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Quality 4.0,
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Souad LAHMINE[1*],
Fatima BENNOUNA[1]

TREATMENT OF AN UNCONFIRMED QUALITY ACCORDING TO 8D USING THE PROBLEM-SOLVING TOOL SYSTEM: A CASE STUDY IN AN INTERNATIONAL COMPANY

This study presents a qualitative case analysis of a global organization addressing a non-conformity in the crimping process of a connector using the 8D methodology and the digital Problem-Solving Tool (PST). The research demonstrates how the PST, a Quality 4.0 tool, enhances the 8D process by streamlining problem-solving workflows, improving traceability, and facilitating collaboration. By leveraging digital technologies, the PST enables faster root cause identification, more effective corrective actions, and better overall production quality. The findings emphasize the value of integrating advanced digital tools in modern manufacturing, highlighting their potential to overcome the limitations of traditional quality methods in resolving complex production challenges. This case study underscores the transformative role of Quality 4.0 technologies in elevating quality control practices and fostering continuous improvement, offering practical insights for organizations seeking to enhance operational efficiency through digital innovation.

1. INTRODUCTION

The fourth industrial revolution or Industry 4.0 refers to integrating cyber-physical systems, the Internet of things, big data, and artificial intelligence in the manufacturing and industrial processes [1]. Thus, it has not only changed how products are manufactured but also how quality is managed throughout the production cycle [2]. The transition that has taken place under Industry 4.0 has induced the emergence of digital quality management tools, which have now become imperative to ensure high standards in an increasingly complex environment of production [3].

While good, old-quality management systems often miss the quick response and data joining needed to handle today's fast-changing factory problems [4]. As making ways get more automatic and based on data, the need for smart quality management tools that can fit

[1] Sidi Mohamed Ben Abdellah University (USMBA), Morocco
[*] E-mail: souad.lahmine@usmba.ac.ma
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in well with new factory systems has become clearer [5] This is where tools like PST can help, giving firms the chance to better follow, examine, and deal with quality problems.

The PST belongs to the wider Quality 4.0 framework, which stands for the digital transformation of quality management practices [6]. Quality 4.0 underlines the use of digital technologies in improving traditional approaches toward quality management, making it more dynamic with a more data-driven approach [7]. Tools such as the PST aim to help in correct problem identification, reduce reaction time to problems, and improve decision-making by providing real-time data [8]. In sectors where slight irregularities in quality might translate into significant downstream impacts on production, costs, and customer satisfaction, such abilities are particularly important [9]. Quality anomalies can be spotted coming from the depth of industrial settings due to multifarious roots such as machinery malfunction, inefficiency in the process, defective materials, and human errors [9]. These, if not recognized and resolved on time, may result in defective products, production downtime, and increased costs [10]. What is essential here is to find the method through which the root cause of an anomaly can be determined and corrected to prevent future instances [11].

It is often cited as one of the good problem-solving frameworks in industry use [12]. A method created by Ford Motor Company has developed a systematic procedure for identifying, correcting, and putting quality defects under control. This was the eight disciplines process [13]. It composes eight steps that were designed to meet the specific requirements of the corresponding aspects of the problem-solving procedure- from problem definition and cross-functional team establishment to corrective action implementation and prevention of recurrence [14].

The 8D process is more about root cause analysis and corrective actions in the long run. The 8D methodology minimizes defining and fighting the symptoms to give quality problems but encourages an approach that will identify actual causes and install solutions related to those causes [15]. This will ensure that the corrective actions to be taken will work in the short run and also prevent such issues in the future[16].

Although highly effective, the 8D process can be labor-intensive and resource-intensive in a complex production environment within a large organization [17]. This is where the PST, a digital tool, comes in [18]. Companies will be able to automate most of the rather time-consuming problem-solving processes by PST integrated with the 8D process, such as data collection and analysis, then the process and possible human error will be hastened considerably [19].

The Problem-Solving Tool is meant to manage quality in a digital environment. It tries to make the problem-solving process easy by giving data right away, analysis done by machine and reporting features together [20]. Using it with the 8D process can help a lot in making the efforts to solve problems better and faster [21].

One of the key benefits of PST involves the ability to collect and assess massive volumes of data in real-time. Such possibilities enable firms to spot quality anomalies at the very instant they take place, which provides a chance to react and deter subsequent issues [22]. The data integration ability of PST also facilitates cross-functional teamwork by making information sharing simpler, which is an integral part of the 8D process [23].

The other offering of the PST is automated detection of the root cause, which can save time and effort in searching for a quality defect’s reason [24]. With the help of advanced

algorithms and machine learning techniques, the PST will be able to perform quick data analysis from numerous sources and detect possible reasons for an anomaly [25]. Such analysis being automated not only accelerates the process of problem-solving but also enhances the ability to identify the root causes of issues; hence, corrective actions are based on real data [26].

Once the deep cause has been found, the PST can also help do the fixes and check them [27]. The tool's built-in reporting abilities let companies follow the progress of fixing steps in real-time, making sure that they are done well and that any extra issues are spotted and dealt with fast [28]. By giving a single place for controlling all the problem-solving steps, the PST helps firms make sure that fix steps are done the same way and that quality issues are solved as soon as they can be [29].

This paper studies how the PST, a major tool in Quality 4.0, can increase the efficiency of the 8D process in handling unverified quality issues at an international firm [30]. Provided by the PST, digital resources have functionalities in different phases of the 8D process, from recognizing problems to executing corrective actions [31]. This is a big leap for contemporary firms regarding the approach to problem resolution and quality assurance: marrying digital instruments with the tenets of quality management [32].

The main objectives of this study are to:

1. Show how the PST can be used to enhance the 8D methodology in addressing non-conformities in a complex industrial environment.
2. Demonstrate the advantages of integrating digital tools like PST into traditional quality management practices, focusing on efficiency, accuracy, and collaboration.
3. Provide practical insights for a firm that is implementing technologies under the Quality 4.0 concept to improve operational efficiency and quality.

This paper is structured as follows: Section 2 describes the methodology applied in research to investigate the use of PST in 8D. This will be followed by Section 3, which will present analyses and results, showing benefits that PST may bring at each stage of the 8D process over and above what is achieved with the use of any other method. Section 4 will discuss the findings in terms of their implications, including how they help validate the results and apply them in real organizations. Such a study contributes important knowledge to the area of Quality 4.0 and industrial problem-solving.

2. RESEARCH METHODOLOGY: ENHANCING THE 8D PROBLEM-SOLVING PROCESS THROUGH DIGITAL TOOL INTEGRATION

2.1. QUALITATIVE RESEARCH APPROACH

This is a qualitative case study within an international railway cabling company. It seeks to explore the use of the Problem-Solving Tool (PST) in addressing a non-conformity issue within an organization.

To achieve this, I participated in observing, through which I had the opportunity to examine operational practices first-hand and analyse how the teams work with and implement

the PST in their daily work routines [33]. This method of observation gives valuable insight into the interaction between the quality engineers and the tool, as well as group dynamics concerning problem-solving activities [34].

A company quality engineer participated in a semi-structured personal interview where reflections and opinions on the effectiveness of PST in managing non-conformities could be gathered [34]. To relate experiences, challenges, and successes related to tool application, the engineers were urged to share individual experiences [35]. This therefore was able to give a deeper dual perspective on the internal workings of the company and practical implications of the PST in railway cabling, where maintaining high quality is of essence for the safety and reliability of products [36].

2.2. DESCRIPTION OF THE COMPANY AND THE PROBLEM

The subject of this study is a global firm based in Morocco that deals with the business of railway cabling. This firm works in a very competitive market where the need for accuracy and dependability is important. The company values its dedication to quality, which is important in keeping railway systems safe and effective. With many production plants, which include the customer site, it has become a major name in the business of railway cabling by supplying important parts that meet its clients' strict requirements.

At the customer's place, a new break-in work on the line raised big worries about how well things were working and the quality of the product [37]. This break, spotted as a job issue, just then a problem with squeezing a part in the right way, led to a wrong thing that hurt how good the final product was. Such wrong things can cause bad results, like making the timing of work slow, raising more money, and creating a safety issue for the final users [38].

The crimping process is very important in making railway connectors since it ensures safe electrical connections which are needed for the right working of railway systems [39]. A problem or mistake in this process can put at risk the performance of the connectors and start ripple effects in the production line [40]. Dealing with this type of rule-breaking is key not just to keeping up the company's rep for quality but also to keeping the trust of clients who use these parts for the safe work of their railway systems [41].

2.3. APPLICATION OF THE 8D METHODOLOGY WITH PST

The methodology that is known for having a structured and thorough approach to problem-solving is the 8D methodology, which was used to analyse the non-conformity problem identified from the crimping process of a connector at the client site [42]. The PST is the digital platform that facilitated the systematic implementation of the 8D process, thereby enabling detailed tracking, reporting, and collaboration across teams. Figure 1 8D roblem-solving process PST.

When the quality team received the client's report of a non-conformity (RNC), the issue was promptly logged into the PST, which is integrated into the company's Quality Portal. The PST is designed to facilitate the entire 8D process, ensuring that each step is properly

documented and monitored. This digital tool also streamlines communication and collaboration between the internal quality team, external stakeholders, and managers.

Each of the eight disciplines was executed through the PST, with particular attention to verification and validation processes. For every step in the 8D process, the team was required to input relevant data into the PST system before advancing to the next discipline. A key feature of the PST is its requirement for approval at multiple stages. Managers, as well as client-designated team members, review and validate the actions before the team is allowed to proceed to the subsequent step. This ensures that every corrective measure is scrutinized and approved, adding an extra layer of quality control.

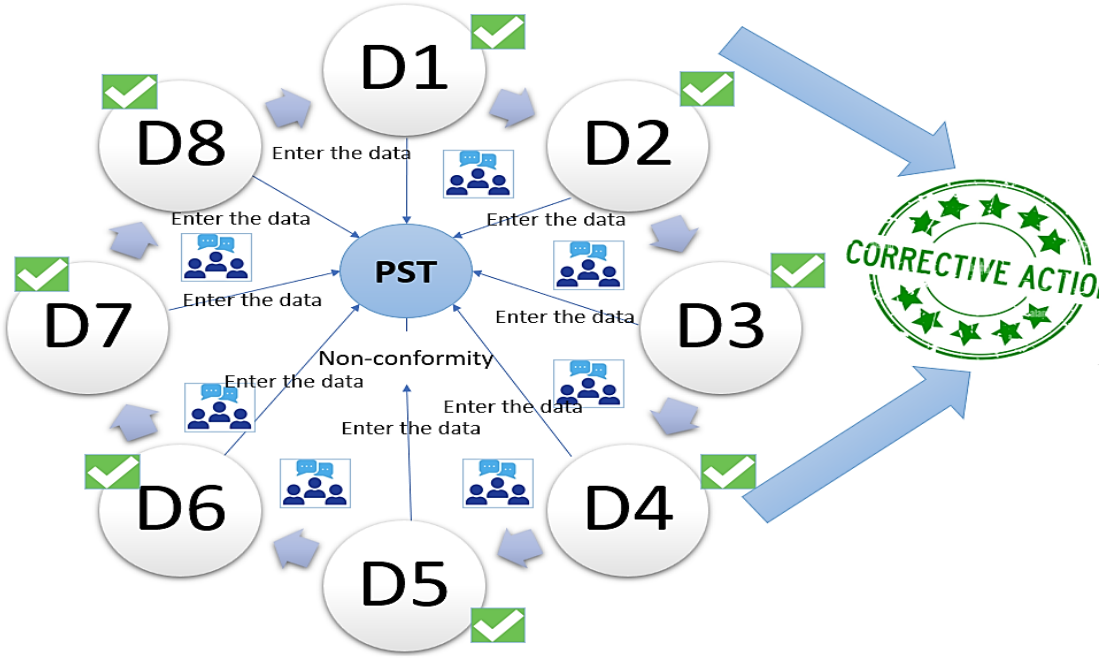

Fig. 1. The 8D problem-solving process using the PST

3. ANALYSES AND RESULTS

3.1. IDENTIFICATION AND DOCUMENTATION OF NON-CONFORMITY

When a client identifies a non-conformity, they report it via the quality portal "Global View" that exists in PST. Figure 2 represents this report includes a detailed description, context, and supporting evidence, such as photographs and technical documents.

In this case, the issue—a crimping defect—was detected during functional tests on NTE trains 11, 12, and 13, and TDF Train 7. The defect manifested as intermittent electrical discontinuity, resulting in wire detachment from its contact, posing a potential risk of short circuits.

Comparison with Traditional Methods:

- Traditional Approach: Usually, it is done manually through paper forms, or there are incomplete digital files which cause delays and do not help in tracing.

- PST Advantage: In the PST, all details related to defects can be reported centrally, ensuring everything such as photos and technical reports is captured and located in one place. This enhances traceability and accessibility to all involved parties.
- Qualitative Improvement: The PST significantly improved the clarity and completeness of defect documentation, reducing ambiguities and ensuring all stakeholders had access to the same information.

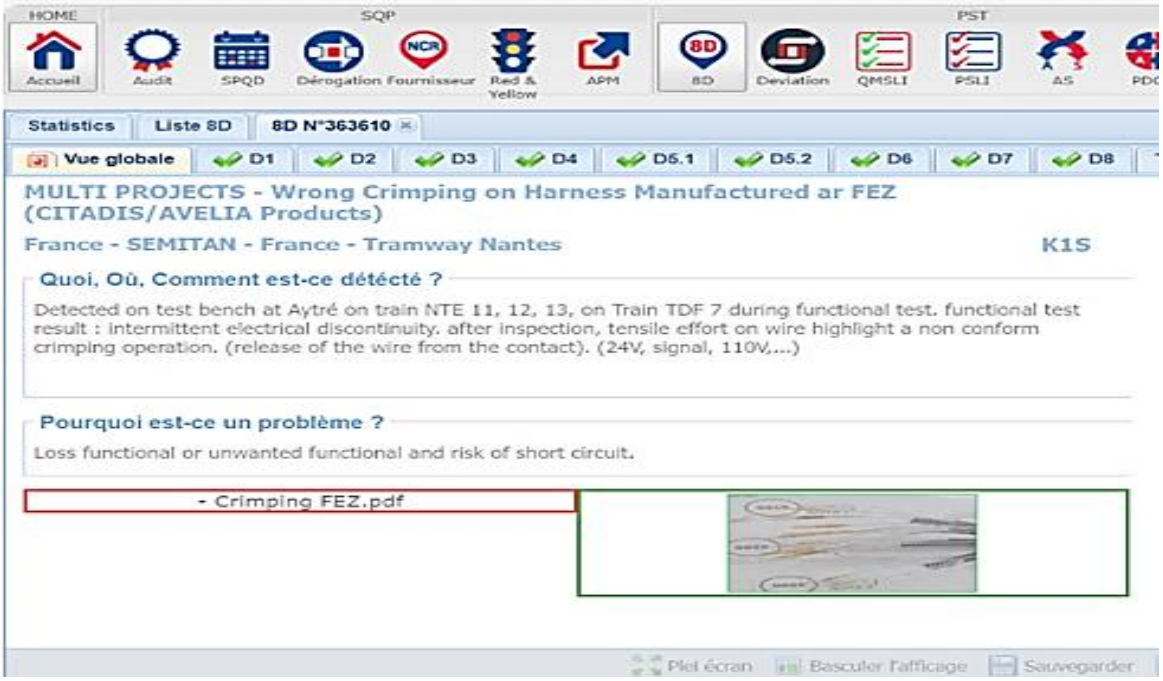

Fig. 2. Global view in PST

3.2. IMPLEMENTATION OF THE 8D METHODOLOGY

3.2.1. D1: Description of the defect

At the Aytré test bench, the defect was identified in functional tests; this consisted of an intermittent electrical discontinuity due to bad crimping, which then compromised the reliability and safety of the system. Complete documentation, comprising photos and reports, was uploaded to the PST for analysis.

Comparison with Traditional Methods:

- Under regular practice, the problem descriptions are made either by hand or on a separate typewritten document which causes delay and information disparity.
- PST Advantage: The defect description is now captured in a structured digital form, ensuring that all details required are available and stored centrally to improve traceability and accessibility for all stakeholders.
- Qualitative Improvement: The structured format of the PST ensured that defect descriptions were more detailed and consistent, reducing the risk of misinterpretation.

3.2.2. D2: Formation of a multidisciplinary team

A dedicated team was assembled to address the issue as Figure 3 shows.

A leader, safety professionals, and process experts made a balanced team to address the problem from all angles Regular updates and feedback from all parties were treated as high priorities to ensure complete transparency and alignment.

Comparison with Traditional Methods: Team formation is not fixed. It normally takes time to identify and contact the right person. Misalignment tends to happen as there is no effective communication channel. PST has in-built team management. The required expert can easily be identified based on role and availability. As a communication tool, real-time collaboration tools logically include chat and task assignments. The PST facilitated faster and more effective team formation, ensuring that all relevant stakeholders were involved from the outset.

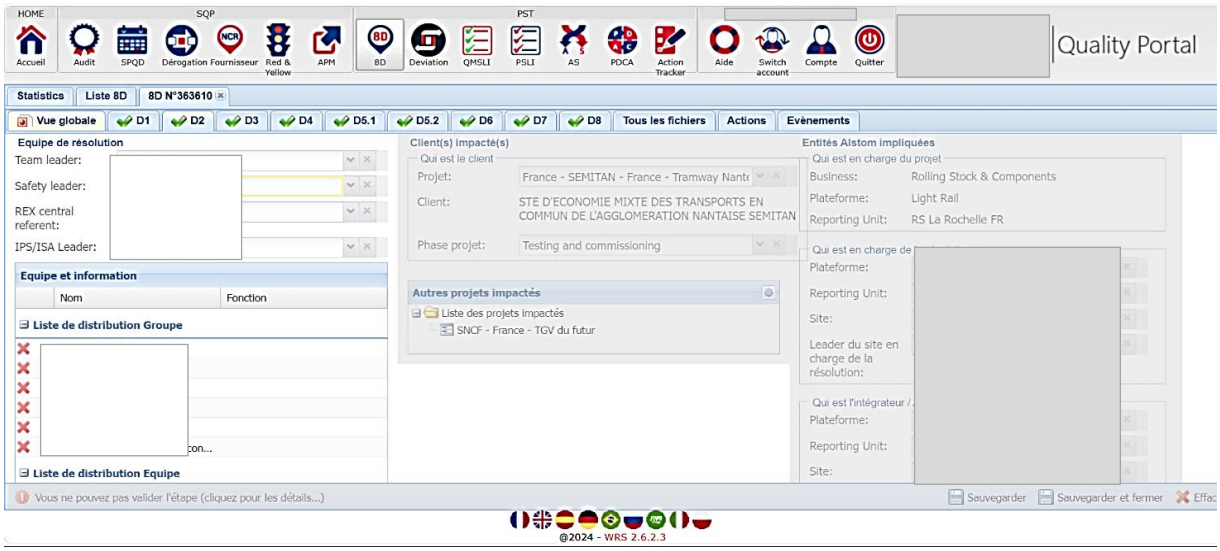

Fig. 3. Multidisciplinary Team Composition in PST

3.2.3. D3: Problem characterization using 5W2H

The 5W2H method was used to frame and articulate the problem that has been identified in this case study [43]. The questions enabled a very detailed insight into the issue by looking at its nature, scope, and impact [44]. As shown in Table 1, it reveals the application of the 5W2H method in answering "who," "what," "where," "when," "why," "how," and "how much" of the problem. Specifically, this problem was related to the harnesses manufactured at the FEZ plant for NTE and TDF projects; non-compliant crimping presents an intermittent electrical discontinuity. First noted on 09/27/2023 during Aytré functional testing, where it could manifest short circuits and failures, it involves 11 connectors in NTE trains 11 and 12 and 12 connectors in NTE train 13.

Comparison with Conventional Methods:

- Standard Way: The nature of the issue is identified manually, which tends to be somewhat incomplete and not always coherent. Facts are found in different files.

- PST Benefit: This tool makes the 5W2H analysis automatic, furnishing a format and pulling together information from various origins (like production logs, and quality reports). That ensures full and even characterization.
- Qualitative Improvement: The PST ensured a more systematic and thorough problem characterization, reducing the risk of overlooking critical details.

Figure 4 shows the containment phase (D3) of the 8D methodology as it exists in the Alstom Quality Portal. In this phase, the system prompts the user to identify and write down immediate actions that will contain the defect and prevent its impact on the operation or the customer. First and foremost, the screen prompts for detail on the description of the defect ("non-compliant connector crimping") and its safety-related classification ("K1 Safety"). Supporting documents, such as characterization files and analyses, are attached to ensure traceability and allow quick decision-making. A very structured method, so that the issue is properly taken care of while long-term corrective actions are to be developed.

Table 1. The 5W2H method

Question	Description	Purpose
Who?	Who is concerned by the problem?	Harnesses manufactured at the FEZ factory for NTE and TDF projects.
What?	What's the problem?	Non-compliant crimping leading to intermittent electrical discontinuity.
Where?	Where did the problem occur?	Detected at the Aytré test bench.
When?	When was the problem detected?	Identified during functional tests on 09/27/2023.
Why?	Why is this a problem?	Defect posed a risk of short circuits and operational failures.
How?	How was the problem detected?	Functional tests revealed the defect, confirmed by visual inspection.
How Much?	How big is the problem?	Affected connectors included 11 units on NTE trains 11 and 12, and 12 units on NTE train 13.

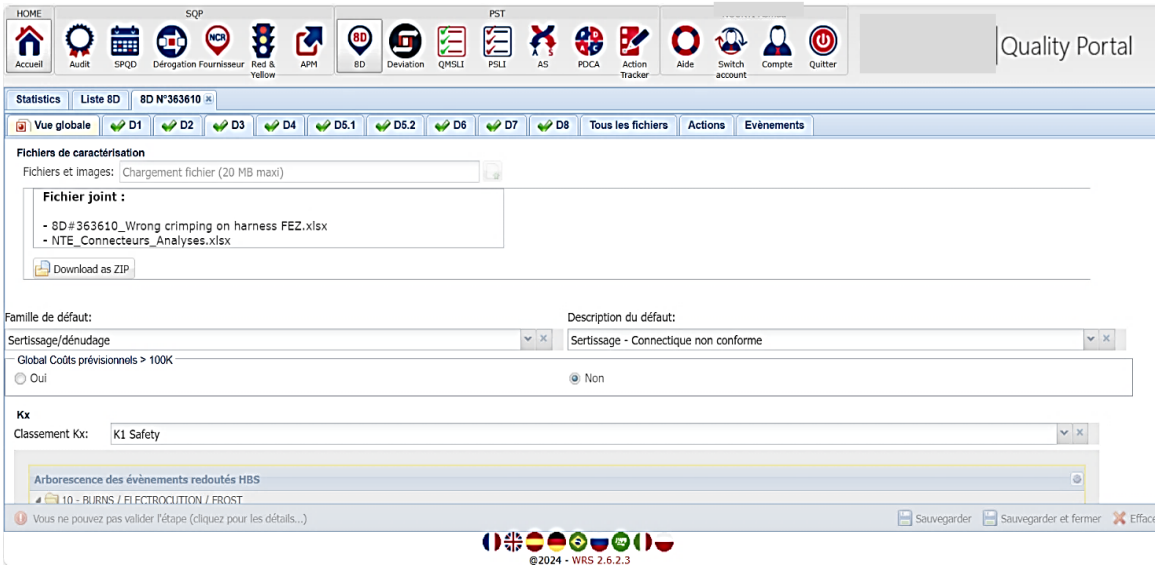

Fig .4. D3 in PST

This orderly description as shown in Table 1 and Figure 4 was very important in finding the main cause and making a good plan to fix it. By using the 5W2H framework, the team made sure to look at the problem carefully, which helped with the problem solving.

3.2.4. D4: Security actions

Step D4 of the 8D methodology requires setting and validating corrective actions to eliminate the root cause of the detected problem [42] In this case, containment actions were implemented promptly to stop further occurrences; these included adding extra quality controls, verifying step-by-step crimping compliance, and marking secured wires for traceability. Proper supporting documents were prepared to aid strict monitoring and traceability in the course of action. Figure 5 gives a graphical representation of how such corrective actions were systematically addressed through the Quality Portal, demonstrating a structured and transparent approach to problem resolution.

Fig. 5. Security Actions in PST

Figure 5 shows how to put things right in the Quality Portal as part of the 8D way. At this time, attention moves to saying and doing things that help with the main issue. The screen gives much detail on the corrective action, which checks if the crimping is right and also does a control in steps to confirm all is okay. Important steps, like when it should be done and when it is finished, are written down nicely. Files with extra help are added to show more about what was done to fix things. This clear writing helps to see what is going on and get everyone working toward good answers.

Comparison with Traditional Methods:

- In the traditional approach, containment actions were usually monitored manually, which led to delays and some of them falling through the cracks. Since

documentation was mostly incomplete, it was somewhat challenging to verify whether or not participants complied with the laid-down measures.

- PST Advantage: The PST ensured real-time tracking of containment actions. Whenever an action is proposed, the system generates automatic reminders; when approval is required, the initiator and the approver receive reminders. Every action is now documented in a digital tool with traceability and accountability.
- Qualitative Improvement: The PST improved the transparency and accountability of containment actions, ensuring they were implemented consistently and effectively.

3.2.5. D5: Root cause analysis

The root cause analysis was done using the Ishikawa diagram (Fig. 6) and the 5 Whys method (shown in Figs. 7a., 7b. and 7c.). A structured framework was offered by the Ishikawa diagram to identify systematically possible causes of the non-conforming crimping issue by placing them in key areas, Material, Method, Manpower, Milieu (Environment), and Machine as categorized by [45].

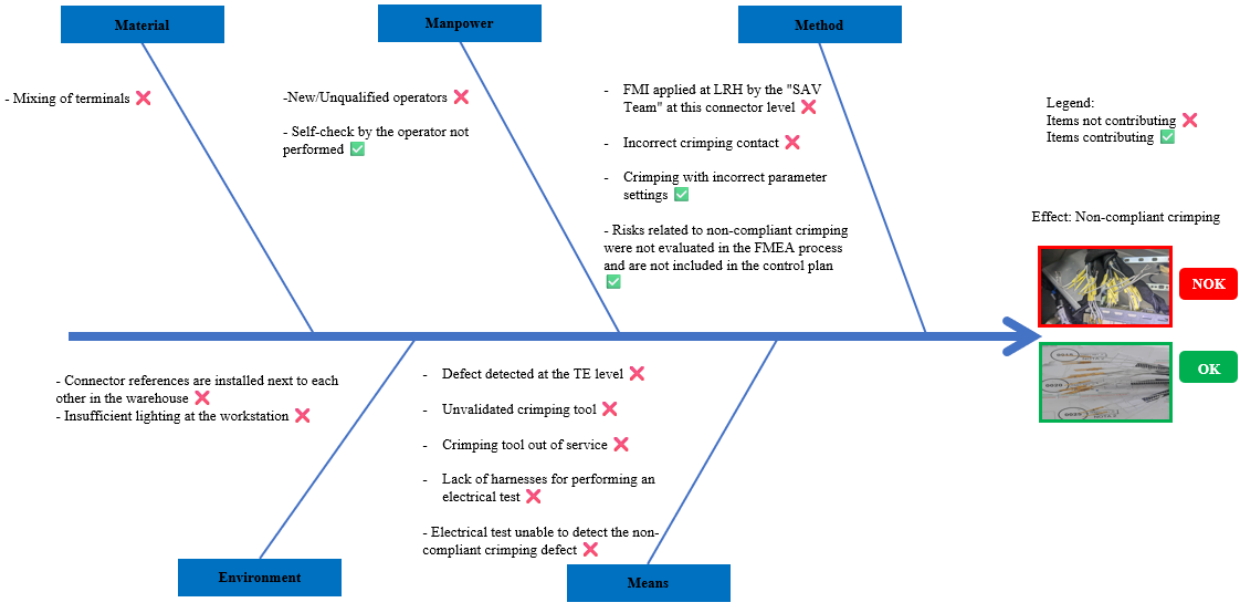

Fig. 6. Ichikawa diagram

This helped the team identify specific factors, such as inadequate operator training and variability in procedures, that added to the problem.

The 5 Whys analysis works hand in hand with the Ishikawa diagram by providing a detailed analysis of the ultimate reasons for the cause. The results of the application of the 5 Whys method to different issues are shown in Fig. 7a, 7b. 7c. These figures give a good account of the order of causes since they bring out very well the exact process and procedural gaps and human elements that resulted in the failures that were witnessed.

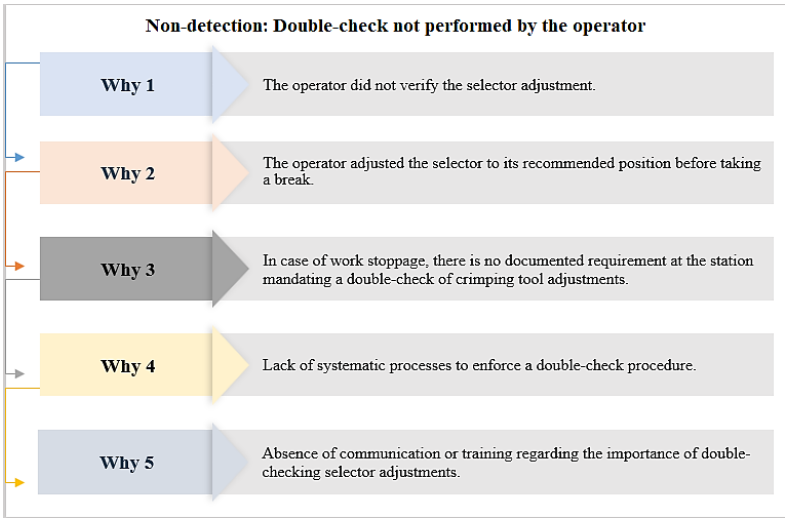

Fig. 7a. Non-detection: Double-check not performed by the operator

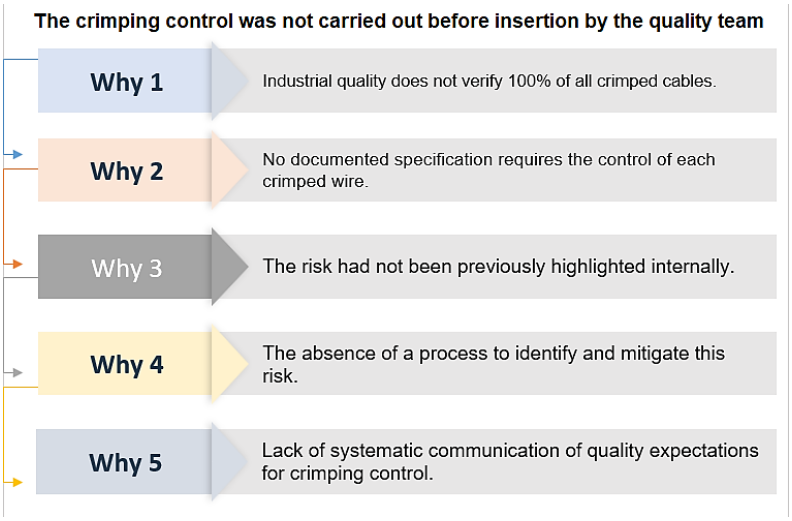

Fig. 7b. The crimping control was not carried out before insertion by the quality team

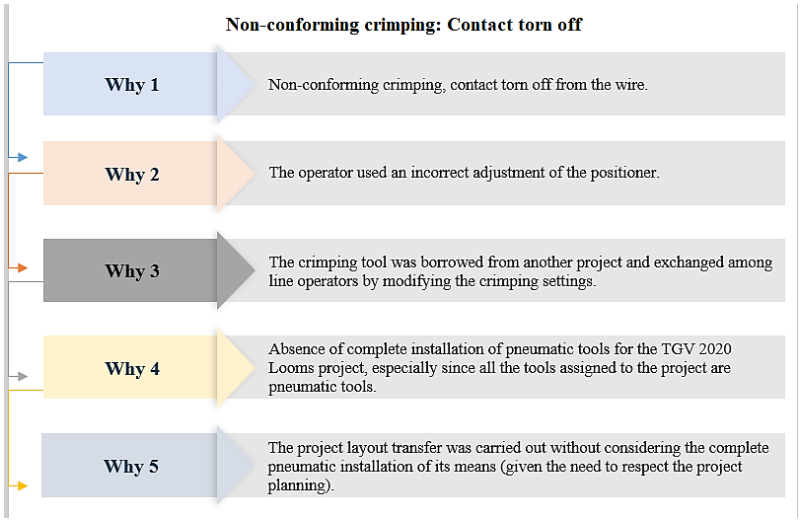

Fig. 7c. Non-confirming crimping: Contact torn off

Results from Figures 7a, 7b, and 7c give the big picture of the root causes of the identified problems. From Fig. 7a: operation gaps due to the absence of a double check at the time of selector adjustment, especially in interrupted work. From Fig. 7b: no systematic quality check on crimped cables, so the control process was overlooked. Figure 7c highlights non-conforming crimps where bad positioner adjustments, tool borrowing from other jobs, and incomplete pneumatic installations added to the defect found. These underline points of action, such as those relating to intensive operator training, tool management, and resource planning for project specificity. There is also, thus the need for good documentation with improved risk identification and standardized practices for preventing the re-occurrence of such issues and enhancing the reliability of the process.

Comparison with Traditional Methods:

- Manual Approach: Root cause analysis depends on collecting data manually and interpreting it subjectively, a process fraught with errors and sometimes delayed.
- PST Advantage: In the Post-Mortem Analysis, tools based on advanced algorithms and machine learning are incorporated for root cause analysis, since patterns and correlations might not be easy to spot manually. This enhances the accuracy as well as speed in identifying the root cause.
- Improvement in Quality: It helped increase the accuracy as well as reliability in determining root causes and seeing to it that corrective actions were taken based on a clear understanding of the issue.

3.2.6. D6: Corrective actions

Key corrective actions taken were:

- Clarification of the crimping process to achieve better visibility and compliance
- Comprehensive training of the operators.
- Quality control measures at production and end-of-line stages were improved.
- Automated control systems for crimping verification were put in place.

The system was monitored by use of a dashboard, and effectiveness was confirmed with the help of internal audits.

Comparison with Traditional Methods:

- Under the Traditional Approach, Corrective actions are planned and monitored manually, which tends to cause delays and make the execution irregular.
- The PST Advantage is that Corrective actions can be planned, monitored, and verified in a centralized platform. Automated workflows make sure that they are approved and implemented on time.
- Qualitative Improvement: The PST improved the efficiency and consistency of corrective action implementation, reducing the risk of recurrence.

3.2.7. D6: Preventive actions

Preventive measures aimed to cushion risks in analogous processes. These were:

- Uniformity in crimping procedures among the various production lines.
- An improved operator training program.
- The investment in more advanced crimping tools that have automatic quality checks.

- Standardized verification procedures to be conducted regularly with feedback established.

Comparison with Conventional Methods:

- Under the conventional approach, preventive actions are usually neglected or very irregularly followed up.
- PST Advantage: The PST comes with the feature of preventive action wherein there are automatic reminders as well as tracking which can be used to follow up on the consistent implementation of lessons learned.
- Qualitative Improvement: The PST ensured the systematic implementation of preventive actions, bringing down the probability of such incidents happening in the future.

3.2.8. D8: Recognition

This non-conformity was resolved due to the commitment and experience of the team. Working together to put strong solutions into place, then help to build quality culture as well as make sure there is always room for improvement.

Comparison with Traditional Methods:

- Traditional Approach: Recognition of team efforts is often informal, and closure documentation is incomplete or inconsistent.
- PST Advantage: The PST provides a structured process for recognizing team contributions and documenting lessons learned. All data is stored digitally for future reference.
- Qualitative Improvement: The PST enhanced the visibility of team contributions and ensured that lessons learned were systematically documented and shared.

3.3. SUMMARY OF BENEFITS

The integration of the PST in the 8D process breakthrough results in all stages:

- Efficiency: PST made communication and data management easy, cutting delays and making the process more efficient.
- Improved Accuracy: Characterization of the problem, and the implementation of the corrective action, the tool made all these more accurate.
- Collaboration: Communication in real-time plus centralized data all improved collaboration and alignment.
- Traceability: With documentation, there could be full traceability and accountability for all actions.

These benefits speak to the PST's value as a Quality 4.0 tool, which is a more structured and efficient way of addressing problems than in the past.

4. DISCUSSION

4.1. THE IMPACT OF PST ON THE EFFICIENCY OF THE 8D PROCESS

The problem-solving tool in the 8D framework has greatly improved problem-resolution efficiency as perceived by the quality team [46]. The main advantage of using PST is better

communication and collaboration [47]. Digitalization of the 8D process steps and having all data placed in a single platform store where PST has been implemented ensures easy information flow between team members, managers, and external stakeholders [48]. The process stages from problem identification to root cause analysis and corrective action implementation are well-documented and easily accessible, hence minimizing the chances of miscommunication and loss of critical data [49]. The PST just comes with real-time updates that open avenues for managers to track and make timely decisions. This thus reduces delays that are prone to occur in the traditional methods of problem-solving because manual data input and paper-based processes take time to initiate a decision [50, 51]. The digital nature of PST results also reduces human errors in data collection and analysis, leading to decisions based on precise and current information [52].

One of the key differences that set the PST-driven 8D process apart from traditional problem-solving approaches is the degree of automation. Earlier systems of problem-solving approaches required lots of manual reporting and documentation, which in actuality was time-consuming and also error-prone [50]. This PST, however, automates many steps involved, including data collection, root cause analysis, and follow-up of corrective actions; hence problems are resolved more quickly [53]. The structured workflow within PST makes it possible for all steps to be followed and, because there is a need for approval at many levels, there is also an added layer of quality control, which means that corrective measures will be thoroughly vetted before being applied [52].

PST's tools for reporting include detailed logs of all actions done in the process of solving problems [47]. Such feature not just enhances transparency but also makes post-analysis more effective by making it easier to spot patterns and prevent future cases of such issues [54]. It is better in terms of documentation and accountability, as compared to the earlier conventional methodologies where most of the tracks were missing [55]. While PST tool can bring a lot of help in optimizing the 8D process, it should be born in mind that the tool's effectiveness will be closely correlated with the team's level of accommodation to digital tools [56]. This great automation by PST speeds up the process radically, but it needs some level of technical knowledge from the team members to work with all the possibilities of this system [57].

5. CONCLUSION

This case study proves that the Problem-Solving Tool (PST) Quality 4.0 very significantly improves the handling of a non-conformity issue within a crimping process when applied with the 8D methodology. The PST contributed to enhancement in all respects related to problem-solving: communication, data analysis, and corrective action implementation, thus reinforcing general efficiency under the 8D approach. A major positive observed from the case study is how PST streamlines communication between members of the quality team, the managers, and some external parties. The lack of proper communication in traditional problem-solving approaches delays weaknesses, especially in specific problems involving many departments and outside partners. The PST solved the challenge by creating one online place that all key people could use to see instant updates and add to fixing the problem. This

made quick choices possible and guaranteed that everybody stayed on the same page in the varied steps of the 8D method.

Besides the communication enhancement, PST was important in data management and analysis. This tool could collect, store, and analyse massive data, enabling the quality team to identify patterns and trends with more agility. Because PST would automate some parts of the data analysis process, like identifying the root cause, it would help the team see strategic parts of problem-solving rather than be engaged in time-consuming manual analysis. This would also minimize the chances of human error; therefore, the decisions to be made would be based on information that is correct and quite reliable.

The PST supported and included documentation for each step of the 8D process which would help easily track the progress of the corrective action taken and thus ensure that the organization met the required industry standards. Such visibility supported accountability to ensure that corrective measures were implemented on time and in the most effective way. Since approvals were required at every step, PST initiated another level of check so that the actions taken should be approved by all the internal managers and their respective client-appointed team members. It, therefore, facilitated long-term corrective action with features that can enable the monitoring of the crimping process after the initial problem has been resolved. This would ensure possible reoccurrence of non-conformity to be detected promptly and thus improve the sustainability of corrective actions taken.

As opposed to the conventional methods of problem-solving, which often included manual activities and incomplete communication, PST supported a more organized quality management approach. Quality 4.0, the incorporation of digital tools such as PST, would highlight the prospect of the revolution that automation combined with data-based judgment bears for changing the practice of quality management in industrial settings.

Results Validation

The effectiveness of the PST in improving the 8D methodology was validated through an observer and stakeholder feedback triangulation:

1. Observational Analysis: Close monitoring of the implementation process of the PST throughout the 8D process revealed significant achievement regarding communication efficiency, data accessibility, and process transparency over and above what would have been achieved with the use of any other methodology. Such improvement was uniformly realized across all steps of the 8D process.
2. Stakeholder Feedback: Quality engineers, managers, and external stakeholders took part in semi-structured interviews/focus feedback sessions. Participants highlighted the PST's ability to bring them together, cut on delays, and enhance the quality of problem-solving. Feedback provided steered strong consensus touching on how this tool helps them manage their workflow and be accountable
3. Documentation Review: Check if the PST has created digital records that are complete and accurate. Because the system keeps a log of each action taken in the 8D process and includes approval steps, there is rigorous control provided as well as compliance with the required standards.

Limitations and Future Work

Although the results are positive, the study was done in just one industrial setting; this fact may limit how the results can be applied. More research should repeat this study in different places to check if the PST is useful in other industries and processes. Also, what the PST will do to the culture of an organization and how many employees will accept it in the long run needs more research.

Industry and Research Implications

The results of the study demonstrate the transformative potential of Quality 4.0 tools, particularly the PST, in contemporary industrial problem-solving. Because it fuses automation, real-time data analysis, and collaboration, features that fill gaps entrenched in traditional methodologies of problem-solving, PST is assumed to usher in efficient sustainable quality management practices.

In summary, the case study highlights how much Quality 4.0 tools, like the PST, can affect the betterment of the effectiveness and efficiency of the 8D methodology. By fostering communication and enhancing data analysis plus the timely response from corrective actions, PST is a very powerful solution that offers significant improvement toward addressing non-conformities and overall product quality in relatively complicated industrial settings.

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