for their behavior under actual production conditions,
- expansion of the raw material qualification program to include mixture reactivity tests,
- training for technologists and operators on the impact of chemical and physical parameters (temperature, viscosity, dosing) on the quality of the final product;
- establishment of a schedule for periodic audits of raw material mixing and dosing;
- verification of technological documentation for the clarity, completeness, and unambiguity of recipe records;
- introduction of a system for early warning of the risk of an incorrect chemical reaction based on historical data and current laboratory analyses.



A3 Report - Title: Resin lumps on the inner surface of the pipe

No. X

Step 1: Clarify the problem

Current State: The presence of gel lumps on the surface of the material, on the inside, which should not be there (during visual control)

- impact on durability, structural integrity, and safety of use
- may lead to micro-cracks, reduced pressure resistance, and even product failure during operation

Ideal State: no lumps

Step 2: Break the problem down

The problem concerns the production of type A pipes, where gel lumps appeared on the inner side of the pipes (later also on type B pipes). The team reported visual irregularities.

Laboratory tests were carried out.The gel time of the hardener was checked using a gelometer:
- the gel time of the hardener taken from the tank was 20:13 min,
- the gel time of the fresh reference sample was 19:45 min.

Despite the slight difference in gel time, a significant visual difference was noticed – the hardener from the tank had an orange tint, while the fresh hardener was colorless.

It dermined that the formation of lumps could be influenced by:
- a decrease in viscosity – this makes the resin more fluid and more difficult to control during the molding process,
- a prolonged reaction time – this can cause incomplete or delayed curing of the mixture in the rotating drum.

As a result of gel lump formation, the material loses its homogeneity and does not meet quality standards.

Step 3: Set a goal

The goal of the remedial actions is to restore stability to the pipe production process by eliminating the formation of gel lumps on the inner surface: ensuring a uniform material structure inside the pipe in accordance with technical and visual requirements, maintaining full control over the gel time and viscosity of the resin and hardener components, minimizing process parameter variability resulting from raw material properties and environmental conditions, securing the process against similar problems recurring in the future.

Indicators:
(1) 0% of pipes with gel lumps for a minimum of 4 weeks of production, (2) stable gel time values in tests (deviation $\leq \pm 0.15$ min relative to the standard), (3) constant resin viscosity within the adopted control range, (4) positive visual and quality assessment of all produced pipes.

Step 4: Find a root cause

Most likely causes: incorrect temperature, incorrect materials, operator error, incorrect recipe, incorrect measurements, damaged machinery

Root cause: incorrect reaction between the hardener and the resin and chalk mixture (the samples did not gel throughout the entire volume, and the reaction time was unnaturally prolonged)

Step 5: Develop countermeasures

Temporary:
- Suspending production until the cause is determined,
- Conducting a series of laboratory tests,
- Identifying and separating the entire batch of defective pipes from the warehouse,
- Increasing visual inspection of each produced pipe in the output area,
- Manually recording mixing parameters and reaction times in trial batches to monitor changes.

Target actions: a permanent change in the hardener, updated technological documentation and production recipes, training of operators and maintenance staff, additional inspection of raw materials before connecting to the system, increasing the level of standardization (daily checklist)

Step 6: Implement solution - Plan

Action	Responsible person	Deadline for action implementation
Suspending production of type A and B pipes until the problem is resolved	Production manager	Immediately
Conducting laboratory hardener reactivity tests	Technologist Quality control department	Up to 1 day
Isolation of defective pipes from batches suspected of non-compliance	Foreman Magazynierzy	Immediately
Increased visual inspection of pipes at the production exit	Shift leader	Immediately
Manual recording of mixing and reaction parameters in trial batches	Operators Technologists	Immediately
Introduction of the new hardener into production	Technologist	Up to 20 days
Updating recipes and technological documentation	Technology department	Up to 30 days
Training of operators and maintenance personnel on the new hardener and its identification	Production manager Technologist	Up to 30 days
Implementation of mandatory reactivity tests before using a new batch of hardener	Laboratory	Immediately after delivery
Introduction of a daily checklist for monitoring raw materials and process parameters	Shift leader	Up to 30 days

Step 7: Monitor Process & Results

Step 8: Standardize & share best practices

The A3 report was presented to other plants as source material

Figure 4. The A3 report.

Source: Own elaboration based on the company's data.

At the end of the process, an A3 report was developed (Figure 4) that concisely outlined the steps for identifying, analyzing, and eliminating nonconformities. The report was prepared on a single sheet, following A3 format guidelines. This provided a comprehensive overview of the actions taken to restore full compliance of the production process with requirements. The A3 report was presented and discussed at a meeting of the team involved in the process, and conclusions from the analysis were shared with other plants within the company.

5. Summary

The A3 report is more than just a form – its main value lies in the cause-and-effect thinking process, also known as A3 Thinking. The A3 report approach stems from the Toyota Production System and is founded on the PDCA cycle. The main goal of the A3 report is to understand the problem in depth and draw logical conclusions from the analysis of data and facts. In the problem-solving process, utilizing tools that support root cause analysis, such as the Ishikawa diagram or 5 Whys, is crucial.

The subject of the analysis was a problem involving gel lumps inside pipes. The A3 report methodology was used to solve the problem. Identifying and describing the problem, followed by formulating the goal, was crucial to initiating a detailed analysis of the current situation and the reasons for the discrepancy between it and the desired situation. The use of an Ishikawa diagram allowed the identification of possible causes of the incompatibility in six categories. Brainstorming within the team allowed us to identify the most likely causes: incorrect temperature, inappropriate materials, operator error, incorrect recipe, incorrect measurements, and faulty machinery. Based on a detailed verification of possible causes, the root cause of the incompatibility was identified. One of the hardeners did not react properly with the resin-chalk mixture. The samples did not gel throughout the volume, and the reaction time was unnaturally prolonged. A change to a different hardener was necessary. As a result of the analysis, the following actions were implemented:

- the procedure for mixing and dosing resin components was changed,
- more frequent inspections of raw materials and process parameters were introduced,
- operator training was conducted on the operation of mixers and the importance of technological parameters.

Solving the problem using the A3 report effectively eliminated it and prevented its recurrence through preventive measures and process standardization. It should be emphasized that the analysis focused on a single issue in the company's pipe production process, which limits the ability to compare the results regarding the effectiveness of the A3 report as a problem-solving tool at this plant. This problem did not recur, but the effectiveness of the implemented actions was observed over a limited timeframe. The results obtained are also dependent to some extent on the competence and commitment of the team conducting the analysis, which may constitute a further direction for research in this area. Employee involvement in the problem-solving process is an important factor in shaping a culture of continuous improvement, which is crucial for a company implementing Lean Manufacturing solutions.

The conclusions from the analysis were shared with other plants within the company where the research was conducted. Solving the problem according to the A3 report methodology can be a source of knowledge for other companies undertaking similar activities. Furthermore, the obtained results can serve as a reference point for further research and comparative analyses in industrial practice.

Based on the obtained results, several key practical conclusions can be formulated:

- proper problem definition enables the identification of appropriate directions for further actions and prevents decision-making based on assumptions rather than factual evidence,
- the A3 report focuses on root cause elimination; the application of quality management tools facilitates the identification of potential causes and supports accurate determination of the problem source,
- effective and sustainable problem resolution requires a comprehensive approach that integrates technical, organizational, and competency-related aspects,

- the A3 report supports preventive measures and contributes to reducing the likelihood of problem recurrence,
- the effectiveness of the A3 report is influenced by the level of team engagement and the presence of an organizational culture oriented toward continuous improvement.

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