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Original Article

Implementation of 5S and Industrial Safety Assessment in a Manufacturing Organization

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Abstract - *Industrial safety is of paramount importance, not only for the well-being of workers but also for ensuring the smooth and trouble-free functioning of the shop floor in any organization. It represents a win-win situation for both parties involved. Safety and diligent observations are inherently interconnected, as a vigilant approach to safety is vital for accident prevention. Implementing the 5S methodology has consistently proven to be an exceptionally effective tool for mitigating potential accident risks. Organizations can systematically improve their safety protocols and create a safer work environment by adhering to the principles of Sort, Set in order, Shine, Standardize, and Sustain. This approach not only safeguards the well-being of employees but also enhances operational efficiency and productivity, aligning the interests of workers and the organization itself. Thus, 5S is pivotal in fostering a safety culture and continuous improvement within industrial settings.*

Keywords - *5S Methodology, Industrial Safety, Workplace Safety, Accident Prevention, Safety Culture, Hazard Mitigation.*

1. Introduction

In the context of industrial operations, ensuring safety is a pivotal concern and a crucial factor in maintaining morale and fostering mutual responsibility among employees and their respective organizations. While implementing industrial safety measures at the ground level is indispensable, it is equally important to instil strong observation skills in every individual engaged in these activities to prevent potential accidents proactively. Moreover, implementing the 5S methodology has been observed to play a significant role in averting accidents that might arise due to last-minute tasks and disorganized work environments.

Industrial safety has emerged as a paramount concern in today's fast-paced manufacturing landscape, influencing operational efficiency, employee morale, and overall productivity. As organizations strive to maximize output while minimizing risk, integrating robust safety protocols is not just a regulatory obligation but a critical component of sustainable business practices. Recent statistics underscore this necessity: the National Safety Council reported that work-related injuries cost employers approximately $171 billion annually in direct and indirect costs. Additionally, companies with strong safety cultures report up to 50% fewer incidents, highlighting the correlation between safety measures and operational success.

One effective approach to enhancing workplace safety and efficiency is the 5S methodology, a cornerstone of lean manufacturing. Originating from Japan, 5S emphasizes the importance of organization and cleanliness, comprising five key principles: Sort, Set in order, Shine, Standardize, and Sustain. This methodology not only fosters a safer work environment but also leads to significant reductions in waste and inefficiencies. For instance, a case study conducted by the Lean Enterprise Institute found that implementing 5S led to a 30% increase in productivity in a manufacturing firm, along with a notable decline in accidents and near misses.

As the manufacturing sector evolves with technological advancements and changing workforce dynamics, the importance of industrial safety and the 5S methodology becomes increasingly clear. This research aims to explore these themes in depth, providing insights into their impact on modern manufacturing practices and offering recommendations for effective implementation.

HOG Engineering, a typical manufacturing industry, recognized the need for solutions in this regard. Consequently, the authors were invited to collaborate with the industry to identify potential safety threats and devise strategies for their mitigation. This collaborative effort also aimed to highlight the day-to-day benefits of 5S implementation, which encompass increased safety, improved productivity, reduced stress, enhanced job satisfaction, better quality, and optimized space utilization. When accumulated over time, these incremental daily benefits translate into substantial yearly improvements in productivity, quality, cost-effectiveness, delivery reliability, safety, and overall workforce morale (C.D. Chapman, 2005).

During the initial discussions with the Managing Director and Managers and subsequent plant visits, the authors made several observations and assessments related to the safety and operational aspects of the plant.

2. Literature Survey

In recent years, industrial safety assessment in manufacturing has evolved with the integration of advanced technologies for enhancing risk detection and accident prevention. These innovations have significantly improved workplace safety practices. The following highlights the various innovative techniques researchers have developed to improve risk detection and accident prevention.

Gul et al. (2019) developed the Pythagorean Fuzzy VIKOR (PFVIKOR) approach for assessing occupational health and safety risks in the mining industry, specifically for underground copper and zinc mines. The model improves traditional risk assessment by incorporating Pythagorean fuzzy sets, which better handle uncertainty and vagueness in expert judgments. The dataset consists of expert evaluations from eight mining professionals. Sensitivity analyses show consistent ranking results, indicating the robustness of the model. The study achieves a more precise prioritization of hazards and provides control measures for risk management. However, the model relies heavily on subjective expert input, and its generalizability to other industries needs further exploration. Lo et al. (2020) suggested a model integrating multiple MCDM techniques with FMEA for comprehensive failure mode identification and ranking in manufacturing. It enhances traditional FMEA by incorporating environmental protection and cost factors. Using DEMATEL, the model determines relationships and weights of risk factors, followed by using SAW, VIKOR, GRA, and COPRAS to rank failure modes. A machine tool manufacturing company dataset is used to validate the model, revealing that noise and waterproofing are critical failure modes. However, the model relies heavily on expert input, limiting objectivity, and could be improved with actual data and additional MCDM methods in future studies. Debnath (2023) the paper proposes a Bayesian Best-Worst Method (BWM) for assessing the Critical Success Factors (CSFs) in Sustainable Lean Manufacturing (SLM) for the furniture industry in an emerging economy like Bangladesh.

The model identifies 16 key CSFs clustered into organizational, supply chain, and technological groups and uses Bayesian BWM to prioritize them based on expert feedback. The dataset consists of expert evaluations, and the results show that sustainable resource management, lead time reduction, and management support are the top CSFs. While the model offers valuable insights for decision-making in SLM, it is limited by the potential for expert judgment bias and its focus on a specific industry and economy. Ferreira (2023) suggests a model that analyzes the five digital technologies (Artificial Intelligence, Cloud Computing, Robotics, Big Data Analytics, and Blockchain) for environmental and social sustainability in European manufacturing Multinational Enterprises (MNEs). The model is based on the Resource-Based View (RBV), which considers digital technologies as strategic resources. The dataset comprises 764 European manufacturing MNEs, with results showing low implementation of these technologies but demonstrating their positive impact on sustainability goals. Cloud computing is the most widely adopted (45.3%), while AI has the least impact. The results highlight the uneven contribution of technologies, suggesting a need for investment prioritization. A drawback is that despite the positive contributions, the overall implementation of digital technologies in MNEs remains low, with only 29.7% of companies using these technologies. Amirah (2024) suggested a Structural Equation Modeling (SEM) approach to assess the impact of safety behavior on fostering a safety culture in the manufacturing sector. It utilized survey data from 342 manufacturing employees and analyzed relationships between safety compliance, safety leadership, and safety culture. The model predicted 53% of the safety culture’s variance and highlighted leadership’s crucial role in promoting safety behaviors. The findings emphasize that safety behavior significantly influences safety culture, but factors like training and management commitment showed a negative impact. The model’s limitation lies in its reliance on employee self-reporting, potentially introducing bias.

3. Review on 5S

The 5S system is a widely recognized methodology for workplace organization extensively used in manufacturing and service industries with the primary goals of enhancing efficiency, productivity, and safety. It derives its name from five Japanese words, each initiated with the letter “S”: Seiri (Sort), Seiton (Set in order), Seiso (Shine), Seiketsu (Standardize), and Shitsuke (Sustain).

3.1. Seiri (Sort)

The Seiri (Sort) step began by cataloguing all items present in the workspace and assessing their necessity. The available space was insufficient for all working activities, so removing unnecessary items would enhance the usable area and allow for more efficient utilization. Initially, more prominent objects were cleared away to create additional space, followed by carelessly removing smaller items dropped or left behind throughout the site. This clutter posed safety risks and made storing large containers in the limited space available impractical. All parts not part of the production flow were identified in this phase. Conforming parts were returned to the industrial unit's stock, while nonconforming parts were collected and set aside for return to the supplier. These actions during the initial implementation of the 5S methodology successfully created more open space in the screening area, enhancing visibility and making it easier to identify potential hazards. The foundation for a safer and more efficient work environment was established by focusing on sorting and organizing the workspace.

3.2. Seiton (Set in Order)

The Seiton (Set in Order) focused on organizing the workspace by designating specific locations for all items and clearly defining zones to optimize the available space. Several copies of the zone layout were printed to facilitate this, incorporating scaled representations of containers to simulate an effective arrangement and identify designated areas. After gathering input from various stakeholders, the engineers selected the most effective layout. The site was strategically divided into two sections, ensuring each sorting company had its dedicated space. This division was accomplished using barriers that reached a maximum height of 2 meters, enhancing safety and organization within the area.

Additionally, one of the storage cabinets was relocated to the opposite corner, while the cabinets belonging to each outsourcing sorting agent were placed adjacent to the offices at the far end of the site. This new arrangement allowed for establishing a designated "safety zone," which was vital for operator protection during break times, particularly when forklifts needed to access the sorting area for container handling. To ensure safety, barriers were installed, accompanied by a detailed specification for their placement. Once the request for these barriers was validated, the installation work commenced. Furthermore, the screening area was secured by adding a chain to the gate, and adhesive tape was used on the floor to mark the designated loading zones for forklifts clearly. This systematic approach to organizing the workspace improved efficiency and significantly enhanced safety within the operational environment.

3.3. Seiso (Shine/Sweep)

One of the most noticeable issues for visitors to the screening site was the level of dirt and clutter present. This uncleanliness stemmed from the high volume of forklift and vehicle traffic and the presence of non-conforming parts undergoing a deburring process, which inevitably generated significant dust. Additionally, the entrance gate for forklift trucks was frequently left open, further contributing to the accumulation of dirt and debris. To tackle these challenges, a comprehensive cleaning strategy was implemented. This strategy involved not only regular cleaning routines but also the establishment of guidelines for maintaining cleanliness in the area. The plan included scheduled cleanings at specific intervals to ensure that dirt and dust were consistently managed. Furthermore, employees were encouraged to take personal responsibility for keeping their immediate workspaces clean and organized. By addressing the cleanliness of the screening site, this initiative aimed to create a more pleasant and safe working environment, ultimately enhancing operational efficiency and reducing safety hazards associated with a dirty workspace.

3.4. Seiketsu (Standardize)

Various standardized forms and documents were created to sustain the improvements achieved through the initial three S steps. These tools helped maintain the progress and enhanced overall site management. Before this initiative, the screening area lacked any form of visual management or documentation that could support daily operations effectively. To address this gap, a control panel was established to streamline information and clarify what is essential for the site's operations. This control panel features sorting ranges crucial for the sorting process, along with a dashboard displaying the area's current status, circulation guidelines, and key performance indicators. By implementing these standardized tools, the organization aimed to ensure that the improvements were maintained over time and continued to evolve, fostering a culture of ongoing enhancement and efficiency within the screening site.

3.5. Shitsuke (Sustain/Self-Discipline)

Shitsuke, or self-discipline, is arguably one of the most vital aspects for successfully implementing the 5S methodology. While the steps of 5S are relatively straightforward to apply, maintaining these principles consistently poses a greater challenge, especially in preventing the re-emergence of old habits. Self-discipline involves employees taking the initiative to uphold these practices without needing constant reminders or supervision. A systematic tool was employed to reinforce self-discipline to ensure that effective practices were ingrained in the workplace and that the improvements achieved were not merely temporary.

This tool was designed to monitor adherence to established standards and identify any sources of non-value-adding activities within the workstation, thereby facilitating overall performance enhancements. Initially, these evaluations were conducted regularly during the early stages of 5S implementation to continually remind employees of the importance of sustaining the changes made. As operators became accustomed to maintaining a clean and organized workspace, the frequency of these assessments transitioned to a weekly basis. This approach helped solidify the new habits and fostered a culture of accountability, ensuring that the benefits of the 5S methodology were preserved over the long term.

Improvements were measured through reduced accident rates, increased worker compliance with safety protocols, and enhanced operational efficiency. Methods such as safety audits, employee feedback, and accident tracking were used to evaluate the effectiveness of the 5S implementation, showing clear improvements in both safety and productivity.

This approach holds the potential to impact workplace operations significantly. It achieves this by eliminating unnecessary items, establishing a well-organized work environment, and standardizing processes. As a result, the 5S methodology can effectively reduce waste, elevate quality, and create a safer and more efficient workspace. It is crucial to emphasize that successfully implementing the 5S approach hinges on all employees' dedication and active involvement.

Additionally, continuous upkeep and refinement are necessary to ensure the sustainability of the improvements achieved over time. In essence, 5S embodies a systematic and holistic approach to workplace improvement that can yield substantial benefits when embraced and maintained by an organization.

4. Objectives

The objectives of this study are twofold. It is to implement and thoroughly evaluate the effectiveness of the 5S methodology as it is practiced within HOG Engineering. This assessment will provide valuable insights into the practical application and outcomes of the 5S system within our organization.

It is focused on recognizing and elucidating the benefits associated with implementing the 5S approach, both for the management and the workers within HOG Engineering, as well as for the stakeholders involved in our operations. By analyzing these benefits, we aim to shed light on how the 5S methodology can positively impact various aspects of our organization, ultimately contributing to its overall success and sustainability. These objectives will serve as the foundation for our study, allowing us to gain a comprehensive understanding of the advantages and implications of the 5S approach in our specific industrial context.

5. Positive Points

HOG Engineering is a distinctive manufacturing industry known for its exceptional commitment to customer satisfaction, boasting a remarkable 100% delivery and quality performance. This stellar record has led to a consistent stream of repeat business, with approximately 70% of our customers never having to revisit the facility due to the consistently high standards we uphold.

Our production processes reflect a dedication to efficiency and sustainability, as we have optimized our cutting processes using round inserts with negative cutting edges, resulting in the creation of ideal hexagonal chips. Moreover, we are proud to maintain a lush green space within our facility, contributing to a pleasant and environmentally-conscious work environment. Safety is paramount at HOG Engineering, as evidenced by the presence of a fully stocked first-aid box with up-to-date medicines, good plant ventilation, and an overall commitment to industrial safety practices.

6. Area of Improvement

Several key improvements should be implemented to enhance the efficiency and safety of our manufacturing organization. Firstly, a well-thought-out plant layout should be established at the entrance, adhering to the principle of "a place for everything and everything at its place" for optimal organization.

Shop floor illumination levels must meet industry standards to ensure a well-lit and safe working environment. Additionally, it is crucial to create visible displays for specific areas, such as the pantry room, power station, and tool room, aiding in easy navigation and accessibility.

Furthermore, our industry's ISO policy should be prominently displayed and made readily available to all employees, ensuring everyone is aligned with our quality and safety standards. The tool room should be properly labelled and arranged for efficient use. To keep our workforce informed and motivated, the plant's performance should be regularly measured and displayed in simple and comprehensible terms.

Lastly, safety measures should be a top priority. Motors, along with driving belts, should be adequately guarded with the installation of belt guards to prevent accidents. A comprehensive risk analysis should also be conducted for areas like ultrasonic testing of compressor receivers, ensuring that all potential hazards are identified and mitigated effectively. These enhancements will contribute to a safer, more organized, and productive manufacturing environment.

7. Implementation Process

The implementation of the 5S methodology took approximately 25 days to complete. Data collection was conducted alongside the previously mentioned risk assessment in the initial phase. Following this, a pre-analysis form was developed for the first three "S" components: Sort, Set in order, and Shine.

Additionally, the initial state of the screening area was documented through photographs to facilitate a clear comparison of the conditions before and after the implementation of the 5S methodology. This comprehensive approach ensured that all aspects of the implementation process were thoroughly assessed and recorded. Figure 1 shows 5S and safety precautions and their implementation.

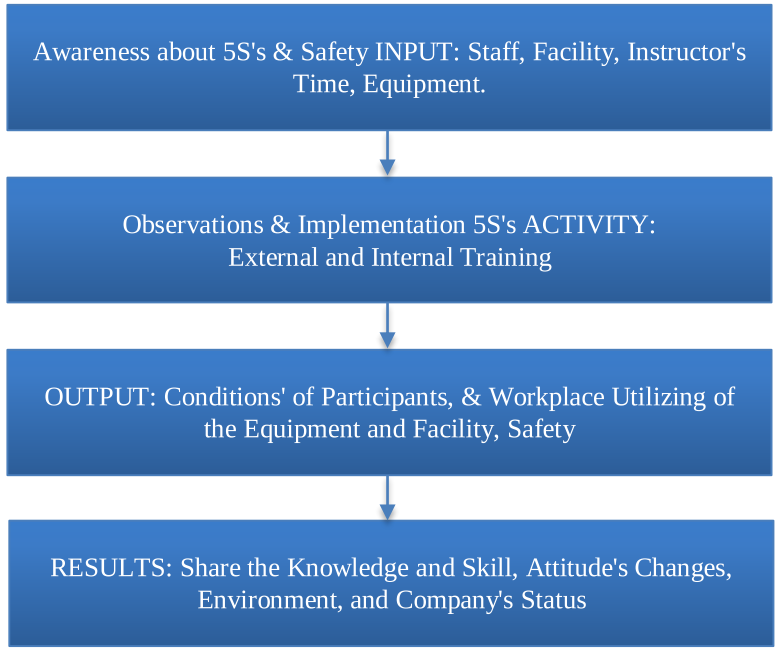

Fig. 1 Implementation process: 5s & safety precautions

Here is Table 1 illustrating the changes implemented at the shop floor level to minimize the risk of accidents, presented in the “Before and After” format:

Table 1. The changes implemented at the shop floor level to minimize the risk of accidents

Aspect of Change	Before Implementation	After Implementation
Plant Layout	No Defined Layout	Organized layout with a “place for everything and everything at its place” principle
Illumination Levels	Inadequate Lighting	Illumination levels meet industry standards
Specific Area Displays	Lack of Visibility	Visible displays for the Pantry room, the power station, tool room, and other key areas
ISO Policy Display	Not Prominently Displayed	ISO policy prominently displayed and accessible to all employees
Tool Room Organization	Unlabelled and Disorganized	Tool room labelled and arranged for efficiency
Performance Measurement	No Performance Tracking	Regular measurement and display of plant performance in simple terms
Motor Safety	Unprotected Motors and Belts	Motors and driving belts are safely guarded with belt guards; Risk analysis conducted for specific areas

These changes have significantly improved safety and organization on the shop floor, reducing the risk of accidents and ensuring a more efficient work environment.

Figure 2 illustrates significant improvements across various operational aspects of a manufacturing process before and after implementing the 5S methodology. Each aspect is measured on an improvement scale from 0 to 6. The red bars, representing the pre-implementation state, show issues like poor motor safety, lack of performance tracking, disorganized tool rooms, and inadequate lighting. After 5S was applied, represented by the green bars, there were substantial enhancements: motor safety improved with proper guarding and risk assessments, performance measurement systems were introduced, and the tool room became more organized with labeled areas. ISO policies, previously not visible, were prominently displayed, and key areas in the plant were clearly marked, improving workflow and safety. Illumination levels were upgraded to meet industry standards, and the plant layout was optimized, ensuring efficiency and minimizing hazards. Overall, the 5S methodology led to a safer, more organized, and more efficient work environment, as shown by the substantial positive changes in each aspect.

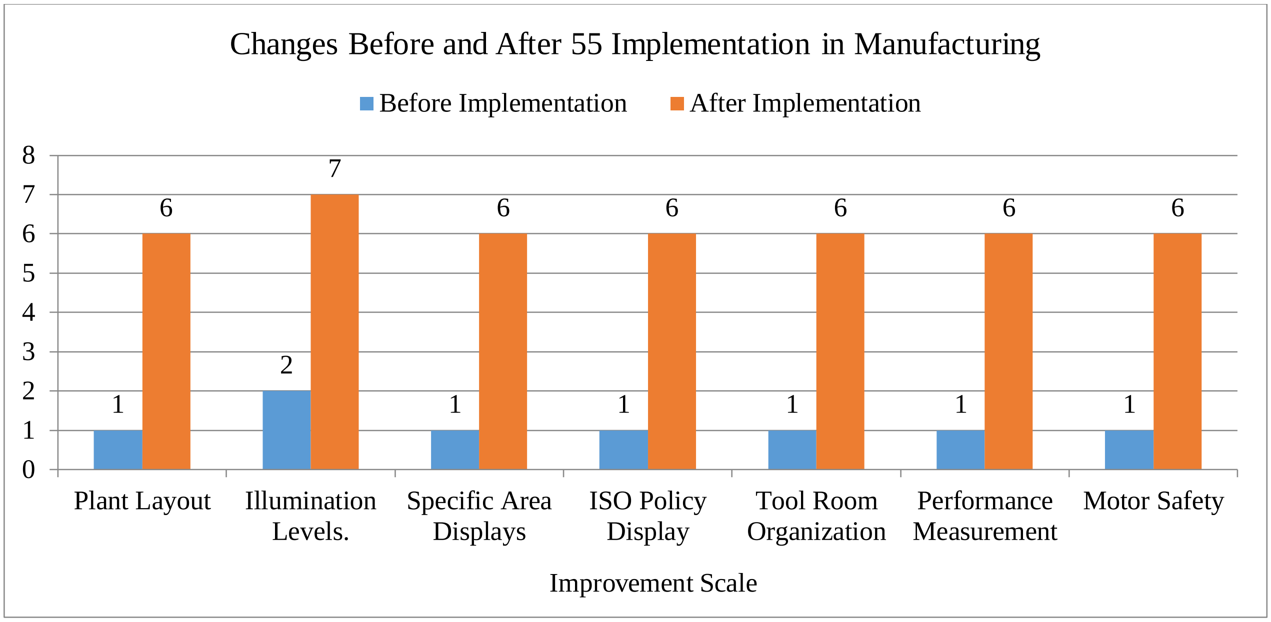

Fig. 2 Improvements before and after 5S implementation in manufacturing

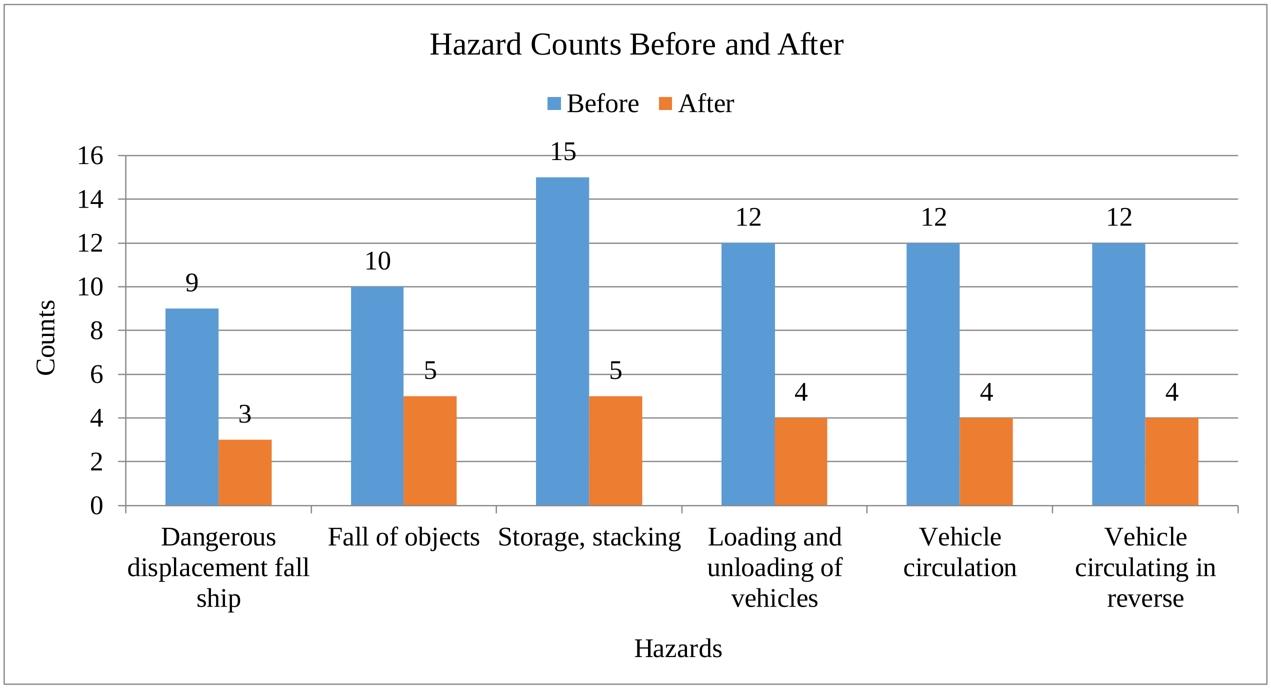

Fig. 3 Hazard reduction comparison before and after 5S implementation

The comparison graph in Figure 3 illustrates the impact of the 5S methodology on reducing workplace hazards in an industrial unit. The comparison shows a significant reduction in the number of safety incidents before and after 5S implementation. Key hazards like dangerous displacement, falling ship, and falling of objects, as well as storage/stacking, saw notable reductions, with the Storage, Stacking category showing the most significant decrease from 15 incidents to 5. Hazards related to loading/unloading vehicles and vehicle circulation also dropped from 12 incidents each to 4. The chart highlights the overall reduction in incidents and demonstrates a 64% decrease in total risk following the 5S methodology. This improvement underscores the effectiveness of 5S in enhancing safety by systematically organizing the work environment, reducing clutter, and fostering a culture of hazard prevention. The chart visually supports the argument that 5S significantly improves workplace safety and operational efficiency.

Observations and improvements on the Shop Floor:

Sr No	Before	After
1	 **Fig. 4(a) Fire extinguisher with the expired date**	 **Fig. 4(b) The due date of the fire extinguisher is pasted on the wall for attention**
2	 Fig. **5(a) LPG & Oxygen cylinders were kept near inflammable materials viz. oil**	 **Fig. 5(b) Warning sign of potential threat is displayed near the inflammable material**
3	 **Fig. 6(a) Open wires on the shop floor near the CNC machine**	 **Fig. 6(b) Open Wires, closed with proper electric boards**

4	 **Fig. 7(a) Scattered dispatch area**	 **Fig. 7(b) Dispatch area within an order**
5	 **Fig. 8(a) Improper arrangements of tools in tool-room**	 **Fig. 8(b) Tools in the tool-room arranged in proper sequence with labels**
6	 **Fig. 9(a) Oil leakage near machines, prone to slippage**	 **Fig. 9(b) Precautionary sign pasted on the machine to keep the floor oil-free, which may lead to an accident**

- Apart from the above changes, a few more changes were made for smooth functioning at the shop floor level, as listed below.

<table>
<tr><td>1</td><td>

Fig. 10 first aid medicines</td><td>To keep track of the expiration dates of various first aid medicines, the expiration date is verified every Friday morning.</td></tr>
<tr><td>2</td><td>
Fig. 11 Employees dress and safety equipment</td><td>• Employees' dress and safety equipment are placed in a fixed location.
• Wear clothes suitable for the job, and wear thick shoes.
• Always wear safety glasses, face shields, and helmets.
• Wear shirts with sleeves cut off or rolled above the elbows.</td></tr>
</table>

8. Conclusion

Implementing the 5S system has effectively improved safety and working conditions in the shop floor environment while reducing potential hazards. Key findings indicate that the systematic application of 5S principles leads to significant accident prevention and enhanced operational efficiency. For practitioners, it is recommended to integrate 5S with safety management systems like OHSAS 18001:2007 to bolster employee knowledge and foster a culture of continuous improvement. The current study has limitations, particularly its focus on a single manufacturing facility, which may not represent broader industry practices. Future research could explore the scalability of the 5S methodology across various sectors and different organizational sizes. Additionally, incorporating qualitative assessments and longitudinal studies would provide deeper insights into the long-term impact of 5S on safety and operational efficiency.

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