Mukesh Shyamkant Desai, et. al. International Journal of Engineering Research and Applications
www.ijera.com
ISSN: 2248-9622, Vol. 12, Issue 7, (Series-I) July 2022, pp. 43-56

RESEARCH ARTICLE OPEN ACCESS

Application of Single Minute Exchange of Die for the Reduction of Loading Time of Auto-car in Railway Wagons

Mukesh Shyamkant Desai*, Kirti Singh Yadav**, S. S. Rathi***
**Associate Professor, Department of Mechanical Engineering, OP Jindal University Raigarh Chhattisgarh, India*
Corresponding author's Email: mukesh.desai@opju.ac.in
*** M. Tech Scholar, Department of Mechanical Engineering, OP Jindal University Raigarh Chhattisgarh, India*
Email : kirtisingh.yadav88@gmail.com
**** Ph.D. Research Scholar, Department of Mechanical Engineering, OP Jindal University Raigarh Chhattisgarh, India*
Email : ssrathi@nalwa.com

ABSTRACT
The aim of this experimental work is to implement Single Minute Exchange of Die (SMED) methodology for the reduction of loading time of auto-car wagons. The experimental work carried out at Jindal Rail Infrastructure Limited, Vadodara, Gujrat, India. Transportation of auto-cars from manufacturing plant to various destinations precisely and timely manner by railway wagons is a challenge for manufacturer and railway department. Loading and unloading of auto-cars to the railway wagons is a complex and time taking activity and it takes around 170 to 200 minutes to full one wagon. After the successful implementation of SMED loading time of auto-cars to the railway wagons has been reduced from 172 minutes and 15 seconds to 124 minutes and 47 seconds i.e. reduction of 50 minutes and 23 seconds. Therefore, it is concluded that modifying the existing practices results in significant reduction in loading time of auto-cars in railway wagons.
Keywords – Reduction, loading time, Single Minute Exchange of Die (SMED), Setup Time, Wagon

I. INTRODUCTION

This study was carried out in operation division which is a part of wagon manufacturing department. The Jindal Rail Infrastructure Limited manufacture of different type of wagons open, covered, Flat and Auto-car wagons. Bogie Covered Auto-rake Double Decker Wagon (BCACBM). This is designed to offer logistics services to the automobile industry. BCACBM wagons for carrying automobile traffic are running on Indian Railway system under Automobile Freight Train Operator (AFTO) Scheme. India Auto Industry is finding good value in transporting its finished goods by the rail route rather than sticking to the conventional truck logistics model. Immediate benefits to OEMs is the Indian Railways' expansive network, better reliability and cost efficiency compared to road logistics. Moreover, it also allows offsetting the carbon. Indian Railways network has attained speedy growth in its automobile of diesel by shipping over 670,000 cars by rail since March 2014.

Rail logistics for automotive freight, therefore, has come a long way in the country and what started off with Maruti Suzuki India in March 2014, carmakers including the likes of Tata Motors, Honda Cars India, Hyundai Motor and newcomers like Kia Motors India have also jumped on the bandwagon recently by dispatching over 5,000 cars on the rail route from its plant in Anantapur, Andhra Pradesh to dealers all across the country.

To Study BCACBM Wagon to carry light automotive vehicles. This is designed to offer logistics services to the automobile industry for transportation of cars. The purpose of this study was to examine the current state of the complete changeover process between 5 to 6 hours loading and unloading of vehicles at railway siding for both upper and lower decker vehicles configuration for identical operation lines and implement process improvements to reduce setup time, referred as SMED tools and develop a new changeover system to allow for future reduction of the overall setup time by 50%. Reducing the overall setup time by 50% would equate to roughly 2000 nos. of additional auto-cars shipped per month.

The aim of this research is to implement Single Minute Exchange of Die (SMED) methodology for the reduction of loading time of auto-car wagons. According to literature survey, various authors carryout their research for the reduction for loading and unloading time of auto- car wagons. After the successful implementation of SMED loading time of auto-cars to the railway wagons has been reduced from

172 minutes and 15 seconds to 124 minutes and 47 seconds i.e. reduction of 50 minutes and 23 seconds.

II. LITERATURE REVIEW

This study is concerned with the application of Single Minute Exchange of Die (SMED) methodology for reduction of loading time of Auto-car wagons. At first, a brief background of SMED methodology is discussed then after the whole literature is divided into two sections. The first section represents, a review of relevant literature related to Single Minute Exchange of Die (SMED) and its applications in various manufacturing industries for the reduction of setup time. The Second section represents a review of Application of various tool/methods for the reduction of loading and unloading time of Auto-car Wagons

Figure 1 shows an overview of the literature review plan

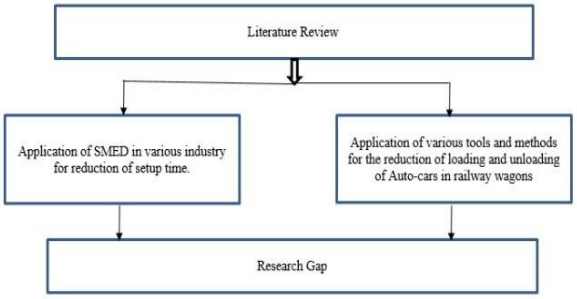


Fig. 1: Literature Review Plan

2.1 Background of Single-Minute Exchange of Die (SMED)

SMED was developed by Dr. Shigeo Shingo at Toyo Kogyo's Mazda plant in Hiroshima, Japan in 1950 at the time of a die change process. It was aimed at dealing with the problems of production which is large in varieties, but less in quantities, as well as decreasing the inventory and improving the rapid response ability of the production system [1]. Generally, SMED is aimed at standardizing and simplifying operations in response to the emerging needs of increasingly smaller production lot sizes, required to meet the desired flexibility in customer demand [2].

SMED is one of the many lean production methods for reducing waste in the manufacturing process. It provides a rapid and efficient way of converting a manufacturing process from running the current product to running the next product. This rapid changeover is the key to reducing production lot sizes and thereby improving flow. The phrase "single minute" does not mean that all changeovers and startups should take only one minute, but that they should take less than 10 minutes, in other words, "single-digit minute" [3]. SMED was originally developed to improve die press and machine tool setup, but its principle applies to change over in all type of processes. The setup operation is defined as the preparation or post-adjustment that is performed once before and once after each lot is processed [4].

Shingo divides the setup operation into two parts -internal setup and external setup. Internal setup operation is one that can be done only when the machine is shut down i.e. attaching or removing the dies. External setup operation is one that can be done when the machine is still running. These operations can be performed either before or after the machine is shut down; for example, getting the equipment ready for the setup operation can be done before the machine is shut down [5], [6], [7], [8], [9].

2.2. Application of SMED in various industry for reduction of setup time.

Desai and Warkhedkar (2011) presents a study of set-up time reduction in a small factory involved in the machining of precision components in small batches with large variety for the automobile industry. The factory has made some set-up reductions mainly using work study related methods and in one manufacturing cell by the use of the Single Minute Exchange of Die (SMED) methodology. The focus of this study, the changeover and set-up times were never measured or, worse still, measured and considered as productive hours. As a consequence, there was no awareness and motivation to reduce set-up times as it was considered that this type of action would reduce the productive efficiency of the plant. The main barriers to the implementation of setup time reductions and mistake proofing were identified to be 1. A lack of financial resources to support the set-up time reduction and mistake proofing devices. 2. A resistance to change from middle managers and operators. 3. A lack of a strategy to apply SMED and mistake proofing. 4. A lack of knowledge and training on these methodologies.

Mohd Norzaimi, et.al (2013) improved the productivity by using SMED technique and waste elimination and achieving 95% of the productivity in CNC process. Based on the study, the result shows lower productivity due to high changeover time during changing model which affected the productivity for the CNC process in the case study company. The scope and limitation are using SMED methodology, PDCA approach to meet the objectives and focusing on CNC machining process, which consider as changeover time.

Desai and Rawani (2017) presents productivity improvement of shaping division of an Automobile industry by using single minute Exchange of die (SMED) methodology. Experimental work carried out

at Varroc Engineering Private Limited, an Automobile industry. Aim of this experimental work is to improve productivity of shaping division of the industry by reducing setup time and tool change time. For this, Single Minute Exchange of Die (SMED) methodology is applied along with Kaizen. Suitable design improvements of critical components viz. clamping fixture and tie rod are also done. Implementation of these resulted in reduction of setup time by 82.44% and tool change time by 44.21%. This helped to produce additional 23 jobs/ shift with same input.

P. Arunagiri, et.al (2017) concerned with implement the concepts of lean production in terms of waste elimination, in the matter of identification of waste time, factors leading to it and eventually reduce eliminate the loading and unloading time. The lean tools used are concepts of Process mapping, 8 step problem-solving methodologies, elimination of waste, Set up time reduction. Here increase in the output in the industrial data analysis results after setting the optimized loading and unloading time increases the number of components per shift. The results indicate that there is impact of lean systems for the productivity improvement in automobile industries. In crank case cell, the number of output per shift before optimization was 148 whereas the number of output per shift after optimization was 161 components per shift. The number of components increased from 444 to 483 components in crank case cell.

Jagdeep Singh et. al (2018) a case study in a small-scale manufacturing unit of northern India to generate an integrated setup reduction approach, utilizing Single Minute Exchange of Die (SMED)-based industrial engineering tools to achieve faster setups. It describes the feasibility of quick changeovers in small enterprises based on an "SMED" approach. Finally, carries out empirical analysis of the financial/non-financial benefits incurred from setup reductions. A SMED approach can help eliminate unwanted activities, externalize the internal activities, demonstrates the practical application of SMED showing how it can bring real breakthroughs in reducing setup time in small-scale manufacturing.

K. Fathurrahman and I.M. Hakim (2020) The objective of this research is to implement Lean Manufacturing in the automotive industry. As the manufacturing markets became more competitive and the success of firms became more transparent. Lean thinking can be summarized in five principles: precisely specify value by specific product, identify the value stream for each product, make value flow without interruptions, let customer pull value from the producer, and pursue perfection. Continuous improvement or the consistent change in processes for overall process improvement was adopted by Taiichi Ohno post World War II.

The SMED methodology along with ECRS (Eliminate, Combine, Reduce, and Simplify) concept was adopted to achieve a reduction in setup change time (Pawar et. al., 2014). The Setup activities are a vital part of the production lead-time and so affect overall product cost. Tools like Pareto analysis, root- cause analysis and method study has been used to analyze the existing procedure of set-ups. Hence, reduction in average set-up time is reduced from 108 minutes to less than 16 minutes [10]. Setup time reduction in a small factory involved in the machining of precision components in small batches with a large variety for the automobile industry implementation of conventional SMED the setup time is reduced by 82.44% and tool change time by 44.21%. This helped to produce an additional 23 jobs/ shift with the same input [11]. The applicability of the proposed SMED approach was tested for shaping machines changeovers in the automotive industry [12]. The setup time from 40 minutes to 12 minutes i.e. 28 minutes is reduced in a forging shop by using SMED technique [13]. In BMS press for the production of hose clamps, set up time reduction and improved the productivity is increased from 60000 clamps/day to 105000 clamps/day [14]. Setup time reduction through SMED with the integration of Planning System Interface, the validation of the proposed method was done through implementation on a manufacturing company which manufactures radiator and compressor by implementing SMED, tool change time was reduced from 113.75 hours in June 2008 to 59.75 hours [15]. The utilization of the synergic potential of SMED and Kaizen techniques. Roll changeover time in an Indian steel pipe manufacturing plant, is reduced by 32 percent [16]. Carried out an experiment to reduce the setup time in an automobile factory, the implementation of SMED on the setup process, is reduced the total set up time for the axle grinder from an initial time of 24.065 minutes to 14.416 minutes (a saving of 58.3% of time) increasing productivity by 65.38% per month calculated at 1500 setups in a month with an economic gain to the extent of 53% (Adanna et. al., 2013). SMED methodology used for the reduction of changeover time in the garment manufacturing industry [17]. The SMED methodology and other Lean Production tools (5S, Visual Management, Kaizen and Standard Work) were applied to reduce the setup time. As a result, the process setup time was significantly lowered from 52 to 24 minutes. The percentage reduction in the set-up time of 53.85% [18]. The setup time reduction for CNC hobbing machine has been done by implementing SMED technique, optimal crane operation and by incorporating the design of the split fixture. The execution of SMED has successfully managed to reduce 02 hours 28 minutes and 30 seconds of setup time per day [19]. By implementation

of SMED in the bar rod mill II at Jindal Steel Work Vijayanagar. The reduction of pass change time by 21.34% after changing some of the internal activities to external activities and proper streamlining of activities [20]. Using SMED methodology the lead time is drastically reduced from 26.2 minutes to 20.9 minutes, therefore, the production rate has been increased from 480 products/day to 510 products/day at gear manufacturing industry [21]. By using SMED the oil filling process gets easier and as well as the time also gets reduced for filling the oil, time saved by 8-9 minutes [22].

2.3. Application of various tool/methods for the reduction of loading and unloading time of Auto-car Wagons

W. Y. Szeto C. S. Shui (2018) Determines the routes of the repositioning vehicles and the loading and unloading quantities at each bike station to firstly minimize the positive deviation from the tolerance of total demand dissatisfaction (TDD) and then service time. Production time and product diversity make rapid tooling a critical economic factor for the company's profitability. The frequent interruption of a process proves to be an obstacle to an efficient production.

Stefano de Luca (2020) aims at minimizing the working time of the loading and unloading equipment and the stay time of the train and truck in the station, and develops a scheduling optimization of loading and unloading model combing equilibrium assignment and flexible scheduling to realize the seamless transfer between rail and road transportation in container terminal.

2.4 Research Gap

Reduction of time is the key indicator of the performance check of vehicles loading and unloading in an Auto-car carrier wagons because it is directly related to cost of the product. SMED is one of the many lean production methods for reducing waste in the manufacturing process. It provides a rapid and efficient way of converting a manufacturing process from running the current product to running the next product. Presented a summary of the literature related to applications of SMED in various industries. Researchers have applied SMED in numerous manufacturing sectors; however, it's a possible application in railway transportation system has never been explored. Mostly SMED methodology is applied for reducing setup time but it is not applied for reduction of loading and unloading time of commodities like coal, food, container, steel product, vehicles etc. in a wagons which are run over Indian railway rack. Transportation of commodities from one place to another place and loading and unloading time which is more relevant for the service industry such as logistics services, firefighting services, food delivery, etc. Therefore, a well considerate approach for reduction of loading and unloading time is needed. Though the need for reduction of loading and unloading time is recognized in the literature, there are no studies providing guidelines or frameworks for reduction of loading time by using Single Minute Exchange of Die (SMED) methodology also no studies found applications of SMED in wagon loading and unloading service sectors.

III. BACKGROUND OF INDUSTRY

This experimental work was carried out at Jindal Rail Infrastructure Limited, Karjan, Vadodara Gujarat, India. It is a completely wagon manufacturing industry, which produces different types of freight wagons.

i. Open wagon.
ii. Covered wagon.
iii. Tank wagon.
iv. Flat wagon.
v. Hopper wagon.
vi. Auto-car wagon
vii. Brake van.

JRIL Incorporated in 2007 and in commercial operations since 2012, Jindal Rail Infrastructure Limited (Jindal Rail or JRIL) is a leading Railway Rolling Stock manufacturer in India, supplying different types of Freight wagons and Special-purpose cars to Indian Railways, Private sector & Export markets.

Jindal Rail Infrastructure Limited (JRIL) has been promoted by Jindal SAW Limited, a leading global manufacturer of submerged arc welded pipes, specialized carbon, alloy & stainless steel pipes & tubes and ductile iron pipes with its products finding applications in oil & gas, water, energy, petrochemicals, engineering and transportation. They have started to work for the reduction of loading and unloading time of auto-car wagons and applied various Industrial engineering tools for the reduction of reduction of loading and unloading time. However, they were looking for further reduction of loading and unloading time up to 50 minutes or higher than that. By keeping this in a view a rigorous application of Single Minute Exchange of Die (SMED) have been applied.

IV. PROBLEM STATEMENT

The aim of this experimental work is to implement Single Minute Exchange of Die (SMED) methodology for the reduction of loading time of auto-car wagons with Kaizen, why-why analysis, Ishikawa/fish bone diagram, Quality circle etc.

V. METHODOLOGY

This experimental work is focused on application of SMED for the reduction of loading time of auto-car wagons at Jindal Rail Infrastructure Limited, Karjan, Vadodara Gujarat, India. The overall goal to reduce loading time of auto-car wagons to implement SMED, which is proven methodology for the reduction of set up time and it is applied in many industries.

The various steps of methodology are as follows;

- The critical areas were identified by reviewing the present changeover procedure of vehicles loading and unloading operation in railway siding (Machine and loading equipment's).
- The activities associated with setup of deck adjustment or movement of deck according to height of cars loading in a wagon were noted from loading operation reports.
- After that identification of activities, the conversion of internal activities into external activities was done.
- A comparison of results and achievements before and after SMED implementation has been made to measure the effectiveness of SMED for reducing set up time.
- Critical area associated with setup time was identified by study of all the machines and tools which are used in loading and unloading operation which were present in plant of wagon manufacturing industry.
- The setup time of tool change of loading siding and operation noted down from operation reports.
- Stop watch technique has been used for measuring set up time.

The various steps of methodology are shown in Fig. no 2. flow chart of research methodology.

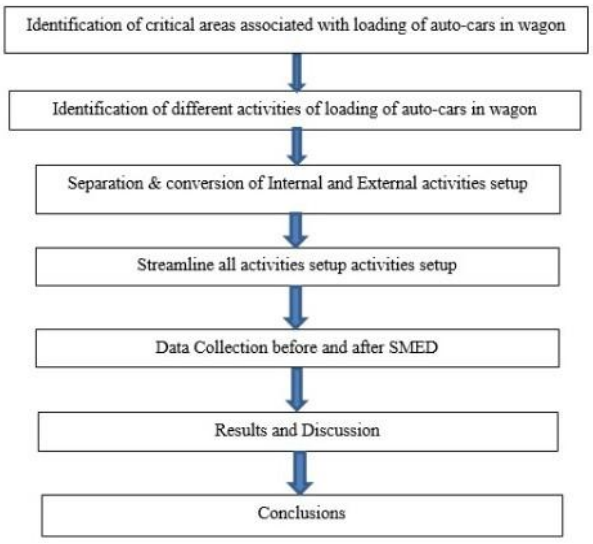


Fig. 2: Flow chart of research methodology

VI. DATA COLLECTION AND ANALYSIS

To implement Single Minute Exchange of Die (SMED) methodology for the reduction of loading time of auto-car wagons at Jindal Rail Infrastructure Limited (JRIL). The following things has been done in the JRIL railyard.

The data has been collected from the loading and unloading department of the Jindal Rail Infrastructure Limited (JRIL). The loading and unloading schedule for the last three months has been analyzed. The analysis showed that loading and unloading time were the bottle neck in the company. Setup process is thoroughly evaluated on the loading and unloading time. It is found that there are several non-value added activities happening during the loading and unloading process. The industry is more into agile manufacturing and it needs varieties of tool changes it is observed that there are many time consuming activities affecting the productivity railway loading and unloading yard. data of such activities are collected from yard dispatch department of the JRIL. Data are tabulated in table no 1 indicating the loading and unloading time consumed in minutes for a given month.

Table 1. Setup Time of Rail yard at JRIL

Workstation	**Setup Time (Min.)**
Loading siding	172.15
Unloading siding	120

Table 2. Setup activities (before SMED)

S. No.	**Activities**	**Total time (min)**
1	Auto ramp operators operate the ramp	21.4
2	**Cleaning the ramp**	**45.15**
3	Remove the wheel stoppers	10.00
4	Mobile access ramps or rails have to be fixed	20.00
5	Inspection of bearing bush	30.20
6	Inspection of parts, tools, and/or materials.	15.00
7	Measurement of aliments of deck	30.00
	Total	**172.15**

Table no 2 shows, setup and adjustment time affects the productivity of the loading operation division. It also reveals information about the time of changeover process of before loading of vehicles on a wagons. There are 7 steps are involving before loading of rake and the total time has been taken are 171.75

minutes. Cleaning of rake takes maximum time (45.15 Min). The individual and total time taken by each process has also shown in this table, time is recorded by the stop watch.

VII. IMPLEMENTATION OF METHODOLOGY

SMED (Single-Minute Exchange of Die) is a system for drastically reducing the time it takes to complete equipment changeovers. The essence of the SMED system is to convert as many changeover steps as possible to "external" (performed while the equipment is running), and to simplify and streamline the remaining steps. The name Single-Minute Exchange of Die comes from the goal of reducing changeover times to the "single" digits (i.e., less than 10 minutes).

The term refers to the theory and techniques for performing setup operations in less than ten minute. Although not every setup can literally be completed in single-digit minutes, this is the goal of the system. Even where it cannot, reduction is still tremendous improvement and setup is scheduled and that idle time will not occur while the new setup material is being accumulated (Kim, 1997). SMED is implemented in many steps as discussed below

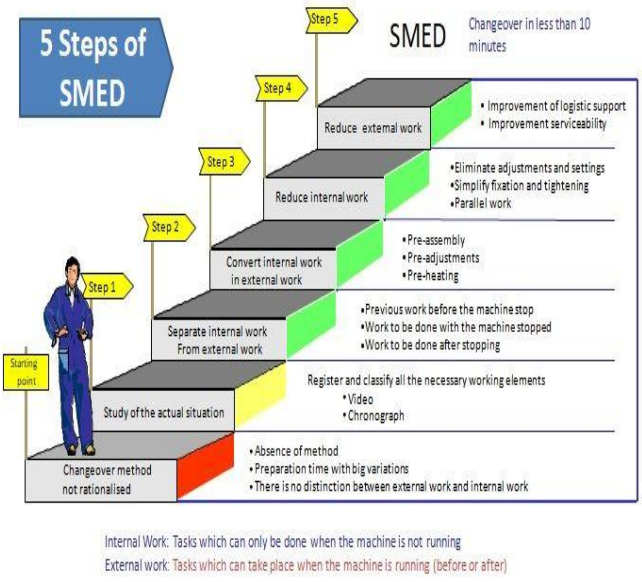


Fig 3: Five Steps of SMED [Madaan Vinay, 2021]

In SMED, changeovers are made up of steps that are termed "elements". There are two types of elements:

- Internal Elements: elements that must be completed while the equipment is stopped
- External Elements: elements that can be completed while the equipment is running

The SMED process focuses on making as many elements as possible external and simplifying and streamlining all elements.

In order for operational excellence there must be a goal or an objective. Once an objective has been determined the appropriate lean application and associated methodologies can be applied. the objective is to reduce overall loading/unloading time, such as the goal of this research project, the key performance indicator would be the overall changeover time for the setup process. The implementation of single minute exchange of dies (SMED) methodology allows for the reduction of loading and unloading time during Auto-car wagons rake ready to transportation of vehicles from railway siding.

The purpose of the methodology is to achieve the objective of the work. It is a guideline to analyze loading time using the six steps Practical Problem Solving (PPS) method. The step by step process as elaborated below was used to find out the operator's manual wait time reduction. The 6 steps problem-solving methodology was used for loading and unloading of wagon in Jindal Rail Infrastructure Limited, Karjan Vadodara, India.

The step by step process involved in the six step PPS methodology is listed below.

i. Clarify the problem

In the current situation, loading of vehicles was focused for the entire operation process at railway siding. The number of the various activity in ideal condition was determined. There was a wide gap between the allocated time and actual time.

ii. Break down the problem

The process involved in the operators manual loading and unloading operation time was carefully studied. Duration of inactivity or time wasted on unnecessary efforts was identified.

iii. Set the target

The current level of operation was observed and operation level considered ideal for the optimal time was set. The aim of the target setting was to increase the output from current level to targeted level.

iv. Analyze the root cause

Fish bone diagram was used to identify the various causes for the reduction of loading and unloading time during the production process as shown in Figure 4 Fish bone diagram

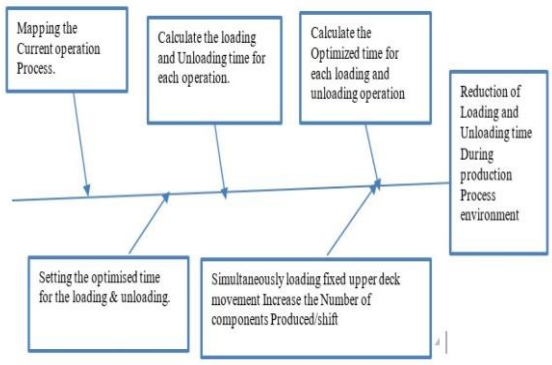


Fig 4: Fish bone diagram to find loading and unloading time

v. Develop countermeasures

- The operator's loading and unloading time for each process was tabulated.
- The total operator allocated and actual time for each level has been calculated.
- Graphs were plotted between the number of operations Vs Operators Allocated time, actual time and optimized time of crank case cell.
- The actual processing time per rake crank were calculated.
- The optimized operators loading and unloading time per rake were calculated.

vi. Implementation of the countermeasures

The various activities carried out in various sections were mapped. The section mapping gave a clear idea of deck movement from the first wagon to the last wagon till it was completed loaded. The implementation of the reduction in operators loading and unloading time was being carried out in the various sections.

Various steps were taken over a period of time for monitoring the operator manual loading and unloading time. Material movements were carefully monitored.

Man and material movement considered unnecessary were avoided by setting the optimized time for the loading and unloading. The setting of the optimized time periodically increased the daily output.

a. Five Steps of SMED Methodology

This is important step for the implementation of SMED methodology. Figure no 3 shows all five steps of SMED and it is described as follows;

i. Identification of critical areas associated with loading of auto-cars in wagon

The study of wagon operation Department of the Jindal rail Infrastructure Ltd. The operation method of loading and unloading of vehicles on a wagons for the last three months has been analyzed. The analysis showed that movement of deck with the help of screw jack machines setting were the bottle neck in the loading operation of vehicles which are more time consumed process. Setup process is thoroughly evaluated on the movement of deck. It is found that there are several non-value added activities happening during the setup process. The operation of loading of vehicles it needs varieties of tool changes it is observed that there are many time consuming activities affecting the productivity of JRIL Yard. Data of such activities are collected from vehicles loading and unloading of wagon at railway siding.

ii. Identification of different activities of loading of auto-cars in wagon

Different activities of loading of auto-cars in wagon are as follows;

i. Auto ramp operators operate the ramp
ii. Cleaning the ramp
iii. Remove the wheel stoppers
iv. Mobile access ramps or rails have to be fixed
v. Inspection of bearing bush
vi. Inspection of parts, tools, and/or materials.
vii. Measurement of aliments of deck

7.1.3. Separation of internal and external activities of loading of auto-cars in wagon

In SMED, changeovers are made up of steps that are termed "elements". There are two types of elements:

- Internal Elements: elements that must be completed while the equipment is stopped
- External Elements: elements that can be completed while the equipment is running

The SMED process focuses on making as many elements as possible external and simplifying and streamlining all elements

This stage consists of separating the operations that should be carried out when the vehicles are loaded on a wagons is still processing the previous lot (external setup) and those where it is necessary to carry out setup with the wagons are fully loaded and stopped loading of vehicles (internal setup). The goal for this stage is to separate/classify setup operations according to the given definition of external and internal setup. This classification takes into account the same operations and duration included in the current method, that is to say, without improving any particular operation.

7.1.4. Conversion of internal and external activities of loading of auto-cars in wagon

To reduce setup time as far as possible or economical,

it is necessary to study the possibility of converting some internal setup operations into external setup, so that they could be carried out while the vehicle's loading and unloading is running. This stage examines two important aspects:

- Re-evaluate the internal setup operations to check or see if some of them were considered erroneously as internal.
- Identify for alternatives that allow internal setup to be carried-out in whole or in part as external operations, with the machine working.

7.1.5. Streamline all activities of loading of auto-cars in wagon

This stage tries to improve all the setup operations, both internal and external, reducing their duration or even, if it is possible, trying to eliminate some operations. Although the SMED methodology recommends that one follows systematically these four stages, common sense can sometime dictate that, in the second stage, time and money should not be invested in operations that previously have not been optimized. A case study was carried out at Jindal Rail Infrastructure Limited manufacturing Freight Wagons in India to reduce product cycle time by implementing SMED technique in the integrated manner and the results were highly encouraging.

7.1.6. Instructions for Loading and Unloading Vehicle Transport Wagons.

The wagons have to be loaded, unloaded and secured according to the current loading regulations and information sheet of the Indian Railway. The safety regulations of the different manufacturers regarding the loading of new vehicles onto wagons have to be complied with. In case of vehicles featuring a reduced ground clearance or other equipment restricting the load ability, it is absolutely necessary to observe the special regulations published by the manufacturers for such models in order to ensure a damage-free transport.

b. Check list

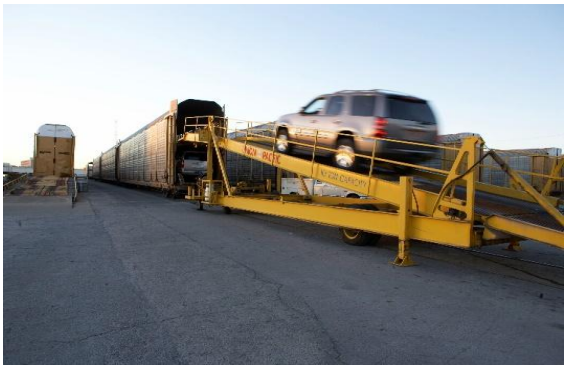
Following points taken in to the consideration at the time of loading and unloading of auto-cars wagons.

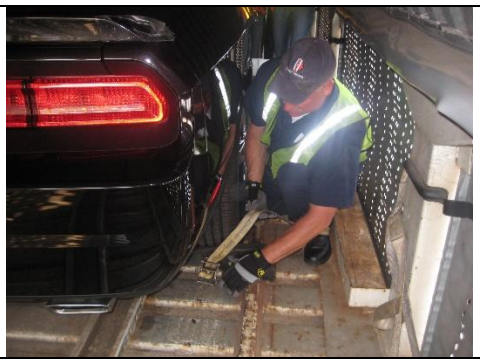
i. First, auto ramp operators open the doors at one end of the Auto-rack. Then, the ramp pulls up to that end of the Auto-rack and is secured to the level to be unloaded.
ii. Once the ramp is securely in place, cars, trucks and SUVs can be driven safely (and slowly) into or out of the rail car.
iii. Inside an auto-rack, each wheel of the vehicle is secured to the rail car with special straps or chocks to keep it in place during transit. Before unloading, these straps and chocks must be moved before vehicles can be driven off.
iv. The ropes of the lifting and lowering device by complete lowered of the upper deck for the designated depositing are relieved.
v. The crank handles of the rope winch have been inserted or secured in the respective mounting bracket. Unnecessary wheel stoppers have been positioned and secured on or beside the wheel stopper rail in such a way that they cannot slide into the clearance zones in the center and at the end of the wagons.
vi. Existing display devices (indicator of upper deck locking, etc.) are no longer visible or have been folded.

VIII. RESULTS AND DISCUSSIONS

Table no 3 shows SMED analysis sheet, in which total seven activities are involved for loading and unloading the Auto-Car Wagons and time required for each activity before and after the application of SMED for the reduction of loading and unloading the Auto-Car Wagons and in the last column shows the remarks/ Justification for the reduction in the loading and unloading time.

Table 3. SMED Analysis Sheet

S. No.	Activities	Internal Activities (Before application of SMED all activities are Internal	Total time (mins) before SMED	Conversion of Activities (Internal to External)	Total time (mins) (after SMED)	Remarks/ Justification
1	Auto ramp operator, operate the ramp	**Internal**	21.4	**External**	15.2	• Automotive rail ramp, where Auto cars come for loading into the trains or for Unloading at the end of their rail journey. • Automatic adjustable ramp control by screw jack is develop. • Depending on the size of the auto ramp and the railroad's loading processes, an auto facility may require delivery of only full rail car loads. . 
2	To Clean the wagons	**Internal**	45.15	**Internal (No change)**	30.15	• **Used cleaning machine:** Before application of SMED, the cleaning of wagons **was done manually** which was a degrading and unhealthy activity. • The possibility of implementing the mechanization of the process was realized. Mechanization as the use of a machine to replace a work done by man. Mechanizing their activities aiming at reducing costs, increasing operational safety and process productivity.  • Another goal that could be met with the mechanization of the process was the synchronization of the process of cleaning with the task of loading of car in a wagon. This would be possible because the equipment should have a production rate that was quicker than the loading task at the cars.
3	Remove the wheel stoppers	**Internal**	10.00	**Internal (No change)**	9.00	• Remove the wheel choke rail from wagons and **used perforated sheet to hold vehicle's wheel**

						
4	To fix Mobile access ramps or rails.	**Internal**	20.00	**Internal (No change)**	15.00	• Fully control by machine/tools/instruments: Used automatic Pneumatic spanners and winch.
5	Inspection of bearing bush	**Internal**	30.20	**External**	25.12	• Converted in to external activity from internal activity. • Inspected bearing bush in advance. • Hence reduction of 5.08 minutes. • Used automatic Pneumatic spanners and winch for checking the bearing bush. • Use of the proper fixture (tooling) needs be ensured. • Axle threads to be checked with Go- No Go gauge and Axle thread holes should be cleaned by compressed air. • Inside surface of Adapter is required to checked for wear on thrust shoulder and bearing seating area/adapter machined relief with proper gauges. • As a result of fewer rollers sharing the load. This reduces fatigue life. Check for loose and/or missing cap screws.  

						
6	Inspection of parts, tools, and/materials.	**Internal**	15.00	**External**	12.45	• Converted in to external activity from internal activity partially. • Inspected some tools and materials in advance. Hence reduction of 2.15 minutes. • Used automatic Pneumatic spanners and winch for checking the tools and materials.
7	Measurement of aliments of deck.	**Internal**	30.00	**Internal (No change)**	15.00	• Fully control by machine/tools/instruments: Used aliment deck machine to check the aliment of the deck also used automatic Pneumatic spanners and winch for aliments of deck.
	Total Time before Application of SMED		**172.15**	**Total Time after Application of SMED**	**122.32**	

Inference of Table no 3:

- Initially, all activities of setup change were performed under internal activities.
- Initially, time required for one complete setup was 170 to 200 minutes.
- Activity numbers 1,5 & 6 has been converted in to external activities from internal activities and drastically time also reduced in those activities.
- Automatic adjustable ramp control by screw jack is develop. Depending on the size of the auto ramp and the railroad's loading processes, an auto facility may require delivery of only full rail car loads.
- Used cleaning machine: Before application of SMED, the cleaning of wagons was done manually which was a degrading and unhealthy activity.
- The possibility of implementing the mechanization of the process was realized. Mechanization as the use of a machine to replace a work done by man. Mechanizing their activities aiming at reducing costs, increasing operational safety and process productivity.
- Another goal that could be met with the mechanization of the process was the synchronization of the process of cleaning with the task of loading of car in a wagon. This would be possible because the equipment should have a production rate that was quicker than the loading task at the cars.
- Fully control by machine/tools/instruments: Used automatic Pneumatic spanners and winch.
- Converted in to external activity from internal activity and Inspected bearing bush in advance. Hence reduction of 5.08 minutes in the activity no 5.
- Used automatic Pneumatic spanners and winch for checking the bearing bush.
- Use of the proper fixture (tooling) needs be ensured.
- Axle threads to be checked with Go- No Go gauge and Axle thread holes should be cleaned by compressed air.
- Inside surface of Adapter is required to checked for wear on thrust shoulder and bearing seating area/adapter machined relief with proper gauges.
- As a result of fewer rollers sharing the load. This reduces fatigue life.
- Inspected some tools and materials in advance. Hence reduction of 2.15 minutes in the activity no 6.

Table 4. Loading time reduction of Auto car wagons after implementation of SMED

Total Loading Time before Application of SMED (Minutes and Seconds)	Total Loading Time after Application of SMED (Minutes and Seconds)	Total Loading Time saved in Minutes (Minutes and Seconds)	Total Loading Time saved in %
172.15	**122.32**	**50.23**	**29.06**

Inference of Table no 4:

- Shows total loading time before and after Application of SMED (Minutes and Seconds) and saving of loading time in minutes and in %.

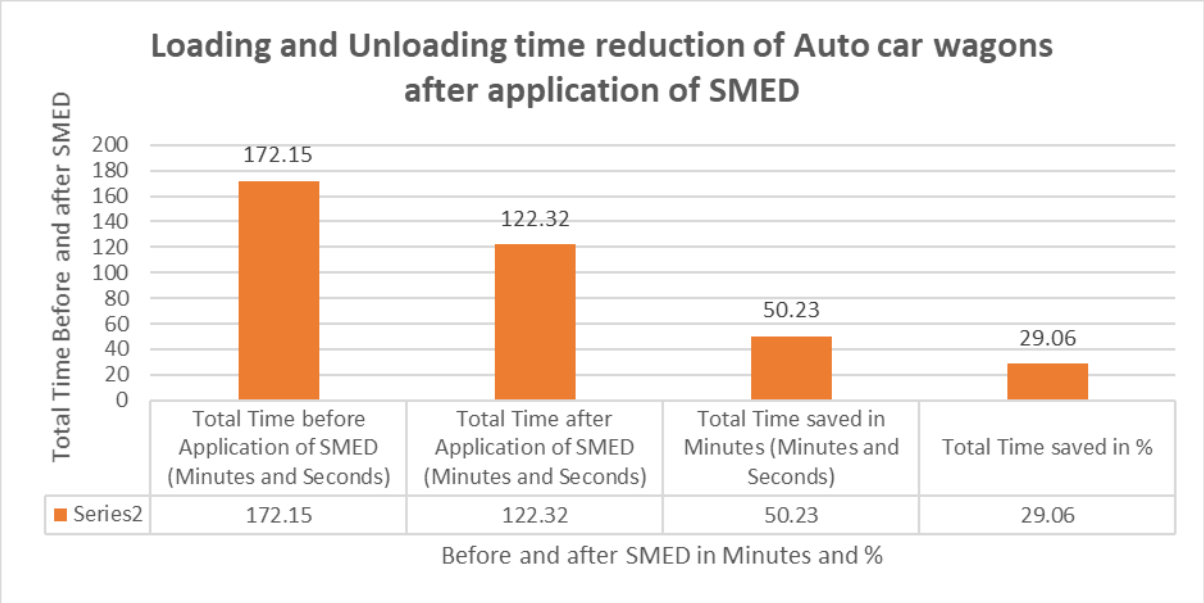


Fig 5: Graphical representation of reduction of loading time of auto-cars wagons before and after implementation of SMED.

IX. CONCLUSIONS

SMED is a proven methodology for the reduction of setup time and it has been applied in many manufacturing industries for the reduction of setup time and after implementation of this methodology many industries improved its productivity.

This research is concerned with the application of SMED for the reduction of loading time of auto-car wagons. According to the research gap, SMED methodology have been used in the industry but not used for the reduction of loading and unloading time of auto car wagons.

In this research work SMED applied successfully for the reduction of loading time of auto car wagons and saved 50 minutes and 23 seconds for loading time of auto car wagons at Jindal Rail Infrastructure Limited, Vadodara, Gujrat, India.

At last we concluded that modifying the existing practices results in significant reduction in loading time of auto-cars in railway wagons.

X. FUTURE SCOPE

This research work opens the new opportunities for the SMED in the area of transportation of railway wagons.

Several points in connection with future scope are as follows;

i. Transport of cars from manufacturing plants to various destinations is one that has to be executed precisely, and in a timely manner. While logistics is continually improving through tried and tested processes. In this regards SMED methodology can be helpful for the reduction of loading and unloading time of auto-car wagons.

ii. Looking back, India's largest car manufacturer, Maruti Suzuki has been using the effective rail mode for transporting cars for over two decades, a key reason behind the minimum waiting period in the company's model lineup.

iii. The induction of flexi deck auto-wagon rake will start a new chapter in automotive logistics in the country. Trains are one of the fastest, safest and eco-friendly modes of transportation. With these newly designed rakes we have been able to increase the load carrying capacity along with a high flexibility to cater to a variety of vehicle dimensions.

iv. By using advanced features such as height adjustable to the middle-deck allows the wagon to carry 318 Alto equivalent compact cars as against 265 cars earlier with double decker using a total of 45 wagons.

ACKNOWLEDGEMENT

Authors would like to thank to Managements of OPJU JSP Raigarh, JRIL Vadodara, for supporting this work by providing a good research environment, motivation to publish a paper.

REFERENCES

[1] Chiarini, A. 2014. 'Sustainable Manufacturing-Greening Processes Using Specific Lean Production Tools: An Empirical Observation from European Motorcycle Component Manufacturers'. International Journal of Clean Production, pp.226– 233.

[2] Shingo, S. (1985) A revolution in manufacturing. In: The SMED System. Productivity Press, Cambridge, MA

[3] Dave, Yash., and Sohani, Nagendra. 2012. 'Single Minute Exchange of Die (SMED) – Review'. International Journal of Lean Thinking, Volume -3 Issue -2.

[4] R. Godolina, E. M. G. Rodrigues, and J. C. O. Matias. 2018 "An Alternative Test of Normality for Improving SPC in a Portuguese Automotive SME," in Closing the Gap Between Practice and Research in Industrial Engineering, Springer, Cham, pp. 277–285.

[5] Almomani, Mohammed Ali., Aladeemy Mohammed., Abdelhadi Abdelhakim., and Mumani, Ahmad. 2012. 'A Proposed Approach for Setup Time Reduction Through Integrating Conventional SMED Method with Multiple Criteria Decision-Making Techniques'. International Journal of Computers and Industrial Engineering, 66. pp.461–469.

[6] Costa, Eric**.,** Braganca, Sara., Rui Sousa, and Anabela, Alves. 2014. 'Benefits from a SMED, Application in a Punching Machine'. International Journal of Mechanical Aerospace, Industrial and Mechatronics Engineering, Vol. 7, Issue5, pp.373-379.

[7] Silva, P.M.S., and Pinto, L.R. 2010. 'Emergency Medical Systems Analysis by Simulation and Optimization'. In Proceedings of the 2010, Winter Simulation Conference, pp.2422–2432.

[8] S. Pellegrini, D. Shetty, and L. Manzione. 2012. "Study and Implementation of Single Minute Exchange of Die (SMED) Methodology in a Setup Reduction Kaizen," presented at the Proceedings of the 2012 International Conference on Industrial Engineering and Operations Management.

[9] B. Ulutas. 2011. 'An application of SMED Methodology', International Journal of Mechanical, Aerospace, Industrial, Mechatronic and Manufacturing Engineering Vol:5, No:7, 2011. p. 1194 1197.

[10] Timasani, Ramesh., and Doss, Kishan. 2011. 'Reducing the Setup Time in a CNC Machining Line Using QCO Methods'. SAS Tech, Volume 10, Issue 2.

[11] Desai, Mukesh., and Rawani, A. M. 2017. 'Productivity Improvement of Shaping Division of an automobile industry by using single minute exchange of die (SMED) methodology'. ARPN Journal of Engineering and Applied Sciences. 2017;12(8).

[12] Desai, M. S., and Warkhedkar, R. M. 2011. 'Productivity Enhancement by Reducing Adjustment Time and Setup Change'. International Journal of Mechanical and Industrial Engineering, Volume-1, Issue-1.

[13] Shobha, N. S., and Subramanya K.N. 2019 'Simulation of Kanban System in an Automobile Component Manufacturing Organization - A Case Study, International Journal of Lean Thinking, Vol. 9, Issue 1.

[14] Abraham**.,** Arun., Ganapathi K. N., and Motwani, Kailash. 2012. 'Setup Time Reduction Through SMED Technique in a Stamping Production Line'. SAS TECH Journals. Volume 11, Issue 2.

[15] Patel, S., Shaw, P., and Dale, B. G. 2001. 'Set-Up Time Reduction and Mistake Proofing Methods: A Study of Application in a Small Company'. Business Process Management Journal. Volume 1, pp.65-75.

[16] Ghosh, S., Chaudhury, P. K., Pramanik, D., and Lal, S. 2013. 'Changeover Time and Its Variability Reduction through SMED – Kaizen Approach: Case Study of an Indian Steel Pipe Manufacturing Unit'. Proceedings of ICIE.N.I.T. Surat, India.

[17] Bajpai, Jonalee D. 2014. 'Single Minute Exchange of Die Methodology in Garment Manufacturing Industry: Case Study in Reducing Style Change over Time'. 5th International and 26th All India Manufacturing Technology, Design and Research Conference, IIT Guwahati, Assam, India.

[18] Shinde, Shashikant., Jahagirdar, Satyasheel. and Sane, Shriram. "Set-up Time Reduction of a Manufacturing Line Using SMED Technique", International Journal of Advance Industrial Engineering. Vol. 2, Issue 2. 2014.

[19] Sharma Neha, Matharou Gurupreet Singh, Kaur Simran & Gupta Pramod. 2018. Lean manufacturing tool and techniques in process industry, International Journal of Scientific Research and Reviews, vol. 2, no. 1, pp. 54-63.

[20] Gandhi, M K. and Singh, Amankumar. 2016. 'Reduction of Setup Time by Implementation of SMED Methodology'. Imperial Journal of Interdisciplinary Research, Vol. 2, Issue 9.

[21] Karthik, N., Prasad, Hari. and Gopi, Balaji. 2016. 'Application of Lean Tools (VSM, SMED, Kaizen) in Minimizing the Lead Time in Gear Manufacturing Process' International Journal of Scientific and Engineering Research. Volume. 7, Issue 5.

[22] Gade, Pallavi A., Chavan, Roshan G. and Bhavsar, Dhananjay N. 2016. 'Reduction in Setup Time by using Single Minute Exchange of Die (SMED) Methodology. International Journal of Science and Technology Research, Vol. 5, Issue 06.

[23] Baishya, Nystha. and Rao, Satish U. 2013. 'Applying SMED/QCO Tool to Improve the Productivity at Screwing Station of HFR Assembly - A Study at Robert Bosch (India) Limited'. International Journal of Mechanical and Industrial Engineering Development and Research, Volume 3, Issue 1.

[24] Singh, Jagdeep., Singh, Harwinder., and Singh, Inderdeep. 2018. 'SMED for Quick Changeover in Manufacturing Industry – A Case Study, Benchmarking'. An International Journal of Production and operation Research, Vol. 25 Issue: 7, pp.2065-2088, https://doi.org/10.1108/BIJ-05-2017-0122.

[25] Desai, M. S. 2011. 'Productivity Enhancement by Reducing Setup Time - SMED: A Case study in the Automobile factory', Global Journal of Researches in Engineering Mechanical and Mechanics Engineering.

[26] G. Hashemzadeh, M. Khoshtarkib, and S. Hajizadeh. 2014. 'Identification and weighting factors influencing the establishment of a single minute exchange of dies in plastic injection industry using VIKOR and Shannon Entropy,' Manag. Sci. Lett., vol. 4, no. 5, pp. 977–984,