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MANAGING CONSTRAINTS IN A MACHINERY COMPANY USING THEORY OF CONSTRAINTS' THINKING PROCESS TOOLS. CASE STUDY

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Abstract:
The main objective of this study is to present the practical application of the Theory of Constraints (TOC) and its Thinking Process Tools (TPT) to identify, analyze, and eliminate constraints in the production department of a machinery company specializing in the production of bearing cages. A case study was used as the research method. Interviews, direct observations, and performance indicator analysis were used to identify the most critical constraints in the production department of the studied company. The research included the application of five TOC-TPT tools: Goal Tree (GT), Current Reality Tree (CRT), Evaporating Cloud (EC), Future Reality Tree (FRT), and Prerequisite Tree (PRT). These tools were used to identify organizational goals, diagnose the root causes of key constraints, resolve internal conflicts, design future solutions, and outline the path for implementing solutions. The study focused on an in-depth analysis of the key constraint in the form of the lack of work instructions at each stage of production. The analysis revealed that the root causes of this limitation were insufficient investment in training and management development. Determining a dedicated budget and resources for a structured, ongoing training and development program that aligns with the company's strategic goals and develops both technical and interpersonal skills at all levels of staff was identified as a critical solution to this problem. The advantages and limitations of using TOC-TPT were also analyzed in response to comments from the working group participating in the study. The results showed the effectiveness of TOC-TPT in solving complex operational problems in the study company and the technical and organizational problems associated with the use of TOC thinking tools. The study indicated that strategic commitment of top management, cross-functional teamwork, and targeted training are key to the successful implementation of TOC tools. The results have practical implications for manufacturing companies seeking to improve the effectiveness and efficiency of their production systems through comprehensive constraint management.

Key words: Case-Study, Constraints Management, Theory of Constraints (TOC), Thinking Process Tools (TPT)

INTRODUCTION

In today's competitive industrial environment, manufacturing companies face a variety of internal and external constraints that make it difficult to achieve their strategic goals. These constraints – from resource shortages and process inefficiencies to outdated technologies and organizational problems – can lead to increased costs, decreased quality, and loss of competitiveness [1]. Constraint management focuses on identifying and eliminating constraints [2]. Effective constraint management is essential to increasing operational efficiency and ensuring the long-term success of an organization [3].

Companies face a variety of internal and external constraints, including those related to resources, processes, technology, organizational structure, market conditions, and mindsets [3, 4, 5]. Resource constraints arise from shortages in human capital, materials, or financial assets. Process-related constraints include production bottlenecks, inefficiencies, and poor-quality outputs. Technological constraints stem from outdated machinery, inadequate IT systems, and a lack of innovation. Organizational constraints manifest in poor work organization, ineffective management, weak communication between departments, or an unsuitable organizational structure. Market constraints involve limited product demand, excessive competition, shifting legal regulations, or challenges in distribution. Another critical and often overlooked factor is mental constraints, which encompass the beliefs, attitudes, and psychological barriers of the company's management. Resistance to change and rigid mindsets can significantly limit an organization's ability to remain competitive. Additionally, constraints related to unused human potential arise when employee talents and skills are not fully leveraged by management, leading to missed opportunities for organizational growth [6].

The dynamic and complex nature of constraints complicates their management and elimination. Even when one constraint is resolved, another often emerges that requires attention [7]. Managers face a unique challenge because they must not only identify the key barriers to a company's growth and performance, but also implement effective strategies to eliminate them and sustain long-term improvement. Traditional management approaches often fail to address these complex and interconnected constraints [8, 9, 10]. The Theory of Constraints (TOC), supported by Thinking Process Tools (TPT), offers a structured methodology for identifying and eliminating system bottlenecks through cause-effect reasoning. These tools support managers and employees in analyzing constraints and finding the most effective solutions to remove them from the organization [11, 12].

The main research problem is the presence of critical operational constraints in the production system of the analyzed machinery company, which negatively affect the efficiency and effectiveness. The main objective of this study is to show the practical application of TOC-TPT in identifying, analyzing and solving critical constraints in the company specializing in bearing cages. The study uses a qualitative case study approach.

LITERATURE REVIEW

Theory of Constraints (TOC), developed by Eliyahu Goldratt in the late 1970s, has evolved from a production planning tool into a comprehensive management philosophy [13, 14, 15]. It encompasses a broad set of methods focused on improving an organization's performance and increasing its profits [16]. A key assumption of TOC is that there is at least one constraint that is holding an organization back from achieving its goals. Effectively identifying and managing that constraint is essential to its growth [17]. Constraints are defined as bottlenecks, critical points, or weak links in the system that block the flow and act as factors that limit the full utilization of the organization's potential. Constraints can take many forms, such as bottlenecks in production processes, resource shortages, poor quality, time constraints, or organizational problems [18]. The goal of TOC is to identify and systematically remove constraints to enhance organizational performance to increase economic value added [16, 17, 18]. Managing constraints is particularly difficult in the dynamic and complex environment of manufacturing companies, where many internal and external factors determine whether the company can achieve its strategic, tractive and operational goals [19]. By effectively managing constraints, companies can achieve higher profitability, higher efficiency, better quality, shorter lead times, and greater customer satisfaction [20].

TOC is a continuous improvement process, known as POOGI, that systematically identifies and eliminates key barriers–both enterprise-wide and department-wide [21]. These constraints block an organization's ability to increase throughput, most often measured in sales revenue, and thus impede the achievement of improved financial results in both the short and long term [22].

The TOC approach is based on a systems view of an organization, in which all processes and resources are part of a larger whole. Improving performance in one area should not come at the expense of others, but should lead to improvements in key performance indicators for the company's operations [23]. TOC also places great emphasis on a culture of continuous improvement, where the organization progressively eliminates constraints one by one, incorporating their management as an integral part of its operational strategy. By eliminating the factors that limit system performance, the company improves its overall productivity, efficiency, and effectiveness [24, 25, 26]. The TOC approach has been adopted across a variety of sectors, including manufacturing, healthcare and service industries, where it has been demonstrated to produce tangible results for organizations [27, 28, 29, 30].

The Thinking Process (TP) serves as the basic mechanism in implementing the TOC philosophy. The Thinking Process Tools (TPT) are used to visualize and systematically analyze key problems [31]. TOC-TPT are integrated problem-solving tools based on rigorous cause-effect logic that provide a comprehensive framework for identifying, analyzing, and mitigating organizational constraints [32]. TOC-TP are six tools that enable targeted improvement of business systems. These tools facilitate breakthrough solutions by identifying, challenging, and refining unexamined assumptions [33, 34]. The TOC-TP aligns with the PDCA (Plan-Do-Check-Act) cycle, which serves as the foundational framework for problem-solving, continuous improvement, and change implementation [35]. The TOC-TP consists of six distinct logic trees, each governed by specific "rules of logic" that guide their construction. These trees include the Goal Tree (GT), Current Reality Tree (CRT), Evaporating Cloud (EC), Future Reality Tree (FRT), Prerequisite Tree (PT), and Transition Tree (TT) [36, 37, 38]. Together, these six logical tools form an integrated thinking process (Table 1).

Table 1
Integrated Thinking Process by TOC

Status of changes	The appropriate logical tree
What is the desired standard? What are we striving for?	Goal Tree/Intermediate Objectives Map
What to change? What is our root problem?	Current Reality Tree
What to change to? How to solve this root problem?	Evaporating Cloud, Future Reality Tree
How to bring about change? How to remove obstacles and implement an action plan?	Prerequisite Tree, Transition Tree

Source: [36, 37, 38].

The Goal Tree (GT) is a hierarchical tool that illustrates a logical path to achieving an organization's primary goal. It consists of three levels: the Goal, a clearly defined and measurable end state; the Critical Success Factors (CSFs), which are the key conditions required to achieve the goal; and the Necessary Conditions (NCs), which support each

CSF. The GT ensures alignment between strategic goals and operational actions [36, 37, 38, 39, 40].

The Current Reality Tree (CRT) is used to diagnose systemic problems by tracing Undesirable Effects (UDEs) to their Critical Root Cause. Undesirable Effects (UDEs) refer to specific, observ-able problems or negative outcomes in the system that indicate the presence of deeper, systemic issues. The Critical Root Cause is the fundamental underlying cause that gives rise to multiple UDEs. It is identified through logical cause-effect chains in the CRT and becomes the main focus of the proposed injections. CRT provides an in-depth analysis of the current state of the system, help-ing to identify what is preventing the organization from achieving its goals, in the form of the Critical Root Cause [36, 37, 38, 39, 40].

The Evaporating Cloud (EC), also known as the Conflict Resolution Diagram, is used to discover and resolve organizational conflicts. By challenging basic assumptions, the EC supports WIN-WIN solutions that reconcile opposing sides of a conflict in the system [36, 37, 38, 39, 40, 41].

The Future Reality Tree (FRT) shows the expected outcomes of proposed changes. The FRT is built on the CRT. By extending it with solution elements (called an injection; the injection is a specific action or change introduced into the system that aims to eliminate a root cause or resolve a conflict), it determines whether actions will effectively transform UDEs into desired outcomes (DEs) [36, 37, 38, 39, 40].

The Prerequisite Tree (PRT) transforms FRT injectables into actionable goals by identifying obstacles and preventive intermediate goals. It serves as a roadmap from the current state to the desired future state [36, 37, 38, 39, 40].

Finally, the Transition Tree (TRT) breaks down these intermediate goals into specific steps, creating a detailed and actionable implementation plan – especially valuable for managing high-risk improvements [36, 37, 38, 39, 40].

METHODOLODGY

In order to achieve the research objective, which is to present the application of the Theory of Constraints (TOC) and its Thinking Process Tools (TPT) in management and to eliminate key constraints in a company from the metal industry, a research method based on a case study [42] was used. The primary aim of the study was exploratory in nature and was to search for ways to eliminate constraints in the production activities of the studied metal industry enterprise using the Theory of Constraints Thinking Process Tools (TOC-TPT). The specific objectives of the research were to identify and classify key constraints in the company's production department, apply TOC Thinking Process Tools to analyze the root causes of these constraints, propose and evaluate practical solutions for their elimination and assess the usefulness and limitations of TOC-TPT in supporting continuous improvement initiatives.

The examined company from the machinery industry is a company located near Częstochowa in the Silesian Voivodeship. It is a manufacturing company specializing in the production of linear elements. The company specializes in the production of bearing cages and the department covered by the identification and elimination of limitations is the production department of the examined company. The company itself was chosen based on the presence of significant operational constraints within its production department, making it an ideal candidate for demonstrating how TOC-TPT can be applied to identify and eliminate key barriers to performance. Additionally, the company's management expressed a strong interest in continuous improvement initiatives aimed at eliminating key issues that impact the company's financial performance. The results of this case study have the potential to provide valuable insights not only for this particular company, but also for other companies facing similar challenges in managing constraints.

To structure the research process and demonstrate the practical implementation of the Theory of Constraints Thinking Process Tools (TOC-TPT) in the production department of the selected machinery company, a seven-stage approach was applied. These stages are shown in Figure 1.

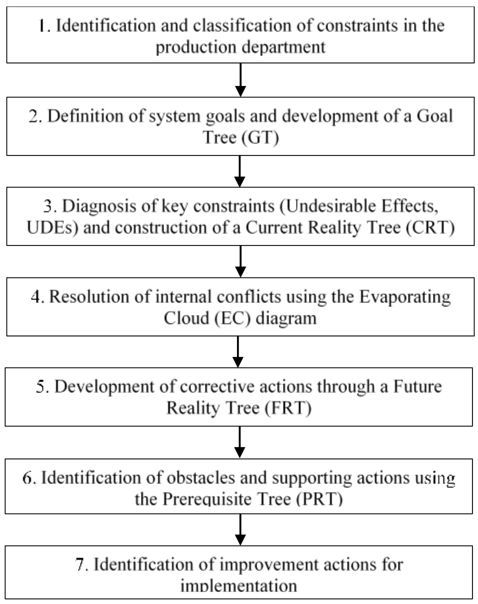

Fig. 1 Structure of research part
Source: adapted from [11].

The study first involved identifying key constraints in the production department of the studied company. This process was based on interviews with management staff, process observations and KPI analysis. Analysis of qualitative insights from interviews and observations with quantitative data from KPIs allowed to identify the most important barriers limiting the efficiency and effectiveness of the production department.

The identified constraints were classified into distinct categories: the area of constraints and the nature of the constraint [5, 43]. The first classification distinguishes between internal constraints, market constraints, and resource availability constraints. Internal constraints include operational barriers within the company, such as inefficient workflows, production bottlenecks, or

management constraints. Market constraints refer to external factors that affect production and sales, including fluctuations in customer demand, high competition, or regulatory changes. Resource availability constraints result from problems related to the supply and availability of necessary resources, such as materials, raw materials, machines, technologies or qualified employees. This category also includes staff shortages, both in terms of the number of employees and their competences [5, 43]. Constraints were further divided into physical constraints, political/procedural constraints, and paradigm constraints based on their underlying nature [5, 43]. Physical constraints include tangible, measurable limitations such as machine inefficiencies, production line bottlenecks, or workforce shortages. Political and procedural constraints refer to formal and informal regulations affecting the company's operations. They include corporate policies and procedures, requirements resulting from legal regulations, decisions of superiors, and established organizational practices that may limit flexibility and efficiency of operation. Paradigm constraints stem from entrenched mindsets, assumptions, and organizational culture [5, 43].
Secondly, the most important goals for the studied production system – specifically, the production department of the company – were identified. One critical goal was then selected for the development of the Goal Tree (GT), along with a justification for its selection.
Thirdly, the key constraints (Undesirable Effects, UDEs) hindering the achievement of the selected system goal were identified. From these, three primary constraints were chosen, each supported by a rationale for them significance. To further analyze these constraints, the Current Reality Tree (CRT) was constructed to identify their root causes, including the Critical Root Cause.
Fourthly, the Evaporating Cloud (EC) tool was applied to address conflicts within the studied system, ensuring a resolution based on a WIN-WIN approach.
Fifthly, corrective actions aimed at eliminating the identified constraints (UDEs) were determined using the Future Reality Tree (FRT).
Sixthly, a key "injections" from the Future Reality Tree (FRT) was selected, accompanied by a justification for their importance. To show "injections" implementation, the Prerequisite Tree (PRT) was developed, outlining potential obstacles and the necessary intermediate actions required to achieve the intended change.
In the final stage of the analysis, a summary was prepared, detailing all the improvement actions that the company's management needed to undertake to achieve the system objective and effectively eliminate the identified constraints.

RESULTS

The result of the identification and classification of key constraints in the production department of the surveyed company producing bearing cages is presented in Table 2.

Table 2
Identification and classification of key constraints in the analysed system

No.	Constraints name/description	Constraint area [internal/ market/ resource availability]	Constraint type [physical/ political/ paradigm]
1	The high degree of diversity of manufactured parts	Internal	Physical
2	Lack of job instructions	Internal	Physical
3	Incorrect information flow	Internal	Paradigm
4	Lack of continuous flow	Internal	Physical
5	Long changeover times	Internal	Physical
6	Low level of automation	Internal	Physical
7	Lack of trained staff	Internal	Physical
8	Lack of proper training of new employees	Internal	Paradigm/ political
9	Lack of proper knowledge management	Internal	Paradigm
10	Problems in the supply chain	Resource availability	Physical

The three most crucial, according to experts, constraints in the studied system are:

1. The high degree of diversity of manufactured elements – production of various finished products in small batches – is a challenge due to the difficult organization and management of the company. Constant changes in the assortment, and consequently the need for frequent and time-consuming machine retooling, generate high costs for the company. Additionally, frequent changes increase the risk of errors by employees carrying out individual stages of production. Another problem related to this limitation is the possibility of irregularities during final inspection, packaging and shipping.
2. Incorrect information flow – due to the complex internal structure of the company, information is transferred slowly. As a result, key decisions are sometimes made with a delay, which generates additional costs, such as late shipments or long machine downtimes during failures. In addition, the organization does not have clearly defined people responsible for receiving reports, which leads to chaos in communication.
3. Lack of job instructions, closely related to the problem of improper knowledge management – due to the lack of job instructions in the company, some work stations are operated only by one employee. This is a significant limitation in situations where the employee is on sick leave, vacation leave or when there is an increased demand for a given product. This is also directly related to poor knowledge management and the lack of an appropriate system for training new employees. No employee should be irreplaceable and each job position should have a detailed instruction.

The three most important goals of the analyzed system were identified, which are: 1. Introduction of instructions at workstations at each stage of production within 3 months, 2. Introduction of structured training for new employees within 1 year, 3. Implementation of a proper knowledge management system within 2 years. These goals were built according to the SMART rule for goal setting [44].

In order to build the Goal Tree (GT) (Figure 2), the following goal of the system was chosen: implementation of job instructions at each production stage within 3 months. Job instructions are crucial for the proper functioning of the examined enterprise and its production department. They will enable faster implementation of new employees. They will also provide greater flexibility of work organization by improving the competences of experienced employees in the event of a potential change of their job positions. In addition, they will affect the comfort of work and improve the efficiency and quality of the process, and consequently the quality of the final products. Employees with job instructions usually react faster to potential irregularities in the process, which additionally increases the efficiency and effectiveness of the process itself.

In the Goal Tree (GT) presented above, which schematically illustrates the activities necessary to implement job instructions at each stage of production within 3 months, three key elements (CSFs) have been distinguished: establishing a team responsible for developing the job instructions and conducting training, changing the internal arrangements in the company – global management of job positions, implementing a structured training program for new employees.

Using a group of experts, contrainsts in the studied system related to the implementation of job instructions at each production stage were identified. Among them, the following were distinguished:

- Lack of employees responsible for creating job instructions.
- Lack of an internal standard for creating job instructions.
- Lack of sufficient data on the course of technological processes.
- Lack of a system for managing job stations.
- Lack of a person coordinating the introduction and updating of job instructions.

Key constraints that stand in the way of implementing job instructions at each production stage were selected in order to find their root causes. These key constraints are:

- Lack of employees responsible for creating job instructions.
- Lack of internal standards for creating job instructions.
- Lack of sufficient data on the course of technological processes.

The Current Reality Tree (CRT) was developed to analyze the limitations associated with the lack of implemented work instructions (Figure 3).

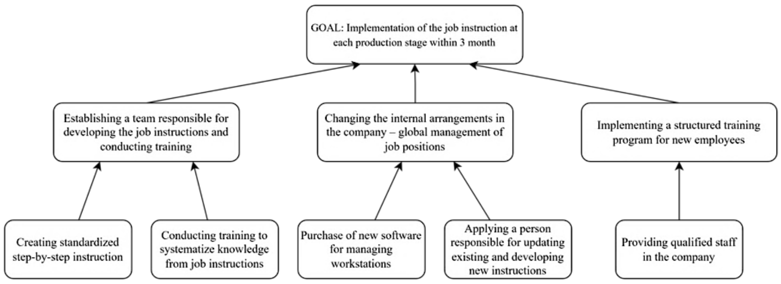

Fig. 2 Goal Tree (GT) for the selected system goal: implementation of job instructions at each production stage within 3 months

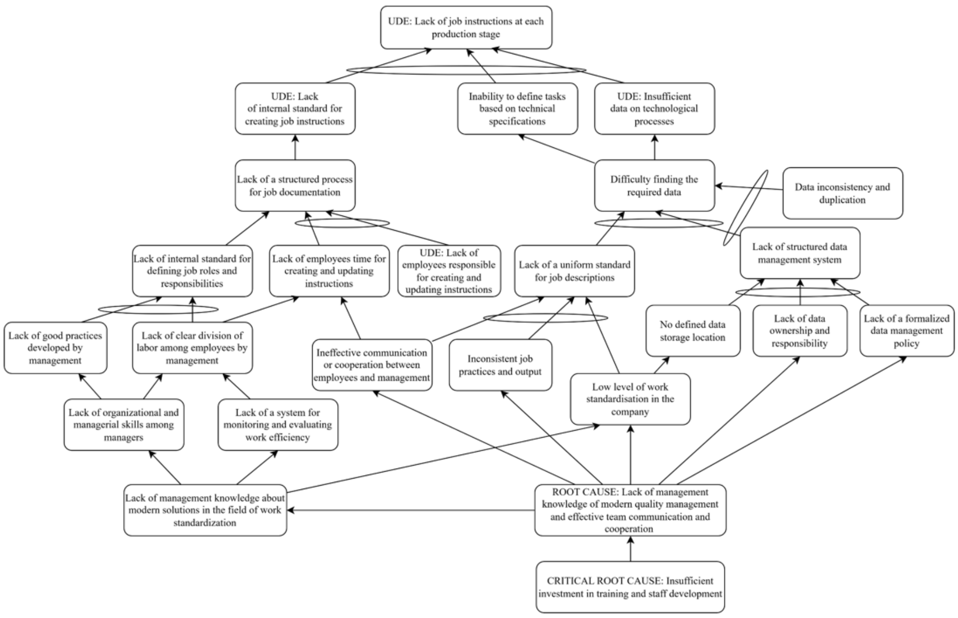

Fig. 3 Current Reality Tree (CRT) to find the critical cause of root cause constraints related to lack of implemented work instructions at each stage of production in the shop floor

The analysis began with the identification of undesirable effects (UDEs) observed in the production process. Using logical cause-and-effect analysis, these UDEs were traced back to a Root Cause and a Critical Root Cause.
Analysis using the CTQ tree showed that the critical cause of the lack of implementation of work instructions at all work stations is insufficient investment in training and development of management staff (Critical Root Cause). Without regular training, managers do not acquire knowledge about modern quality management methods and effective team communication and cooperation (Root Cause). The lack of knowledge of management staff in the field of work standardization techniques results in low awareness of their importance for quality assurance. Management staff is not aware of the benefits of introducing work standardization related to the elimination of variability, improvement of repeatability of operations and minimization of errors, which translates into higher quality of products. Without appropriate training, both management staff and employees may not be aware of the benefits of using work standards, which leads to inconsistent work methods and a greater risk of defects.
The conflict between the quality management department manager and the company's management was analyzed using the Evaporating Cloud (EC) Tree. The department manager wanted to implement job instructions at each stage of production, which required the involvement of one of the current employees or hiring a new person responsible for this process. However, the company's management did not see the need to develop such documents, considering them unnecessary and likely to disrupt the work of assemblers and operators. Therefore, they were not willing to allocate the budget to create a new position. The result of the development of the evaporating cloud tree (CRT) for the purpose of resolving the analyzed conflict in the system on a WIN-WIN basis is presented in Figure 4.

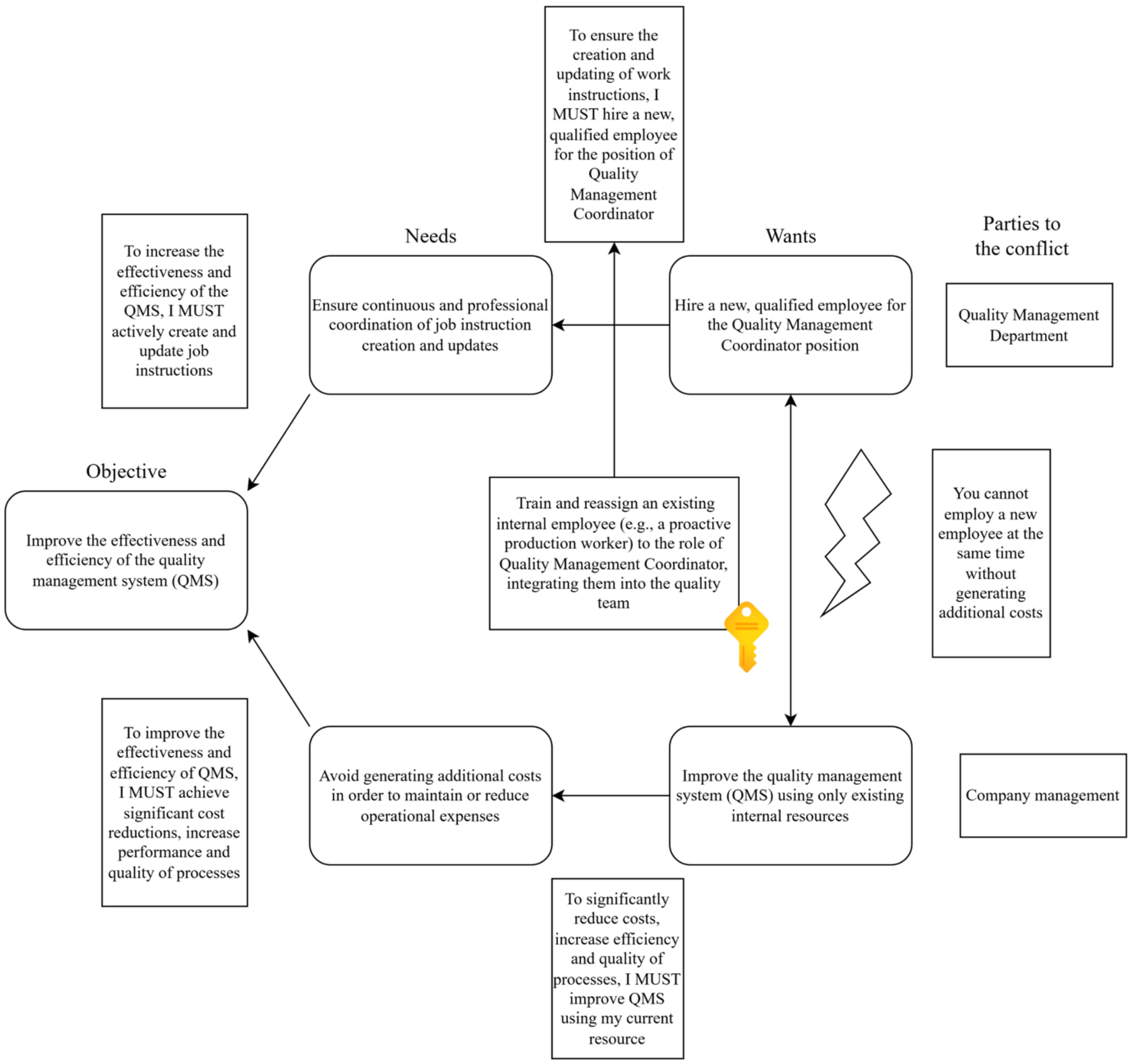

Fig. 4 Evaporating Cloud (EC) for resolving the analyzed conflict in the system on a WIN-WIN basis

The analysis of the conflict situation between the quality department and the company's management using EV allowed to conclude that both sides of the conflict had a common goal: to improve the efficiency and effectiveness of the company's quality management system. The management wanted to achieve this goal without incurring additional costs, while the quality manager needed an additional employee to develop and update work instructions. The solution to the conflict would be to train a junior employee in the tools of work standardization – a production employee with experience and knowledge of processes, who has a predisposition to conduct training and shows a desire for development. This employee would then be integrated with the Quality Management Department and would be the Quality Management Coordinator, and his task would be, among others, to conduct training in the field of work standardization.

Future Reality Tree (FRT) was used to visualize the expected effects of the proposed changes to the system (Figure 5). It indicated a series of actions that should be taken to ultimately ensure the implementation of work instructions at each production stage.

Based on the constructed Future Reality Tree (FRT), a major injection – i.e., a specific solution designed to eliminate a previously identified Critical Root Cause – was proposed to achieve the goal of having working instructions at every workstation. This injection directly addresses the UDEs revealed during the CRT analysis.

It was determined that it is crucial that managers have organizational and management skills, including knowledge of modern quality management solutions (Injection), which will translate into ensuring a high level of standardization of work in the company. Employees will be responsible for creating and updating work instructions, for this purpose they will have the necessary data on the course of technological processes, which will ensure internal standards in creating work instructions. However, the basic condition for achieving the overriding goal is investment in management training and employee development. Allocating a dedicated budget and resources for a structured, continuous training and development program that is consistent with the company's strategic goals and builds both technical and interpersonal skills at all levels of staff is a critical solution to the problem of the lack of work instructions at every stage of production (Critical Injection).

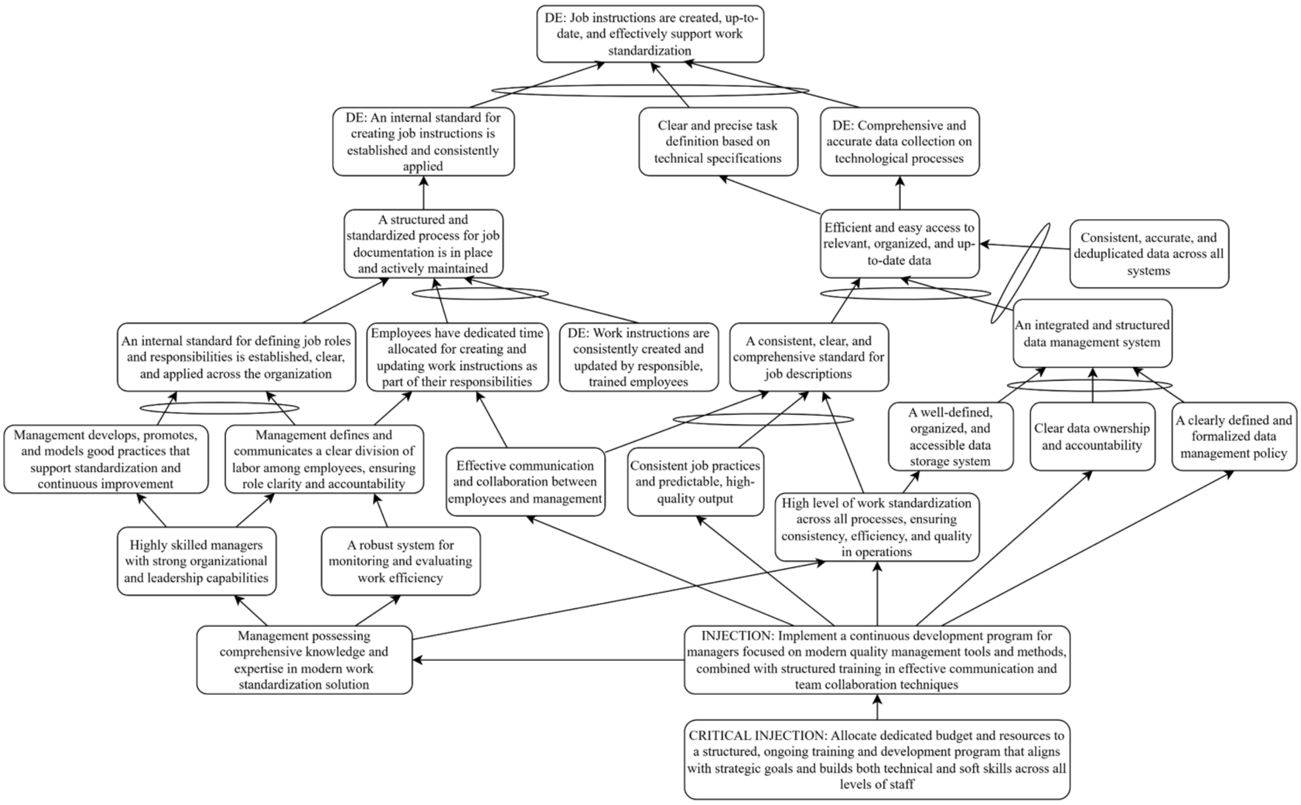

Fig. 5 Future Reality Tree (FRT) to show how the introduction of specific changes will eliminate the main undesirable effects (UDE) in the form of lack of work instructions at each workstation in the system

A Prerequisite Tree (PRT) was used to identify and overcome obstacles during the implementation of a key injection: a structured, ongoing training and development program aligned with strategic goals. The PRT identifies the intermediate objectives required to ensure that this injection is effectively implemented and sustained (Figure 6). It helped plan the necessary steps by breaking down a complex goals into manageable actions.

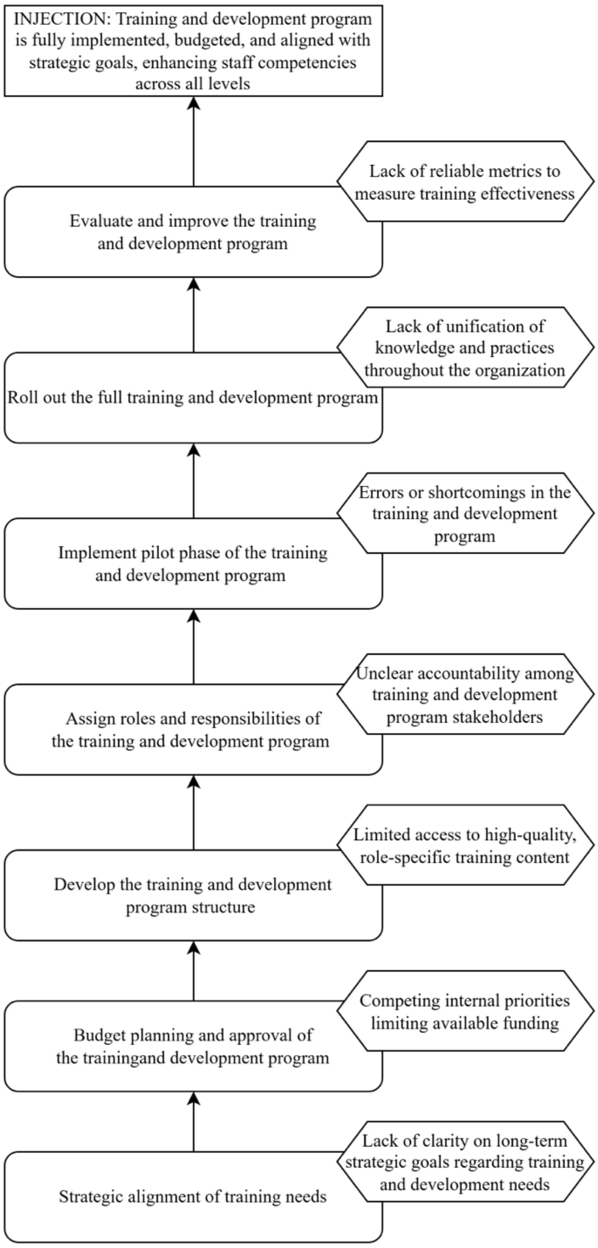

Fig. 6 Prerequisite Tree (PRT) to identify and overcome obstacles during injection implementation

The ultimate goal of a company is to fully implement, budget, and align a training and development program with strategic goals, empowering employees at all levels (Critical Injection). To achieve this goal, the company must take a series of actions and overcome obstacles in implementing these actions. The first step in implementing the Critical Injection is to strategically align training needs, which overcomes the obstacle of lack of clarity about long-term strategic goals for training and development needs. Second, the company must budget and approve training needs, which resolves the obstacle of competing internal priorities that limit available funds. The next step is to develop a training program structure, which is a consequence of limited access to high-quality, role-specific training content. Next, the company should assign roles and responsibilities for the training and development program, which is a consequence of unclear accountability among the stakeholders of such a program. The next step is to pilot the training and development program, which is a consequence of possible errors or shortcomings in the full program. This phase allows the methodology, training materials, and delivery to be refined before the program is implemented more broadly. The next step, implementing a full training and development program, overcomes the obstacle of a lack of uniform knowledge and practices across the organization. The final step is evaluating and refining the training and development program, which overcomes the obstacle of a lack of reliable metrics to measure training effectiveness. In summary, the PRT revealed all the obstacles the company must overcome to implement a training and development program that is fully implemented, on budget, aligned with strategic goals, and enables employees at all levels to perform their proper roles.

Summarizing, implementing work instructions at each workstation in the company requires a comprehensive approach, including both training and the development of an organizational culture based on continuous improvement. The key action that needs to be taken is investment in management training and employee development. Particular emphasis should be placed on creating a culture of knowledge sharing that will allow for the effective implementation and functioning of work standardization and maintaining a high level of quality and efficiency of production processes [45]. Implementing work standards is essential, but it is equally important to ensure their proper functioning. Standards should not only be established, but also regularly reviewed and updated to reflect changes in processes. Training for management staff should include modern quality management solutions, including work standardization tools, which will constitute the basis for implementing consistent instructions at all positions. Employees should also be involved in this process, which will ensure their involvement in the process of creating instructions and better adaptation of instructions to real working conditions. In order to ensure the long-term effectiveness of the implemented standards, it is necessary to create a system of rewards and recognition for above-standard activity in creating and updating work instructions. The management staff, in cooperation with employees, should develop a set of "good practices", i.e. proven and effective actions, procedures and standards supporting quality, efficiency and safety of work. Standard work instruction documents should constitute the company's "know-how" and be the basis for further improvement of processes. For this purpose, it is necessary to conduct a thorough analysis of the course of technological processes, including key information for employees, such as: sequence of operations, their duration, required equipment, critical control points, potential quality problems. This knowledge should be collected in standard work documents (e.g. SOS – Standard Operating Sheet, WES – Work Element Sheet, OPL – One Point Lesson), which will enable employees to correctly perform technological operations. To effectively implement work standardization, it is also necessary to equip management staff with soft skills, especially in the area of: stimulating creativity, effective problem-solving skills, effective communication. Developing an employee competency matrix will help identify skill gaps and determine areas requiring further training. Taking the above actions will ensure effective implementation and maintenance of work instructions at each workstation, which will translate into increased quality, efficiency and stability of production processes in the analysed company. Maintaining the stability of the production process and ensuring predictable results also requires efficient machines and devices and reliable quality control processes [46]. Assessment of the technical condition of machines and devices [47] is a necessary first step on the way to ensuring stability and predictability of processes from the a technical resources perspective. Additionally, analysis of the impact of effective time management on the efficiency of workstations [48], striving for sustainable development [49, 50, 51] by, among others, implementing the principles of the circular economy [52] and reducing the risk of non-compliance in the production process [53, 54] will increase the operational efficiency of the enterprise and improve the quality of products.

To ensure that the changes implemented are sustained and continually improved over time, the company plans to implement periodic internal audits to monitor compliance with standard procedures and ensure that work instructions remain current. Key performance indicators (KPIs) such as training completion rates, error rates, and process compliance metrics will be monitored regularly to assess ongoing effectiveness. In addition, the organization intends to implement change management practices, cross-functional review meetings, and ongoing coaching for team leaders. These mechanisms will be designed to reinforce a culture of continuous improvement and prevent regression to previous habits.

Based on the use of thinking tools in the surveyed enterprise and feedback from employees involved in their creation, a summary of advantages and limitations of using TOC Thinking Process Tools (TOC-TPT) was prepared, which was presented in Table 3.

As can be seen from the presented comparison of TOC-TPT advantages and limitations, their implementation in an organization is not an easy task. Using these tools requires specialist knowledge from employees, acquired during training, as well as the involvement of the entire team. The implementation process must be clearly supported by management, primarily due to the need to provide an appropriate amount of time and resources.

Table 3
Summary of TOC-TPT Benefits and Limitations

Advantages	Limitations
They provide a logical framework for identifying constraints and understanding the cause-effect relationships between them	They require deep understanding and training
They help determine which constraints have the greatest impact on the organization's performance, allowing you to focus your efforts on eliminating them and improving processes	They are laborious to develop and conduct thorough analyses
They help identify the fundamental causes of key organizational constraints, the elimination of which will allow the company to increase throughput and efficiency	They are largely based on subjective team judgment, without empirical support
They promote teamwork, cooperation between different departments of the organization, which facilitates better coordination of activities and joint decision-making	They require cultural and organizational commitment
They support the philosophy of continuous improvement (POOGI), enabling the systematic elimination of constraints, which translates into long-term improvements in key performance	In organizations with highly volatile environments, where constraints can change rapidly, their use may be less effective because the process of developing them takes time
They can be applied in different sectors and for different types of problems, making them a universal tool for managing constraints in the organization	They are specific and may be difficult to integrate with other quality management methods, which limits their universality

It is necessary to establish a small, cross-functional team that will be trained and will be responsible for the implementation of TOC-TPT. Starting the implementation from a pilot strategic area of the company can bring measurable benefits and provide evidence of the effectiveness of these tools even before their widespread use in the organization. Indicating specific results – such as identifying the root causes of limitations, eliminating systemic bottlenecks and achieving breakthrough improvements in line with the strategic goals of the company – will increase the chance of engaging management in further implementation. Through active, teamwork on the use of TOC-TPT, employees will gain a sense of common action towards clearly defined organizational goals. For this process to be successful, it is also necessary to support management in the form of motivators – both financial and non-financial - that will encourage employees to actively participate in the implementation of TOC-TPT. TOC-TPT will not only support solving key organizational problems, but also build a common language of thinking and acting throughout the company. This can be a significant competitive advantage for the company in the form of having effective know-how to solve key and complex problems and faster achievement of organizational goals.

In conclusion, it should be stated that this study was based on a single case from the machinery industry, which limits the possibility of generalizing the results. In addition, the effectiveness of the proposed solutions was not assessed in a longer time perspective. The study also did not include a quantitative analysis of the costs and resources necessary to implement TOC-TPT tools, as well as a data analysis comparing operational indicators (KPIs) before and after the implementation of TOC-TPT tools. Due to the nature of the study and the limited time of observation and analysis, only qualitative analysis was focused on. The main goal of the study was to investigate the methodological application of TOC thinking tools in diagnosing and solving organizational constraints. Future research will aim to fill the above gaps.

CONCLUSIONS

The aim of the study was to present the application of Theory of Constraints (TOC) and its Thinking Process Tools (TPT) in managing and eliminating key constraints in a selected company from the machinery industry. The study aimed to demonstrate how TOC-TPT can be effectively used to diagnose and improve production processes by identifying, analyzing and solving constraints that limit the operational performance of the company. To achieve this aim, the study used a case study methodology, focusing on a machinery manufacturing company specializing in bearing cages.

The literature review highlighted the importance of TOC in improving operational efficiency and the effectiveness of TOC Thinking Process tools in identifying and eliminating constraints in various industries. It was also emphasized that constraints are dynamic and may change over time, which requires continuous monitoring of constraints and eliminating them.

In the study, management interviews, process observations and KPIs analysis were used to identify the most important constraints in the company's production system. The TOC Thinking Process tools used in the study included Goal Tree (GT), Current Reality Tree (CRT), Evaporating Cloud (EC), Future Reality Tree (FRT), and Prerequisite Tree (PRT). These tools enabled the analysis of the main constraints and the formulation of targeted solutions. The study demonstrated the effectiveness of TOC tools in managing constraints and presented an approach to solving them.

The study identified three key constraints in the production department of the examined company:

1. High diversity of manufactured elements, leading to frequent and costly machine retooling.
2. Lack of job instructions, resulting in inefficient knowledge transfer and operational inefficiencies.
3. Inefficient information flow, causing delays in decision-making and increased operational costs.

Using TOC-TPT, the study showed that investment in management training and employee development is a basic requirement to solve these constraints. The analysis showed that insufficient training led to poor work standardization, inefficient knowledge sharing, lack of accountability and insufficient data on technological processes. By eliminating these constraints, the company will achieve better operational efficiency, process effectiveness and product quality.

Key detailed findings from the study include:

- The lack of standardized work instructions is a critical constraint that negatively impacts production efficiency and knowledge management in the study company.
- The lack of clear accountability for creating and updating work instructions leads to process inconsistencies and operational inefficiencies.
- Properly trained managers play a key role in driving continuous improvement and ensuring the sustainability of work standardization efforts.
- Allocating a dedicated budget and resources for a structured, ongoing training and development program that aligns with strategic goals and builds both technical and interpersonal skills at all levels of staff will effectively address the studied organizational constraints.
- Creating a dedicated job position in the form of a Quality Management Coordinator and appointing a trained employee from the study company with the appropriate personal profile to this position will increase the effectiveness of the company's quality management system.
- When implementing solutions to eliminate constraints, attention should be paid to obstacles that may limit the final effects of these solutions.
- Effective implementation of this demanding method of continuous improvement (TOC-TPT) requires active support from management, an attractive motivational system, appropriate spending of time and resources on training and dissemination of tools in key strategic areas of the organization.

Additional general findings from the study suggest that:

- Implementing work instructions should be part of a culture of continuous improvement and knowledge sharing to ensure long-term effectiveness.
- Encouraging a culture of continuous improvement and knowledge sharing fosters employee engagement and contributes to organizational learning.
- Effective resolution of internal conflicts is possible through win-win negotiation strategies facilitated by TOC tools.
- Companies should adopt a systematic approach to managing constraints by incorporating TOC tools into their strategic decision-making processes.

Future research will include a cost-effectiveness perspective and tracking quantitative performance measures over time to provide more solid evidence for the effectiveness and sustainability of TOC-based improvements. They will also focus on comparative analysis between TOC and other process improvement methodologies such as Lean Management, Six Sigma, or TRIZ to identify which tools are most effective for specific types of organizational constraints. Finally, developing a standard framework for monitoring and sustaining improvements can help companies incorporate TOC-TPT tools into their long-term operational strategy. Additionally, the integration of modern decision-support methods, such as artificial intelligence and reinforcement learning in production planning [55], may further enhance the effectiveness of constraint management by providing data-driven recommendations and automating complex optimization tasks.

REFERENCES

[1] Berry, R., Smith, L. (2005). Conceptual foundations for the theory of constraints. *Human Systems Management*, 24(1), 83-94. https://doi.org/10.3233/hsm-2005-24107

[2] Gupta, M. Boyd, L. (2008). Theory of constraints: a theory for operations management. International *Journal of Operations & Production Management*, 28(10), pp. 991-1012. https://doi.org/10.1108/01443570810903122

[3] Knop, K. (2019). Elimination of constraints in the production process of power equipment components and the analysis of the resulting benefits. *Production Engineering Archives*, 24(24), pp. 37-42. https://doi.org/10.30657/pea.2019.24.09

[4] Dettmer, H.W. (1997). Goldratt's Theory of Constraints: A Systems Approach to Continuous Improvement. Milwaukee: ASQC Quality Press.

[5] Knop, K. (2024). Using the theory of constraints thinking process tools to solve critical problems in the organization. Scientific Papers of Silesian University of Technology. *Organization and Management Series*, 197, pp. 305-331. https://doi.org/10.29119/1641-3466.2024.197.18

[6] Scheinkopf, L. (2010). Thinking Process Including S&T Trees. In: J.F. Cox III, J.G. Schleier (Eds.), Theory of Constraints Handbook (pp. 729-786). New York, NY: McGraw-Hill.

[7] Mabin, V. Balderstone, S. (2003). The performance of the theory of constraints methodology. International *Journal of Operations & Production Management*, 23(6), pp. 568-595. https://doi.org/10.1108/01443570310476636

[8] Sahin, A. (2024). Root cause analysis of quality issues in watch manufacturing using ishikawa and pareto diagrams. Archives of Engineering Knowledge, 10(1), pp. 18-23. https://doi.org/10.30657/aek.2024.10.4

[9] Pacheco, D., Pergher, I., Antunes, J., Vaccaro, G. (2019). Exploring the integration between lean and the theory of constraints in operations management. *International Journal of Lean Six Sigma*, 10(3), pp. 718-742. https://doi.org/10.1108/ijlss-08-2017-0095

[10] Biadacz, R. (2024). Application of Kaizen and Kaizen Costing in SMEs. *Production Engineering Archives*, 30(1), pp. 17-35. https://doi.org/10.30657/pea.2024.30.2

[11] Bauer, J., Vargas, A., Sellitto, M., Souza, M., Vaccaro, G. (2019). The thinking process of the theory of constraints applied to public healthcare. *Business Process Management Journal*, 25(7), pp. 1543-1563. https://doi.org/10.1108/bpmj-06-2016-0118

[12] Gaspar, M., Cristovão, L., Tenera, A. (2019). Theory of constraints thinking processes on operational lean programs management improvement: an energy producer company case. pp. 125-142. https://doi.org/10.1007/978-3-030-17771-3_11

[13] Ikeziri, L., Souza, F., Gupta, M., Fiorini, P. (2018). Theory of constraints: review and bibliometric analysis. *International Journal of Production Research*, 57(15-16), pp. 5068-5102. https://doi.org/10.1080/00207543.2018.1518602

[14] McMullen, T. (2013). Introduction to the theory of constraints (toc) management system. https://doi.org/10.1201/b14833

[15] Watson, K., Blackstone, J., Gardiner, S. (2006). The evolution of a management philosophy: the theory of constraints. *Journal of Operations Management*, 25(2), pp. 387-402. https://doi.org/10.1016/j.jom.2006.04.004

[16] Irasuegi, A., Lizarralde, A., Amorrortu, I., Apaolaza, U. (2021). Theory of constraints case study in the make to order environment. *Journal of Industrial Engineering and Management*, 14(1), 72. https://doi.org/10.3926/jiem.3283

[17] Simatupang, T., Wright, A., Sridharan, R. (2004). Applying the theory of constraints to supply chain collaboration. *Supply Chain Management an International Journal*, 9(1), pp. 57-70. https://doi.org/10.1108/13598540410517584

[18] Smith, M. Pretorius, P. (2012). Applying the theory of constraints to increase economic value added: part 2 implementation. *The South African Journal of Industrial Engineering*, 13(2). https://doi.org/10.7166/13-2-309

[19] Dettmer, H.W. (2007). The Logical Thinking Process: A Systems Approach to Complex Problem Solving. Milwaukee: ASQ Quality Press.

[20] Inman, R., Sale, M., Green, K. (2009). Analysis of the relationships among toc use, toc outcomes, and organizational performance. *International Journal of Operations & Production Management*, 29(4), pp. 341-356. https://doi.org/10.1108/01443570910945819

[21] Ehie, I., Sheu, C. (2005). Integrating six sigma and theory of constraints for continuous improvement: a case study. *Journal of Manufacturing Technology Management*, 16(5), pp. 542-553. https://doi.org/10.1108/1741038051060051

[22] Kohli, A., Gupta, M. (2010). Improving operations strategy: application of toc principles in a small business. *Journal of Business & Economics Research* (Jber), 8(4). https://doi.org/10.19030/jber.v8i4.713

[23] Pegels, C., Watrous, C. (2005). Application of the theory of constraints to a bottleneck operation in a manufacturing plant. *Journal of Manufacturing Technology Management*, 16(3), pp. 302-311. https://doi.org/10.1108/17410380510583617

[24] Abdi, M., Hasanzadeh, A., Fani, A., Poor, S. (2014). Exploring the bottleneck of iran's national innovation system by toc thinking process. *Technological and Economic Development of Economy*, 20(4), pp. 601-623. https://doi.org/10.3846/20294913.2014.880960

[25] Sahraoui, A. Elarref, M. (2014). Bed crisis and elective surgery late cancellations: an approach using the theory of constraints. *Qatar Medical Journal*, 2014(1). https://doi.org/10.5339/qmj.2014.1

[26] Kim, S., Mabin, V., Davies, J. (2008). The theory of constraints thinking processes: retrospect and prospect. *International Journal of Operations & Production Management*, 28(2), pp. 155-184. https://doi.org/10.1108/01443570810846883

[27] Sadat, S., Carter, M., Golden, B. (2012). Theory of constraints for publicly funded health systems. *Health Care Management Science*, 16(1), pp. 62-74. https://doi.org/10.1007/s10729-012-9208-9

[28] Reid, R., Cormier, J. (2003). Applying the toc tp: a case study in the service sector. *Managing Service Quality*, 13(5), pp. 349-369. https://doi.org/10.1108/09604520310495831

[29] Grida, M. Zeid, M. (2018). A system dynamics-based model to implement the theory of constraints in a healthcare system. *Simulation*, 95(7), pp. 593-605. https://doi.org/10.1177/0037549718788953

[30] Songkhwan, S., Meathawiroon, C. & Thunyachairat, A. (2025). The influence of lean manufacturing and green supply chain management on firm performance: the mediating role of supply chain resilience. *Production Engineering Archives*, 31(1), pp. 41-53. https://doi.org/10.30657/pea.2025.31.4

[31] Scheinkopf, L.J. (1999). Thinking for a change: Putting the TOC thinking processes to use. Boca Raton, FL: St. Lucie Press.

[32] Mabin, V. Cavana, R. (2024). A framework for using theory of constraints thinking processes and tools to complement qualitative system dynamics modelling. System Dynamics Review, 40(4). https://doi.org/10.1002/sdr.1768

[33] Reid, R. (2007). Applying the toc five-step focusing process in the service sector. *Managing Service Quality*, 17(2), pp. 209-234. https://doi.org/10.1108/09604520710735209

[34] Upreti, N., Sunder, R., Dalei, N., Garg, S. (2019). Application of theory of constraints to foster the services of indian power transmission system. *International Journal of Energy Sector Management*, 14(3), pp. 547-568. https://doi.org/10.1108/ijesm-05-2019-0007

[35] Aljaž, T. (2024). Leveraging chatgpt for enhanced logical analysis in the theory of constraints thinking process. *Organizacija*, 57(2), pp. 202-214. https://doi.org/10.2478/orga-2024-0014

[36] Stopka, O., Zitrický, V., Ľupták, V., Stopková, M. (2023). Application of specific tools of the theory of constraints – a case study. *Cognitive Sustainability*, 2(1). https://doi.org/10.55343/cogsust.48

[37] Mabin, V., Davies, J., Cox, J. (2006). Using the theory of constraints thinking processes to complement system dynamics' causal loop diagrams in developing fundamental solutions. *International Transactions in Operational Research*, 13(1), pp. 33-57. https://doi.org/10.1111/j.1475-3995.2006.00532.x

[38] Lacerda, D., Cassel, R., Rodrigues, L. (2010). Service process analysis using process engineering and the theory of constraints thinking process. *Business Process Management Journal*, 16(2), pp. 264-281. https://doi.org/10.1108/14637151011035598

[39] Gupta, M., Lowalekar, H., Chaudhari, C., Groop, J. (2024). A design science approach to manage spare parts distribution: combining design logic and goldratt's thinking processes. International *Journal of Physical Distribution & Logistics Management*, 54(7/8), pp. 775-801. https://doi.org/10.1108/ijpdlm-08-2023-0288

[40] Shoemaker, T.E., Reid, R.A. (2005). Applying the TOC Thinking Process: A Case Study in the Government Sector. *Human Systems Management*, 24(1), pp. 21-37. https://doi.org/10.3233/HSM-2005-24104

[41] Gupta, M.L., Boyd, H., Kuzmits, F. (2011). The Evaporating Cloud: A Tool for Resolving Workplace Conflict. *International Journal of Conflict Management*, 22(4), pp. 394-412. https://doi.org/10.1108/10444061111171387

[42] Yin, R.K. (2003). Case Study Research: Design and Methods, Sage Publications, Thousand Oaks, CA.

[43] Schmidt, P. (2021). Jak rozpierTOCić system? Praktycznie i bez ograniczeń, Instytut Zarządzania Ograniczanimi TOC+, Drukma Sp. j., Komorniki.

[44] Swann, C., Jackman, P. C., Lawrence, A., Hawkins, R. M., Goddard, S. G., Williamson, O., Ekkekakis, P. (2022). The (over)use of SMART goals for physical activity promotion: A narrative review and critique. *Health Psychology Review*, 17(2), pp. 211-226. https://doi.org/10.1080/17437199.2021.2023608

[45] Stasiak-Betlejewska, R., Ali, A. (2024). The Product and Process Quality Level Analysis in the Automotive Elements Production Management. *Management Systems in Production Engineering*, 32(4), pp. 514-524. https://doi.org/10.2478/mspe-2024-0049

[46] Cieśla, J., Ulewicz, R. (2024). The Future of Automotive Quality Control: How Cloud-Based Reporting is Changing the Game, *Management Systems in Production Engineering*, 32(1), pp. 72-79. https://doi.org/10.2478/mspe-2024-0008

[47] Biały, W. (2024). Assessment of the technical state of mining machinery and devices with the use of diagnostic methods. *Production Engineering Archives*, 30(2), pp. 266-272. https://doi.org/10.30657/pea.2024.30.26

[48] Krynke, M. (2023). Analysis of the Impact of Effective Time Management on Workstation Efficiency Using a Multi-Criteria Optimization Approach. *Management Systems in Production Engineering*, 31(3), pp. 306-311. https://doi.org/10.2478/mspe-2023-0034

[49] Ingaldi, M., Ulewicz, R. (2025). Sustainable Development and Technological Advancements in Industry 4.0: Overcoming Barriers in SME Sector Integration. *Management Systems in Production Engineering*, 33(1), pp. 144-162. https://doi.org/10.2478/mspe-2025-0015

[50] Czajkowska, A., Ingaldi, M. (2019). Analysis of the impact of individual phases in the building process cycle on the environment with respect to the principles of sustainable development. *IOP Conf. Ser.: Earth Environ*. Sci. 214 012012. https://doi.org/10.1088/1755-1315/214/1/012012

[51] Czajkowska, A., Ingaldi, M. (2023). Analysis of the survey results on the pro-ecological awareness of young people in the aspect of sustainable development. *Management Systems in Production Engineering*, 31(3), pp. 312-321. https://doi.org/10.2478/mspe-2023-0035

[52] Ingaldi, M., Ulewicz, R. (2024). The Business Model of a Circular Economy in the Innovation and Improvement of Metal Processing. *Sustainability*, 16(13), 5513. https://doi.org/10.3390/su16135513

[53] Szczyrba, A., Ingaldi, M. (2024). Implementation of the FMEA Method as a Support for the HACCP System in the Polish Food Industry. *Management Systems in Production Engineering*, 32(3), pp. 357-371. https://doi.org/10.2478/mspe-2024-0034

[54] Szyszka, M., Ulewicz, R. (2024). Quality improvement in bottle production: a case study on FMEA and Pareto-Lorenz methodologies. *Archives of Engineering Knowledge*, 10(1), pp. 148-152. https://doi.org/10.30657/aek.2024.10.21

[55] El Marzougui, M., Messaoudi, N., Dachry, W. & Bensassi, B. (2024). A Model for Decision-making to Parameterizing Demand Driven Material Requirement Planning Using Deep Reinforcement Learning. *Production Engineering Archives*, 30(3), pp. 377-393. https://doi.org/10.30657/pea.2024.30.37

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