Proceedings of the 7th African International Conference on Industrial Engineering and Operations Management
Cape Town, South Africa, May 13-15, 2026

Proceedings of the International Conference on Industrial Engineering and Operations Management

Publisher: IEOM Society International, USA DOI: 10.46254/AF07.20260360
Published: May 13, 2026

Characterization of Manufacturing Downtimes in the Automotive Industry in South Africa

John Zvidzayi
Mangosuthu University of Technology
Department of Mechanical Engineering, South Africa
johnz@mut.ac, rejohzvidzayi@gmail.com

Abstract

In manufacturing sustainability is determined by the time the machine is adding value per shift. If the machine stops due to breakdown the cost of production increases and profitability falls because of the downtimes. The five causes of manufacturing downtimes in the automotive industry were found to be Manpower, Methods, Machine, Materials and Maintenance of the equipment or the 5Ms. The 5Ms are responsible for the eight wastes in manufacturing hence the need to analyse the manufacturing process and impact of the eight wastes. The Total Productive Maintenance (TPM) strategy involves all workers in reducing the downtimes in the automotive industry. TPM and total Quality management systems is effective in increasing the plant availability. To increase availability or uptime of manufacturing equipment need to be services, repaired and operated by trained personnel. Operators are trained to do minor repairs and services whist specialized technicians do major repairs and overhauls during shutdowns. The automotive industry has incorporated the Poka Yoke and Jidoka tool using machine history to detect and show an error before it happens using visual Andon lights.

Keywords
Sustainability, Total Productive Maintenance, Manpower, Machine, Methods, and Materials

1. Introduction
1.1 Background
The manufacturing production lines need to run efficiently with minimum to zero breakdowns to reduce defects whilst increasing profitability. The adoption of Lean principles and methods such as Total productive maintenance (TPM), Total Quality Management (TQM) and Single Minute Exchange of Dies (SMED) (Ondra 2022).

TPM is necessary for operation of a plant at the optimum level by keeping the plant and equipment well maintained. The objectives of TPM according to (Saxena 2022) are to:

i. Sustain equipment capacity by training, motivating and involve operators in decision-making.
ii. Establish cross function maintenance teams for continuous improvement.

TPM and TQM are applied at concurrently in the automotive supply chain where Lean manufacturing is practiced. Every automotive part is checked at every value adding section to meet the requirements. The DMAIC (Define, Measure, Analyse, Improve, and Control) cycle, Pareto diagram, and fishbone diagrams are used frequently to improve processes and reduce the rejection rate. Total Quality management embraces the continuous effort by employees to ensure high quality products whilst the six-sigma method use feedback from customers to improve a process, system. Its focus is on scientific and statistical methods to reduce the defect rate (Jou *et al.* 2022).
Global competition compels the manufacturing companies to improve and optimize productivity, production, flexibility to and gain competitive advantage. To enhance this competitiveness, the application of SMED and TPM in

managing machines and equipment, to reduce waste and lead times has been adopted to improve and monito Overall Equipment Effectiveness (OEE) (Ondra 2022).

Down time include loading/unloading time, excessive tool changeover, excessive job changeover, unavailability of an operator, machine breakdown, to mention but a few. Tracking downtimes involve monitoring a machine process for shutdown conditions. The expected and unexpected causes of downtime in the shop floor have to be determined and improved to reduce the costs of manufacturing (Achal Kandoi1 2023).

The paper focuses on the analysis of downtime and its reduction. The Pareto analysis and statistical analysis of downtime was conducted to identify the downtime factors hierarchically.

1.2 Aims and Objectives

The study seeks to establish the causes of downtimes in the production of automotive components with respect to the Manpower, Machine, Materials and Method (4Ms).

1.3 Research questions

RQ1 To what extent does each element affect the downtimes?
RQ2 What improvements are done by the automotive industry to reduce times?

1.4 Scope

The study focuses on how TPM, Poka Yoke, SMED and other Lean tools affects the OEE and improves the quality of the products to increase profitability.

1.5 Significance

The analysis of downtimes and establishing methods of eliminating them will increase the productivity of the manufacturing industry. The study will establish the best practice methods of reducing downtimes in a mass production automotive industry and develop a generic framework for use in various industries other than the automotive industry.
.

1.6 Compliance to Standards

The extent to which ISO standards are used in the automotive industry to attain the customer quality, protect the environment and maintain the safety of both equipment and personnel. Today's industries use green materials and machinery to minimize pollution.

2. Literature review

The literature will consider how various industries apply TPM and SMED to increase the uptime and availability of the plant equipment for the 4Ms. Downtime in a production line is the period during which equipment or machinery is not operational, leading to a halt in production activities. It can be planned downtime when the equipment is stopped for scheduled maintenance, upgrades, and calibration. Unplanned downtime is an unforeseen failure caused by internal (operator errors) or external factors (power outages, waiting for materials, methods and operator training). Today ,manufacturers are urged to invest in monitoring tools, employee training, and continuous performance assessments to sustain improvements.

2.1 Method

Total productive maintenance (TPM) is a popular Lean maintenance strategy that ensure high machine reliability by increasing OEE of plant equipment. If an organization purchases advanced equipment the sustainability will be low if the quality of products and downtimes are high. TPM method is used to fully utilize the equipment by keeping it running in tiptop condition (Chowdury M. L. Rahman1* 2014). The study by (Mthetheleli Joseph Kwaso 2018) showed that OEE consistently improved its value above eighty percent (80%) when TPM is implemented in a manufacturing industry in South Africa (SA).

The improvement was caused by maintaining the equipment to increase availability.
Both studies show the importance of TPM in reducing downtime in both manufacturing and service industry. In the automotive industry the method will reduce downtime and increase machine productivity.

The study by (I Rizkya* 2021) showed 10 managers, and supervisors that were directly involved in implementing 5S on the production floor. The assessment revealed a 5S application of 82%, Autonomous Maintenance of 83%, focussed Maintenance of 75%, Planned Maintenance of 80%, Quality Management of 84%, Education and Training of 88%. The Safety, Health & Environment was 78% which was helpful in sustainability of both quality safety and environmental ISO standards. A development management of 75% was realized in the Research and development section using the Poka Yoke method.

The 5S tool is instrumental in improving productivity by increasing efficiency in the manufacturing process. The 5S tool enhances autonomous maintenance which is successful only when operators have been trained. 5S in some cases provides visual identification of work floor problems lading to continuous improvement such redesign of production tools, improving the safety of workers and machines.

(C Saleh1* 2019) applied the theory of constraints (Tomoyuki Fujiia* and Ojimad) method to overcome the challenges in downtimes in manufacturing. The theory effectively manages constraints that prevent companies from achieving their goals. The system focuses on capacity constraints to minimizing inventory and operating costs. All the unwanted items are kept at the central red tag area if no longer useful whilst items that can be used are kept in the local red tag area in the department.

The SMED is used to speed up the exchange of dies in the mass production of similar parts for different customers. In SA the automotive industry under study supplies door hinges to Nissan, Toyota, Mazda, VW and Renault. For each mini car the hinges will be similar but different. In batch production, the dies for the doors need to be change quickly if switching from Toyota to any other model. The SMED method is critical in reducing the down times (Ondra 2022).

The SMED Lean principle improves productivity by reducing the changeover times. The R& D department design production tools that are interchangeable and easy to remove and install using clamps instead of threaded fasteners. The reduction in the changeover times improves productivity.

2.2 Manpower

(Yang and Yang 2023) hinted that employee participation is reinforced by sharing outcomes, rewarding correct behaviour and practices, and recognising the work of all employees. A sense of belonging pushes the workers' desire to see the company succeed due to longstanding relationship, trust in colleagues and the management and a sense of ownership. The benefits of TPM affect employees' attitudes towards participation leading to acquisition of new skills and knowledge that improves their job security. Communication among workers, workers and management, and worker motivation was improved through autonomous maintenance and continuous improvement of skills through short courses at the plant (I Rizkya* 2021).

In the SA context, the manpower is a critical performance indicator that reduces defects and increase productivity in the manufacturing, service and mining industry. Training and empowerment of operators to stop and make minor adjustments on the machine were crucial for a successful implementation and machine upkeep. Job satisfaction is improved by training and empowering, engaging and involvement of all employees.

The workforce needs to apply the TOC to identify a deficiency and isolate it to allow the production line to run. In Lean the Gemba walk is done by the line manager or delegated employee to asses and evaluate the production line. The evaluation is inclusive of all employees in the department through a brain storming session (C Saleh1* 2019). The method has been found to be very effective in Lean manufacturing.

(Wolska, Gorewoda, Roszak and Gajda 2023) highlighted that the application of TPM by workers determines the maintenance schedules required for each machine in the production line. The indicators for technical problems of the tested production line are MTTR (Mean Time to Repair), MTTF (Mean Time to Failure), and MTBF (Mean Time Between Failures).
The workforce needs to determine the numerical values for these indicators to eliminate failures and, maximize the value of MTBF indicators. The MTTR (Mean Time to Repair) is the time it takes to repair a machine using Standard Operating procedure.

$$MTTR = failure\ time/number\ of\ recovery\ events \qquad 1$$

MTTF (Mean Time to Failure) determines the average operating time of a device from the beginning from its last repair until the next failure occurs.

$$MTTF = (available\ uptime - failure\ time)/number\ of\ events \qquad 2$$

The Mean time before failure is the period during which the device can operate without interruption given by:

$$MTBF = MTTR + MTTF \qquad 3$$

Figure 1 the parameters for determining the plant availability in manufacturing. An increased mean time to fail means the plant will be production most of the times before it fails. When the equipment fails the repair time must be minimum to bring the machine back to production. Long repair times keeps operators idle whilst no production is taking place.

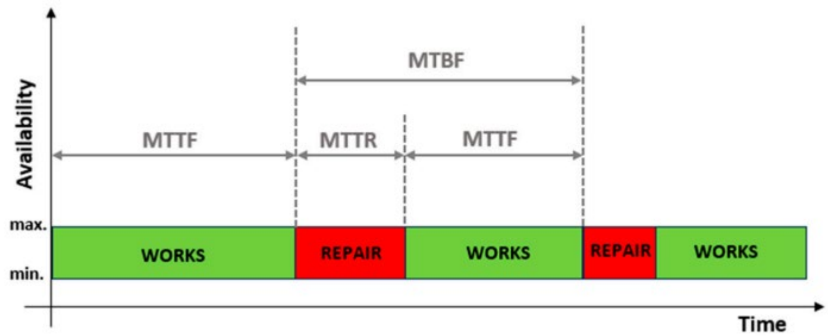

Figure 1. MTTF, MTBF, and MTTR in production time(Wolska, Gorewoda, Roszak and Gajda 2023)

2.3 Machine

TPM significantly reduces machine downtime in production lines by shifting from reactive to proactive maintenance which targets the "Six Big Losses" (breakdowns, setup/adjustments, idling/minor stops, reduced speed, defects, start-up losses. If TPM is implemented the six big losses are reduced significantly (Tamrat Yifter Meles 2024).

(Callan-Villanueva, Núñez-Gonzales and Calderón-Gonzales 2025) indicated that implementing a Lean-TPM production model integrates SMED and Poka Yoke reduced the set-up times by 35.99% and MTTR by 39.71 % whilst the MTBF increased by 32.66%. Integrating SMED and Poka Yoke with the TPM maintenance approach improved the efficiency of machines. The application of the Lean tool Poka-Yoke which is error proof provides customer satisfaction since it is defect free.

Modern machines are fully computerised and have sensors that can detect a defect before it is made using machine history to develop Jidoka programmes that activate Andon lights. The system senses a defect before it happens and send a signal that activates an orange light or alarm. The nearest operator will quickly attend to the machine and rectify the anomaly before a defect is formed. If not attended the machine will stop and avoid the formation of a defective part. This is possible when applying TPM where operators are allowed to do minor services and prevent breakdowns but allows short stoppages (Mouhib *et al.* 2025).

2.4 Maintenance

The TPM pillar of Autonomous Maintenance (AM) assigns minor adjustments and repairs to machine operators and instils a sense of ownership and responsibility among workers. The training of operators to do minor repairs and setting standard operating conditions helps to reduce breakdowns. The operators compile a machine history which the specialized maintenance teams use to plan for the planned shutdown. Today AM is digital and uses the Andon lights to detect a looming fault which the operator corrects at low cost and improves availability (Widya, Suef and Widodo 2025).

The study by (P. Guarientea 2017)Autonomous Maintenance was implemented and associated with other Lean philosophy tools (5S, TPM and Visual Management) with the purpose of improving actions in the maintenance sector of a production line, which would then reduce the stoppage rates resulting from machine breakdowns.

2.5 Measurement

It is critical to focus on doing right things that keeps the business goal of the company by measuring the value created by maintenance process in the plant. Key performance indicator (KPI) is set for measuring the value of maintenance management in terms of rejects, downtimes, and rework. The effectiveness of Maintenance Planning and Control (MPC) processes is set on the Andon lights system where preset MTTF and MTTR is set for the machine and operators (Callan-Villanueva, Núñez-Gonzales and Calderón-Gonzales 2025).

The Andon system is created to increase and improve production lines by notifying worker if the production line needs to be stopped or even stopped by itself. Andon systems are visual management tools used in manufacturing to signal abnormalities in real time to facilitate maintenance response and measurement through various KPIs (Muhammad Ary Murti 2020).

2.6 Materials

Manufacturing industries use material requirements planning (MRP) systems for inventory management and for planning and forecasting the quantities of parts and components required for production. Inadequate forecasting can lead to downtimes due to waiting losses. Poor quality materials in the automotive bending operations tend to crack. Demand uncertainties compel the planning systems to follow either a supply-oriented or a demand-oriented approach. When the materials are stocked in the warehouse first in first out (FIFO) or last in first out (LIFO) approaches can be used. The production logistics in the automotive industrial has several bottlenecks unless they use the Kanban principle (Najy 2020) and (Rahul Hencha 2019).

Materials quality, condition and availability cause downtimes that reduces productivity in the manufacturing industry. (Wolniak 2019) study revealed that downtime in the production line is reduced by using good quality tools and welding electrodes. The failure of welding electrodes in the tested period were 135 with a total downtime of 4,185 minutes. The downtime or MTTR was 31 minutes whilst uptime or MTTF was 5,238 minutes. The mean time between failures (MTBF) was 5,269 minutes, which translates into 87 hours and 49 minutes of machine operation.

(Thanou and Matopoulos 2021) carried out a study to smoothen the flow of materials in a workshop or production line. The application of housekeeping rules in line with the 7S principle reduces the downtime by designing good storage of materials and components in relation to retrieval , sequence of usage and location. Disturbances in material flow in the production line led to unplanned downtimes.

Figure 2 shows the cause-and-effect diagram of the downtimes experienced in the manufacturing sector. Workers and management have been dealt with separately. Method and measurement were treated separately according to (Tamrat Yifter Meles 2024)

The just in time (JIT) tool in Lean manufacturing works with the Kanban principle that only allows required material to the production centre (Ukey *et al.* 2025).
The number of Kanban cards (n) $= \frac{D \times RT \times (1+\alpha)}{Q}$

Where D = average daily demand
RT = replenishment time or total lead time to produce and restock the item.
α = safety factor based on uncertainty
Q = Lot size

Figure 2 is a root cause analysis diagram that was used to the effect of manpower, management, method, measurement and maintenance in a manufacturing process that does not use TPM. In the study a similar approach is used to determine the origin of any failure of the machine, defect in the product and increased takt time. The ability to control these parameters will reduce down times and improve productivity.

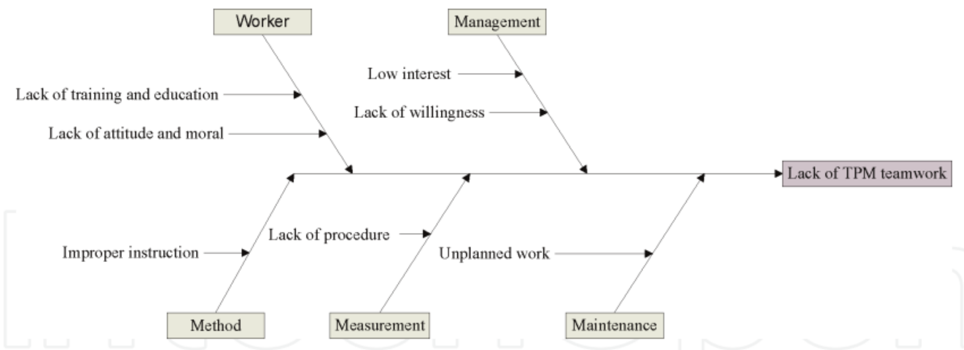

Figure 2. The cause and effect diagram for TPM (Tamrat Yifter Meles 2024)

3. Methodology

The work study method is used to identify the potential bottlenecks and apply the Theory of constraints to eliminate the bottlenecks. The observation method is used to identify and request official data from the respective automotive industry is collected and used for statistical analysis and develop the Corrective Action and Preventive Action (CAPA) plan. The literature survey is critical to understand the Lean philosophy as applied by the automotive industry and the gap to be filled.

Figure 3 shows the methods used to collect data. The study observed the manufacturing process and identified statistical records on noticeboards that were used for work study. The line managers, technicians and operators were interviewed with strict anonymity since the industry has high global competition.

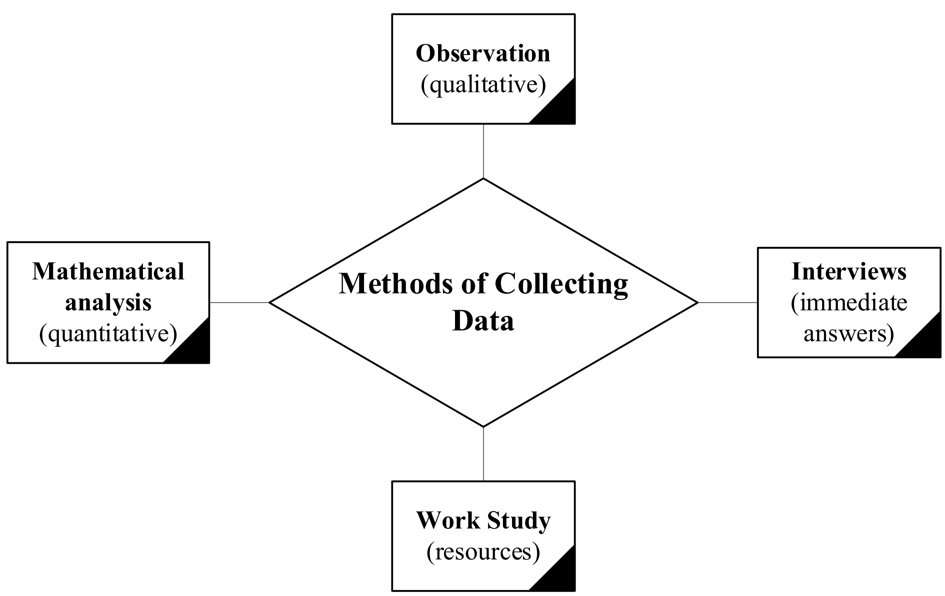

Figure 3. The method of collecting data used(Mazhar 2021)

4. Results

The results have been presented as graphical. Numerical and qualitative discussions.

4.1 Graphical & Numerical

Figure 4 shows the numerical values of downtimes as a percentage for the three weeks of manufacturing door 1 for a specific mini car model first quarter. The work study and observation enabled the study to identify statistics and graphical work for the actual production status in terms of plant availability per shift. During week 22 the downtimes ranged from 0 to 3% and productivity was high because of less rejects and rework

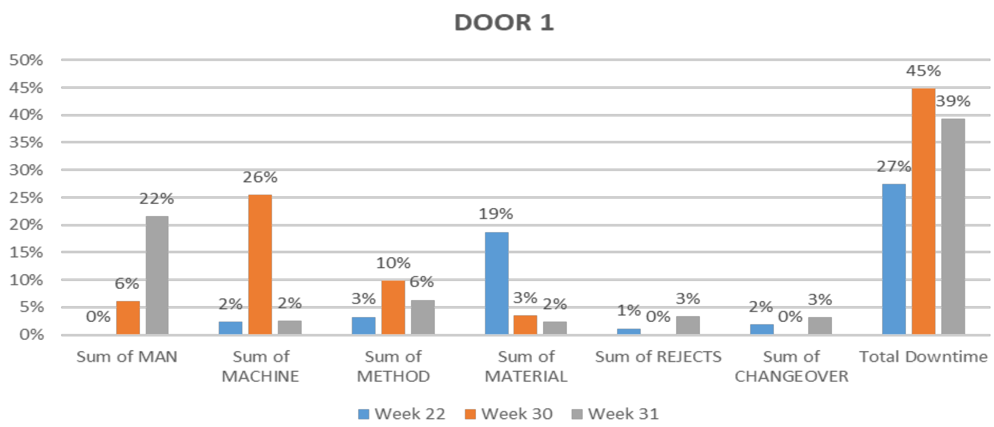

Figure 4. The downtimes experienced in the production of door 1 in 2024

The total downtimes for week 22 are 27% and the productivity was high (Figure 5). In week 30 the downtimes ranged from 6 to 26 % meaning the week had many downtimes caused by minor adjustments, rework and rejects totalling to 45%. The productivity decreased to lowest in week 30. Week 31 downtimes ranged from 2 to 26 % and the total was 39 %.

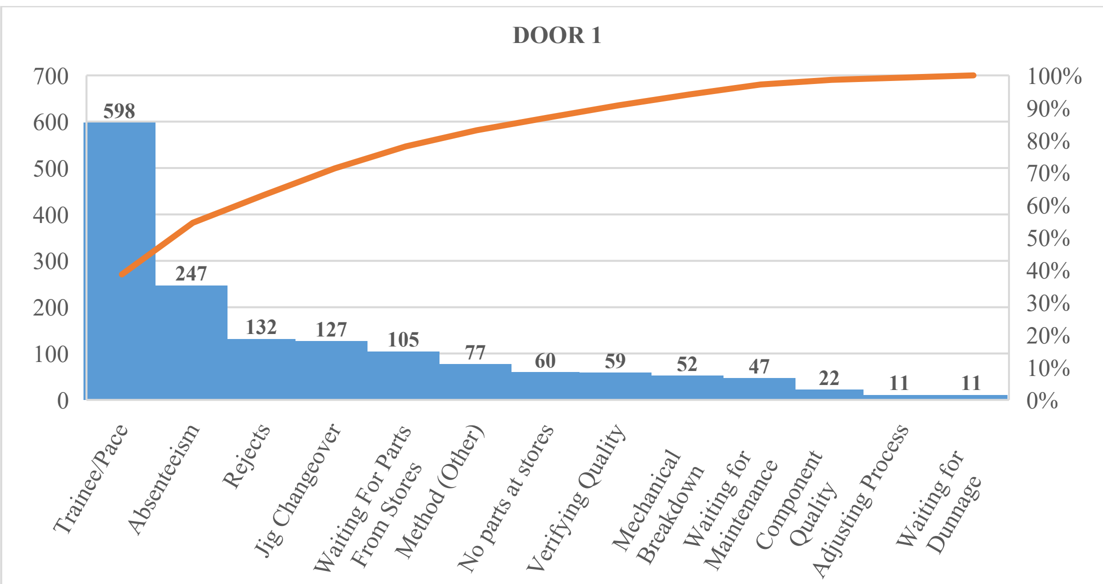

Figure 5. The Pareto analysis of door 1 production

4.2 Qualitative

By appointing a person responsible for the correction of data in technological cards is critical in keeping more accurate data for use. The data must be reviewed periodically to control the production process. The review will help to evaluate areas that cause most problems and need to be prioritized. The data relationship is used to establish the cause of failures or downtimes.

5. Discussions

The key downtime indicators are the 4Ms together with measurement. The manpower requires adequate skills through training, motivation and planning to execute their duties without causing unplanned downtimes.

The Lean philosophy requires the employees to be trained in multiple skills then they will be placed where their talent is to be innovative because of self-motivation. Operators are trained periodically and participate in brainstorming and decision making . The mangers motivate the employees by consulting and engaging them in most decision-making operations. All employees are made to know the customer value requirements and thrive to satisfy the customers. Job and customer satisfaction is pivotal in the automotive industry.

The method used in the automotive industry applies the Lean principle where TPM is the preferred maintenance strategy. The training of all workers to acquire the basic maintenance skills and the mandate to stop a machine for minor services reduces the unplanned downtime durations in the plant. In Lean the organization set standard operating procedures (SoPs) for each department or section which guides the employees to do standard work. For each maintenance activity in the plant a designed procedure is followed every time.

Machines are serviced and maintained periodically to prevent premature failure. The loading and speeds of machines are set and standardized for each operation. The use of manufacturer's guidelines such as oils, cutting fluids, feed rates and speeds help keep the machine up.

Materials used must be as per manufacturer specifications in terms of grade and quality. Any compromise will cause unplanned breakdowns. The cutting tools, dies , jigs and fixtures must be made using the appropriate material to reduce unplanned breakdowns. Lack of material quality causes the material to fail due to fatigue and overheating. Surface protection of materials is critical to prevent damage due to environmental contamination.

Manpower determines the sizes of machines, bill of materials, MRP, and performance measuring is critical for planning purposes to have adequate materials in line with the JIT philosophy. Overstocking materials , machines and finished products is a cost to the company. It can cause downtime in the search for wanted parts and their retrieval.

6. Future Improvements

The automotive industry must thrive to reduce times on their machines and save money in manufacturing. The industry must focus on eliminating the eight wastes by applying different lean manufacturing tools. The personnel need to be educated and trained on the importance of Lean. The training by specialist can be done on the job and at benchmarked companies.

7. Conclusions

Reducing downtime through proactive maintenance of the KPI of the 5Ms is essential for manufacturing. For each KPI a root cause analysis can be done to identify the causes of downtime and develop the standard procedures. The identified cause of downtime must be seen as an event that initiates continuous improvement rather than fault finding to blame the workers involved. The production data must be recorded and reviewed to enforce continuous improvement initiatives and policies. Some industries develop standard operating conditions to minimize downtimes and increase productivity. The reduction of waste, and costs is critical in maintaining a competitive edge in their industries. The success in eliminating the problem must be rewarded to the team instead of individuals.

Downtimes caused by manpower was dure to lack of training and empowering of operators by management. Management must empower operators to decide when the machine needs to be stopped and adjusted without calling the maintenance technician. Management must engage and involve the operators and all stake holders such as equipment and material suppliers. In the application of methods suitable methods that are user friendly must be decided with consultation of the operators as well. Any modifications and improvements must be communicated to all staff. The material suppliers should be carefully selected so that the company can collaborate with them when developing certain materials for specific applications.

References

Achal Kandoi1, J. M. Optimizing Production Efficiency: A Case Study on Machine Downtime Analysis and Implementation of Quality Control Tools and Action Plans. International Journal for Research in Engineering Application & Management (IJREAM), 8 (11), 2023.

C Saleh1, T. I., A B Hassan2 and M N Zakka1. Profit Optimization Through the Application of Theory of Constraints (TOC): A Case Study in Printing Company. IOP Conf. Series: Materials Science and Engineering, Article ID, 2019.

Callan-Villanueva, A. J., Núñez-Gonzales, S. A. and Calderón-Gonzales, W. D. Addressing Operational Challenges in Plastic Manufacturing SMEs: A Lean-TPM Model for Improved Efficiency and Quality. International Journal of Economics and Management Studies, 12 (2): 1-10, 2025.

Chowdury M. L. Rahman1*, M. A. H., Syed Misbah Uddin1. Assessment of Total Productive Maintenance Implementation through Downtime and Mean Downtime Analysis (Case study: a Semi-automated Manufacturing Company of Bangladesh). IOSR Journal of Engineering (IOSRJEN), 4 (9), 2014.

I Rizkya, R. M. S., K Syahputri and U Tarigan. Evaluation of total productive maintenance implementation in manufacture. IOP Conf. Series: Materials Science and Engineering, Article ID, 2021.

Jou, Y.-T., Silitonga, R. M., Lin, M.-C., Sukwadi, R. and Rivaldo, J. Application of Six Sigma Methodology in an Automotive Manufacturing Company: A Case Study. Sustainability, 14 (21), 2022.

Mazhar, S. A. Methods of Data Collection: A Fundamental Tool of Research. Journal of Integrated Community Health, 10 (01): 6-10, 2021.

Mouhib, Z., Gallab, M., Merzouk, S., Soulhi, A. and Di Nardo, M. Total Productive Maintenance and Industry 4.0: A Literature-Based Path Toward a Proposed Standardized Framework. Applied System Innovation, 8 (4), 2025.

Mthetheleli Joseph Kwaso, A. T. Evaluating the Impact of Total Productive Maintenance elements on a Manufacturing Process. Paper presented at the Industrial Engineering and Operations Management Paris, France, IEOM, 2018.

Muhammad Ary Murti, A. Z. F. Andon System using Industrial IoT for Controlled Production Line by conventional PLC. International Journal of Engineering Research & Technology (IJERT) ISSN 9(9): 2278-0181, 2020.

Najy, R. J. MRP (Material Requirement Planning) Applications In Industry - A REVIEW. IJRDO - Journal of Business Management, Article ID, 2020.

Ondra, P. The Impact of Single Minute Exchange of Die and Total Productive Maintenance on Overall Equipment Effectiveness. Journal of Competitiveness, 14 (2): 113–132, 2022.

P. Guarientea, I. A., L. Pinto Ferreiraa, T. Pereiraa,b, F.J.G. Silvaa. Implementing autonomous maintenance in an automotive components manufacturer. Elsevier ScienceDirect, 13: 1128–1134, 2017.

Rahul Hencha, D. D. S. V. Study Of Material Requirement Planning Processes & Its Analysis And Implementation (A Case Study Of Automobile Industry). International Journal Of Scientific & Technology Research, 8(08), 2019.

Saxena, M. M. Total Productive Maintenance (Tpm); As A Vital Function In Manufacturing Systems. Journal of Applied Research in Technology & Engineering, 3 (1): 19-27, 2022.

Tamrat Yifter Meles, A. M. W. Enhancing Total Productive Maintenance Strategy for Improved Productivity and Performance. In: Open, I. ed. Systems Engineering – Design, Analysis, Programming, and Maintenance of Complex Systems, 2024.

Thanou, E. and Matopoulos, A. Improving efficiency of material flows in an automotive assembly plant: A case study. CIRP Journal of Manufacturing Science and Technology, 35: 959-967, 2021.

Tomoyuki Fujiia*, K. T., Yukinori Suzukib, Takahiro Yamamotoc, and Ojimad, Y. S. a. Y. Fatigue Properties of Spot Welded and Spot Weld-Bonded Joints of Steel Sheet. Elsevier Science Direct Procedia Engineering, 10: 1075–1080, 2011.

Ukey, K., Gajghate, S. S., Kumar, S., Kumar Behera, A. and Majumder, H. Execution of Pull System and Constant Work-in-Process Using Kanban System—A Case Study. Paper presented at the AdvaMAP 2025, 2025.

Widya, A. R., Suef, M. and Widodo, E. Development of Digitalized Autonomous Maintenance to Simplify the Application of Autonomous Maintenance in The Automotive Part Industry. In: Proceedings of the 10th International Conference on Science and Technology (ICST 2024), 222-236, 2025.

Wolniak, R. Downtime in the Automotive Industry Production Process – Cause Analysis. Quality Innovation Prosperity, 23 (2): 101-118, 2019.

Wolska, M., Gorewoda, T., Roszak, M. and Gajda, L. Implementation and Improvement of the Total Productive Maintenance Concept in an Organization. Encyclopedia, 3 (4): 1537-1564, 2023.

Yang, Y. and Yang, B. Employee participation in total productive maintenance – a bottom-up perspective. International Journal of Quality & Reliability Management, 41 (1): 269-290, 2023.