Innovating Through Disruption: A Blend of TRIZ Principles and Classical Problem-Solving Models for Agile Solutions

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Abstract. *We are living fast-changing times, and especially in the context where businesses want to remain competitive, they must adopt and implement tailored problem-solving approaches to navigate modern disruptions. In this research, the authors are presenting and proposing the integration of TRIZ's Contradiction Matrix and 40 Inventive Principles for generating solutions of the identified root causes after using classical problem-solving models, as literature and experience show how struggling is to brainstorming actions when faced with a technical contradiction after the root cause analysis. By combining these approaches, companies can develop agile, systematic, and inventive solutions that drive their business to success. Literature has highlighted how powerful TRIZ is by itself, but not how enriching it can be when introducing principles of it in one of the steps of the classical problem-solving methodologies. This paper revolves around the question of how the solutions generated with problem-solving methods can eradicate the identified root cause and prevent recurrence when dealing with technical contradictions. Consequently, the authors have made a thorough literature review on the most used models and their supporting tools for generating solutions. A comparative analysis highlighting the advantages and disadvantages of classical methods has been performed to pave the way to the existing need for a stronger approach to problem eradication through powerful solutions. The article presents a case study from a manufacturing company, starting from a case already tackled through an 8D Report, but where there were challenges in finding a solution for the identified technical contradiction that would eradicate the problem. A case study using the hybrid model is presented without having a result after the action implementation, offering a roadmap for organizations seeking to lead change in a disruptive landscape.*

Keywords: TRIZ, Contradiction Matrix, 40 Inventive Principles, Agile Problem Solving, Problem Solutions.

Introduction

In one of his studies, Sewpersadh highlights how everything changed in the business environment after the pandemic and how easily, from that point on, we can face disruption on a global level (2023). In this context, businesses must understand how to reshape themselves overnight, as time is no longer on their side and problem-solving is an essential pillar in this matter. Traditional methods and their affiliated tools usually struggle to keep pace with the speed and complexity of modern problems. So, how can businesses go from firefighting to fire prevention regarding the technical challenges encountered? The answer is by ensuring sustainable solutions that would not only fix the problem temporarily but would eradicate even the most difficult to tackle issues.

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In the manufacturing industry, a wide number of problem-solving models have been integrated and personalized, and literature has spotlighted with a higher frequency of usage for some of them. 8D (disciplines), with the primary objective to eradicate the root cause of the defect responsible for the issues (Krajnc, 2012), followed closely by the A3 methodology, born from Deming's PDCA (plant-do-check-act), with the purpose of process improvement, found in different shapes according to the enterprise using it (Grobelna and Wasilewska, 2023), are two of the most used in practice methods. Six Sigma is also one of the first options encountered in companies in terms of problem-solving applications. Back in 2012, Gygi and Williams were describing how the world's top manufacturing corporations at that moment used this powerful tool to increase their profits by improving their process and eliminating issues. In his problem-solving models, Nickols (2020) highlights, besides the three models already mentioned, the K-T (Kepner-Tregoe) method, a process in stages for successfully solving problems and facilitating decision making in companies. The same author has listed in his classification the Six-Step Model, its uniqueness being the repeatable nature of the six steps.

All these methodologies have a step-by-step approach and aim to solve technical issues, as our focus is the problems encountered in the manufacturing companies. Despite their ability to identify root causes and brainstorm possible solutions, they lack the ability to solve technical contradictions and eliminate the defect.

In this article, the authors are exploring the possibility of integrating the 40 Inventive Principles of the well-rooted TRIZ (Theory of Inventive Problem Solving) with the generation of possible solutions for the identified root causes from traditional models for the problem-solving. This would be a powerful mixture, allowing the practitioners of problem-solving to benchmark patents already installed and use them as a basis for generating innovative actions.

Mahto (2013) writes about TRIZ approaching problem-solving in a scientific manner, compared to any other problem-solving technique available at the time, treating problems as inventive challenges and linking strategies to generate solutions. After a decade, Al-Dwairi (2023) has categorized TRIZ as a systematic problem-solving methodology based on the principle that similar challenges have been encountered and successfully resolved in the past. What none of the authors highlight is that a key strength of TRIZ thinking and its tools lies in the ability to shift between real-world problems and a more abstract, conceptual perspective by using one of TRIZ's tools, "The Prism of TRIZ", as explained in Figure 1.

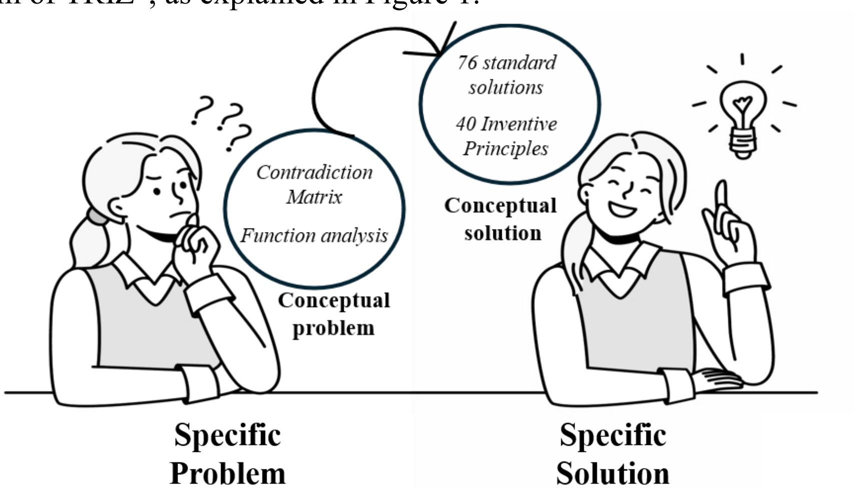

Figure 1. "Prism of TRIZ" interpretation

Source: Authors' own research.

What is really the peculiarity of TRIZ is its fight against technical and physical contradictions. Contradictions are usually the output of the solutions generated through classical problem-solving approaches, where the actions proposed are helpful from one point a view, but harmful from another. Engineers have been fighting contradictions and TRIZ Inventive Principles have been exactly the tools needed to solve them. So why not include them as a tool to generate solutions, and solve contradictions within any of the problem-solving models used traditionally?

Despite its proven success, TRIZ has not been classified as the most preferred problem-solving model, due to its complexity and high number of tools implied, and literature has highlighted mostly its use alone, but not combined with other problem-solving tools. For our research, we are focusing on one of the outmost influential tools of TRIZ, the Contradiction Matrix, amongst the first developed to address conflicts in technical systems, particularly those involving technical or physical contradictions. It provides a structured approach by suggesting Inventive Principles for each parameter that needs improvement, helping to resolve conflicts by enhancing that one aspect may lead to the deterioration of another, enabling problem solvers to find innovative solutions without compromising other critical factors (Ross, 2006). However, it must be mentioned that the Inventive Principles only suggest general principles, which must be analyzed afterwards and personalized accordingly to the situation encountered. Returning to the Prism of TRIZ, depicted in Fig. 1, these principles generated must be taken from the conceptual solution to your specific solution, so using this tool implies a high-level of knowledge of its principles, and technical knowledge of the process in discussion.

The Contradiction Matrix maps 39 parameters (regarding shape, structure and others) for which solutions to the contradictions have been found. Today, all this information gathered back then has been digitized, and now any person or company can access the Matrix, the Principles and generate online solutions.

Literature review

Problem-solving is universally defined by solutions. The basic expectation one has when applying any method for problem solving is to generate improvement actions for the difficulty tackled. Literature has alluded that no matter the model used, what all of them have in common is a step for solution generation, consisting of different tools and approaches.

In his research regarding the 8D method, Krajnc (2012) mentions that step five (D5) of the procedure is where "basically" a preventive measure is proposed to permanently solve the issue. For Six Sigma, which uses the DMAIC approach (Define-Measure-Analyze-Improve-Control), the improve phase concentrates on improvement actions. What is particular about Six Sigma is its openness to additional techniques in each of its proposed steps, to adapt to other domains such as supply chain management issues or financial ones (De Mast, Lokkerbol, 2012). The A3 methodology, based on Toyota's TPS (Total Production System), tackles in step "Develop Countermeasures" the actions that should, at least in theory, remove the root cause of the problem and return the process to its original state or even enhance it (Filho, Simão, 2023). In a slightly different manner, the Kepner-Tregoe procedure has its "Decision Analysis", where all the information gathered is used to make a series of comparisons to find out the best solutions (Hall, 2013). When researching the Six-Step Model for problem-solving, we have seen that in its step 3 solution are generated (Nickols, 2020).

In Table 1, an overview of some of the most known and used problem-solving methods in manufacturing companies is depicted, and what it highlighted is that each of them has a specific step in which solutions are generated. They are all using diverse tools for generating these solutions, and these tools have their advantages and disadvantages when applied to difficult technical issues.

Table 1. An overview of the solution step in problem-solving models

Method	Steps	Solution Generation Step	Tools for solution generation	Advantages of tools used	Disadvantages of the tools used
8D Report	D1 – Create a team D2 – Define the problem D3 - Containment actions D4 - Root Cause Analysis D5 - Develop permanent solutions D6 - Implement the permanent solutions D7 - Prevent recurrence D8 - Recognize the team success	D5 phase focuses on developing and selecting corrective actions to address the root causes.	Brainstorming, Failure Mode and Effects Analysis (FMEA), Fishbone Diagram, and 5 Whys (input for the actions generation).	Uses risk assessment (FMEA) to validate and prioritize solutions.	It can be time-consuming due to detailed risk assessment, and the input from step D4 might not be sufficient to brainstorm the necessary actions.
DMAIC (Six Sigma)	Define, Measure, Analyze, Improve, Control	The improve phase focuses on generating solutions based on statistical analysis and process optimization.	Design of Experiments, Benchmarking, Simulation, Pugh Matrix	Data-driven approach ensures solutions are measurable and validated.	Too analytic, limiting creativity as it only focuses on process data.
A3 Report	Step A - Identify Problem Step B - Root Cause Analysis Step C - Develop Countermeasures and implement them Step D - Evaluate and standardize	In step C, we develop countermeasures.	5 Whys, Value Stream Mapping, Fishbone Diagram, Brainstorming, Effort-Effect matrix for deciding on an action	Visual and structured, it makes solutions easy to track and to understand their benefit reported to the effort needed	Might oversimplify problems, missing deeper, innovative solutions.

Method	Steps	Solution Generation Step	Tools for solution generation	Advantages of tools used	Disadvantages of the tools used
Kepner-Tregoe	Situation Appraisal, Problem Analysis, Decis ion Analysis, Potential Problem Analysis	The Decision Analysis step systematically evaluates potential solutions based on risks and benefits.	Decision Matrix, Risk Analysis, Decision Trees, Cause-and-Effect Analysis	Highly structured, reduces bias in solution selection.	It can be rigid and slow, limiting creativity.
Six-Step Model	Step 1- Identify Problem Step 2 - Analyze Data Step 3 - Generate Solutions Step 4 - Evaluate Options Step 5 - Implement Step 6 - Monitor Results	The Generate Solutions step is where actions are defined within this methodology.	Brainstorming, Force Field Analysis, SWOT Analysis	Simple and adaptable, allows for multiple solution perspectives	Lacks technical depth analysis for complex or highly technical problems

Source: Authors' own research.

All these methodologies presented above are using up to an extent the same type of supporting tools for generating solutions: Brainstorming, SWOT analysis, Decision Matrix, Benchmarking, etc. But are these sufficient when a tough, technological topic needs a solution? As highlighted in the above table, they all have their downsides. Some of them lack the depth needed in such complicated cases, others are too rigid, and most of them are time-consuming. Isn't it our goal, in today's fast-evolving world, to make use of what technology and innovation have brought to ease our search for the greatest solution to the difficulty encountered in our manufacturing process?

The conclusion of this literature review is that solution generation is an imminent step in problem-solving, but sometimes the traditional tools that stand as a support are not sufficient to generate the solution that would completely eradicate the problem. So far, the literature has only alluded to the use of several tools, but as not proposed, as this current research is doing, to the merging of two different problem-solving models and their principles in generating solutions that would solve either technological contradictions or highly complicated problems. And the goal is not only to integrate TRIZ's Contradiction Matrix and Inventive principles in this action searching step, but also to elevate it to the next logical advancement: using the online tool, free to use by any person or company.

Methodology

In this research, a blend of existing literature review and comparative analysis is undertaken for the solution generation step and its associated tools among problem-solving models. This is done as a starting point to answer the research questions addressed ever since the introduction of the article.

Five models have been chosen intentionally, as most articles found and referred to in the references section pointed them out as prone to be used in problem-solving of manufacturing challenges: 8D, A3, Six Sigma, Kepner-Tregoe, and Six-Step Model. These models were born in manufacturing companies (such as Toyota's A3) and are suitable for solution generation that eliminates recurrence. However, the present research points out the weaknesses of these approaches and proposes a TRIZ principles blend regarding solution generation (the Contradiction Matrix and the 40 Inventive Principles). This blend would enhance the company's strategy, and a case study is presented to highlight the possible benefits.

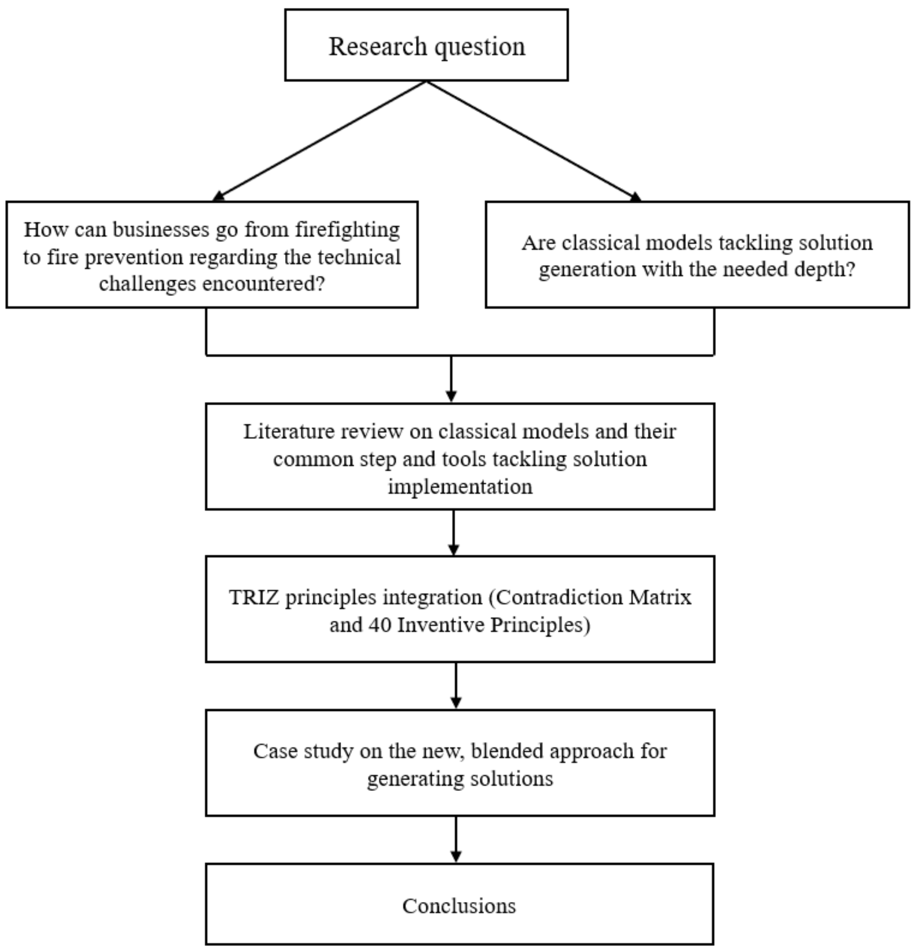

Figure 2. Present research methodology

Source: Authors' own research.

Case study

For the present case study, we are analyzing a persistent issue confronted by a tire manufacturing company from Romania, where customer satisfaction is highly impacted, and although the classical tools and steps from the 8D Report have been implemented, the systemic issue has not been eradicated.

The company is faced with the following complaint: their truck tires wear out too quickly on rough terrain, leading to frequent replacements and higher costs from the field complaints (tires used in the market and after a few kilometers are being complained about). The problem has been analyzed using traditional steps of the 8D problem-solving model, and although the problem has been understood and the technical root cause found out, the expert team working on the case has found a technical contradiction for which they didn't have the tool or knowledge to generate a solution. In Table 2, a short overview of the investigation undertaken so far is presented:

Table 2. 8D Report overview for truck tires worn out too quickly on rough terrain

Step	Step description	Summary
D1: Establish the Team	Form a cross-functional team with diverse expertise.	The team consists of Quality Engineers, R&D Engineers (including raw material and components specialists), Production Engineers, Customer Service, and Supply Management Specialist.
D2: Define the Problem	Clear description of the issue using available data from traceability and customer description	Tires show excessive tread wear within 10000 km, while the expected lifespan is 80000 km. Data available from the field is that 35 complaints were raised in the last 3 months, and in all cases, it's reported a high worn pattern in the tread blocks. Mainly affected articles are truck tires manufactured between July and December 2024, and in total, 2 articles are affected (articles XCJ 200 & XCQ 250), both having a similar construction pattern, and the same compound used. The manufacturing site is located in the Eastern side of Europe, and the complaints are all coming from Turkey as a geographical area.
D3: Containment Actions	Take immediate actions to protect the customer (firewall)	Stop shipments of affected tires; Offer free replacement tires to affected customers; Tire inspection for customer stocks (visual inspection); 100% reinspection of the stock available in the plant warehouse from July to December 2024; Destructive tests done on a tire from current production to compare it with the tires reported by the customers.
D4: Identify and Verify Root Cause	Root cause analysis using the Ishikawa Diagram (see Fig. 3) and Why Why questionnaire	The key discoveries from D4 are that high abrasion from rough surfaces accelerates tread wear. After brainstorming all possible causes and requesting more information regarding the geographical areas and road conditions where the tires were used, the root cause identified

Step	Step description	Summary
		through the why-why questionnaire is that the tread material is too soft for the highly abrasive surface on the roads where the tires have been used.

Source: Authors' own research.

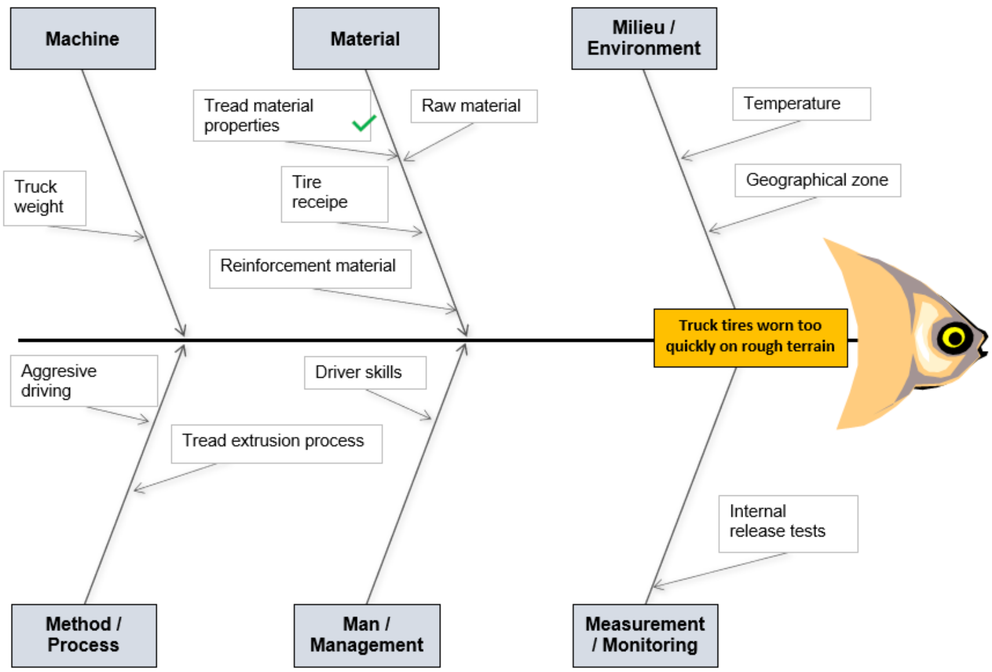

Figure 3. Ishikawa Diagram on truck tires worn too quickly on rough terrain

Source: Authors' own research.

The only solution foreseen to tackle this root cause is to increase tread thickness, which extends durability but increases rolling resistance, reducing fuel efficiency (which leads to a higher consumption). The multidisciplinary team in charge of solving this problem has analyzed the possibility of using a harder compound, which would reduce wear but compromise traction and ride comfort, so they were faced with a contradiction: trying to improve durability without sacrificing fuel efficiency and traction.

As the available tools within the 8D Report in step D5 (Corrective Actions) did not facilitate the team's need for brainstorming a solution that would solve the contradiction, TRIZ principles were applied, using the online database *https://www.triz40.com/TRIZ_GB.php* to generate the most appropriate principles that would generate a conceptual solution for the contradiction identified. The online tool is simplified and only requires you to enter the feature you want to improve and the feature you want to preserve in your system. To apply it to our concrete problem, the prism of TRIZ has been applied, meaning the real contradiction is transformed into a conceptual one. Practically, "trying to improve durability without sacrificing fuel efficiency and traction" has been conceptually transformed. The feature to improve from the list available has been chosen as object-generated harmful, which in our case is sacrificing fuel efficiency and traction, while the feature to preserve from the available list is force (intensity), which in our case is tire durability. Figure 4 depicts the selection of the two variables in the online database for browsing the Contradiction Matrix.

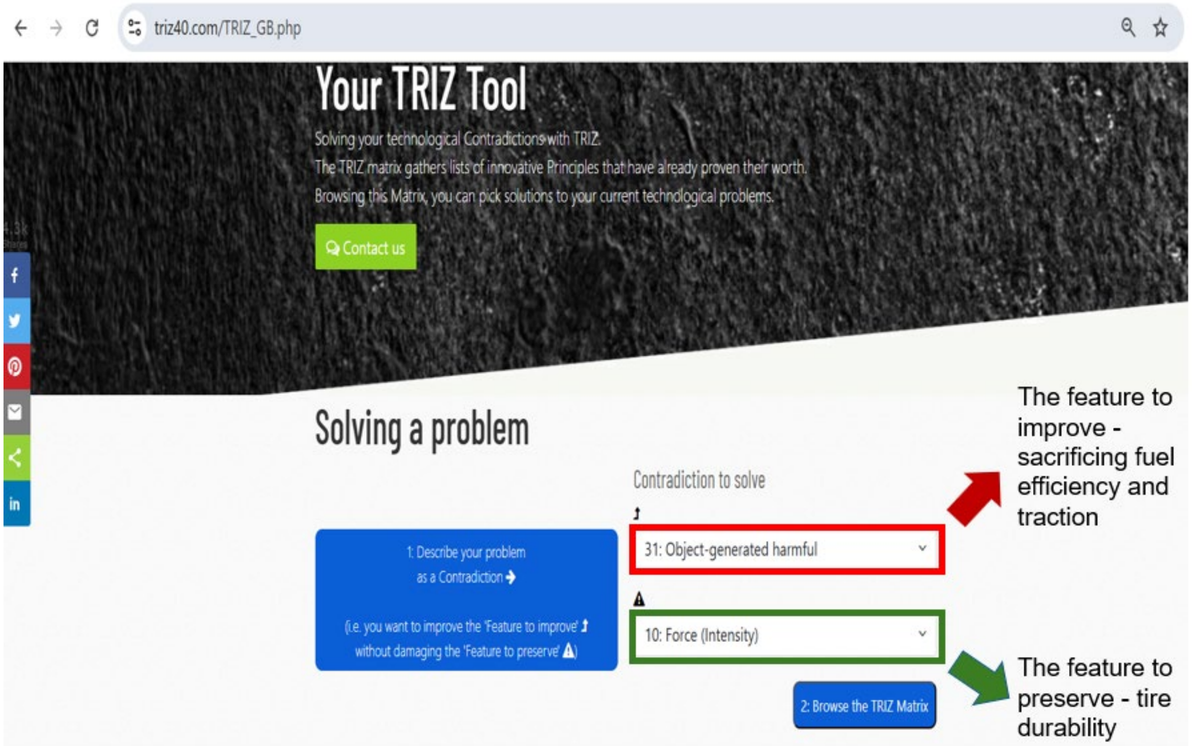

Figure 4. An online tool for the TRIZ Contradiction Matrix applied for generating solutions

Source: Authors' own research.

By applying the Contradiction Matrix, the contradiction identified in the 8D Report (keep durability without compromising efficiency/traction) was matched with the following relevant TRIZ principles, presented in Table 3.

Table 3. Specific solutions overview based on TRIZ principles

Principle	Conceptual solution	Specific solution
1. Segmentation	Splitting a system into multiple sub-systems to isolate one function, or, on the opposite way of thinking, combining several parts of a system where each part is used to do something specific.	In our case, the segmentation principle can be translated into developing a dual-layer tread design: a tough, wear-resistant outer layer for durability and a softer inner layer for better grip (see Figure 5).
28. Mechanics substitution	The main idea would be to substitute mechanical means with sensory ones.	A solution for the detection of the problem rather than its occurrence, which already exists for other types of tires, would a be sensor for the tread wear.

Principle	Conceptual solution	Specific solution
35. Parameter changes	Changing an object's physical state or any of its parameters.	A possible solution would be a changing the curing time of the rubber. A longer curing time for a harder compound. However, multiple tests must be undergone to understand the other properties that might be affected by this change.
40. Composite materials	The goal is to change from uniform to composite materials.	Use of reinforced silica-based compounds that, at least in theory, would improve wear resistance while maintaining flexibility for traction. As for the action above, a full experiment must be started to analyze short- and long-term effects of these changes.

Source: Authors' own research.

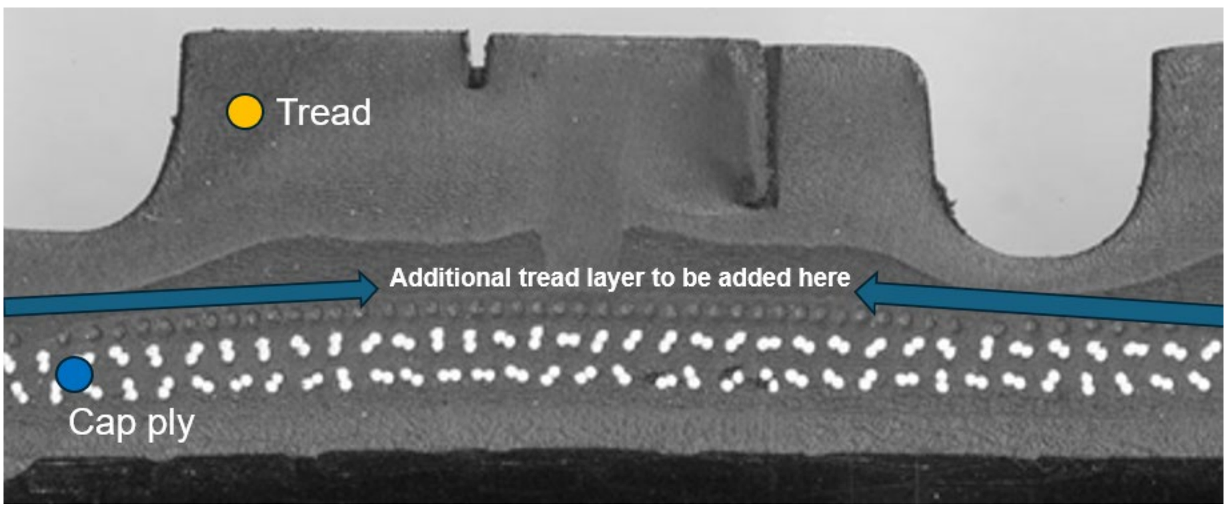

Figure 5. Additional tread layer position simulation on a tire section

Source: Authors' own research.

With the solutions generated by the tool, the management has multiple possibilities from which they can choose, based on different parameters: company know-how, financial impact, time needed for execution (especially for the two solutions where a change in the material or curing time is done and the effects must be analyze for a longer period) etc. For this case study, the best solution generated after team and management evaluation was the dual-layer tread, which is both cost-effective and easier to implement, as the know-how and lessons learned are available in the market. Further on, the implementation and effectiveness of the chosen action is being followed and the expected result is a confirmed extended tire life by 20% without compromising fuel efficiency. Overall, with this action applied, customer satisfaction improves, and the company gains a competitive position in the tire market industry. However, there are no results available of the actual implementation of the chosen solution, only a forecast of the impact it would have if implemented.

Results and discussions

Integrating TRIZ principles in customer complaint resolution transforms reactive fixes into systematic, innovative solutions. This approach not only resolves the issue but also enhances product value and customer loyalty. However, looking at the downsides of the present research, more than one case study is necessary to confirm its usability in such cases. Also worth mentioning for the discussion is that not all contradictions have a principle that generates possible solutions, according to the Contradiction Matrix.

The subjectivity of the person translating the real problem into the conceptual problem and then from the conceptual solution into the real solution is extremely high, and only people with highly technical skills and critical thinking could master this. So, instead of a powerful tool, TRIZ principles could be a waste of time if not interpreted correctly and with proper knowledge.

The future steps of this research foreseen by the authors are implementing the combined methodology of TRIZ with different problem-solving models for various technological challenges. Additionally, as mentioned in the case study, the solution has only been proposed, not yet implemented. This implies that future research should focus on presenting the implementation and effectiveness of the action(s) proposed with the help of TRIZ principles.

Conclusion

In times of disruption, whether due to technological shifts, economic crises, or customer complaints, the organization's triumph is managing the best solutions for their problems.

Since the introduction, the authors have introduced the TRIZ's principles that can be a powerful tool for generating solutions. The Contradiction Matrix and the 40 Inventive Principles, in the form of an online tool that already translates all the information behind these principles, can and should be used in combination with the classical models for problem solving, in the step of solution generation. Traditional problem-solving models (8D, A3, Six Sigma, Kepner-Tregoe, and Six-Step Model), as literature showed, have a similar approach when it comes to the action generation step. The literature review chapter had the intention to bring this aspect to light and, at the same time, to describe the tools used for brainstorming actions. It was revealed that besides their known qualities, these classical approaches have their drawbacks, which are mainly linked to their capacity to answer deep technological root causes.

The case study used for illustration showed the first practical application of the mixture proposed by the authors. An example from the tire industry, where the team in charge of a problem complained in the market, causing the company a lot of losses, has reached a blocking point with the ongoing 8D report initiated. The identified root cause revealed a technical contradiction that could not be solved with the model's tools. By using the online tool of TRIZ, four principles were presented as an option and translated into the real solution to be implemented. By implementing it, the company would offer a 20% increase in life durability for their truck tires, although the study does not incorporate results after implementation, which necessarily implies further research to prove the effectiveness of the blend proposed by the authors.

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