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# Lean Manufacturing Methodology with Kaizen Improves Quality in Small Scale Industry in India

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***ABSTRACT:*** *Kaizen is an idea for discovering the scope of improvement in any organization which is a necessity for achieving goals of every organization. To get opportunities of improvement in an organization is a tedious task. There are various techniques available to improve an organization. The present work discussed the lean manufacturing methodology in association with Kaizen in the practical industrial environment of the organization which improves the quality of product of small scale industry. The main focus of this study is to solve the industrial problem by using lean manufacturing concept that provides relevant and fruitful information towards implementation of Kaizen in the form of reduction in defects of products. It provides a healthier opportunity for every individual of organization for taking part in achieving goals of the organization. The methodology provides better understanding of Kaizen activity in the industrial environment.*

***Keywords:*** *Lean Manufacturing, Kaizen, why-why analysis, Root Cause Analysis, Quality Improvement*

## I. INTRODUCTION

The lean manufacturing improves quality system by providing proper documentation(Kumar and Harms 2004). Lean Manufacturing introduced and successfully implemented first by Toyota Production System, then to other manufacturing settings,enterprises, healthcare, and government services. InLean Manufacturing, waste can be identified during manufacturing process converting raw material into finished product in small and medium scale industry (Thanki and Thakkar, 2014). The Seven Waste of Process is discussed as follows-

**1. Over Production:** The Overproduction means manufacture an item more than the actual requirement. This can be understand by producing excessive items (more than work order) on any stage of production which increases lead times, results in high storage costs, and makes it difficult to detect defects. The excessive production consumes extra time of production, produces defective items in that time, utilizes man power, machine etc. which results in delay in delivering urgent items. The concept is to schedule and produce only what can be immediately sold / shipped and improve machine changeover /set-up capability.

**2. Idle Time (Waiting Time):** Idle time means when any delay occurs in getting order, getting item, getting tools & instruments or any personal delay due to human personal intervene (go to bathroom, washroom etc.). It can simply understand when goods are not moving or beingprocessed, the waste of waiting occurs. It happens due to poor material flow or production runs are too long and large distances between work centers. The Idle time can be minimize by linking processes together so that one feedsdirectly into the next can dramatically reduce waiting.

**3. Unnecessary Transportation:** Transportation means to move any material from one place to another place. The Faulty layout of industry results in unnecessary transportation of any product which adds no value to the product. The excessive movement of the products increases material handling which causedamage and deteriorate the quality of the product. Sometimes it happens that the material fall out of specification due to transportation leads to scrap which increase the cost of production. In the transportation Visual Defects may arises which are easy to determine by individual. Thus a special care of any product is required in Transportation. The transportation can be minimized through preparing easy mapping product flows which can make this easierto visualize.

**4. Inappropriate Processing:** Sometime it happens that product fall in excessive dimension during inspection of any product which can be converted with in the tolerance by rework by any process. This is done due to fine tolerance of the product or producing high quality work on any machine. Many organizations use expensive high precisionequipment where simpler tools would be sufficient. The unnecessary process generates due to poor layout of plant. This can be minimize by combining steps will greatly reduce thewaste of inappropriate processing.

**5. Producing Defective Items:** Higher production triggers high chance of producing defective items due to inadvertent human errors. Quality defects resulting in rework or scrap are atremendous cost to organizations. Associated costs includequarantining inventory, re-inspecting, rescheduling, and capacityloss. This can be reduce through proper employee involvement and Continuous Improvement (CI) in process which results in huge opportunity toreduce defects at many facilities.

6. **Over Inventory:** Excessive inventory is called storing excess products with no orders in the warehouse and having excess WIP. This will impede and tie up the flow of products.

7. **Defects and Errors:** Defects will add additional rework, inspection (both expensive and time consuming),design changes, process changes, and machine downtime to analyzeproblems. In the plastics industry errors and defects include mold qualificationtime, engineering time, excess mold fabrication time and cost, and more productionreplacements. Errors in paperwork and engineering design will requireadditional time. The original cost must be absorbed, and unnecessary rework orreplacement costs need to be captured.

## II. LITERATURE SURVEY

Kaizen is a combination of two words. 'Kai' means 'change for' and 'Zen' means 'betterment' or completely it is said as continuous improvement. It involves every individual employee of the industry to work together for attain customer-driven strategy for improvement (Imai M., 1986). There is a lot of controversy in the literature as well as the industry as to what Kaizen signifies. It is a philosophy of never being satisfied with what was accomplished last week or last year (Barnes T., 1996)**.** Improvement begins with problems in industry which provide opportunities for improvement or any change. Kaizen function is largely depends on cross-functional teams that can be empowered employees status.Although improvements under Kaizen are small and incremental, the Kaizen process brings about dramatic results over time (PakdilFatma, Karen Moustafa Leonard, 2015). The Kaizen concept explains why companies cannot remain static for long in Japan. Managers always can go back to the old way without incurring large costs(BhamuJaiPrakash, Kuldip Singh Sangwan, 2014).The Kaizen is activity which is performed by employees who is knowledgeable about task, involve team to perform task effectively and efficiently, show confidence in their capabilities and take ownership of the task so that process is raised to itshighest level (Kobayashi I.,1990). The objective of a Kaizen workshop is tomake people's jobs easier by taking innovative actions which makes a number of improvements in the industry premises. This message is distributed to everyone in the industry so that everyone plays a role of contributor (Cheser R., 1994). Thus an optimum process is achieved by getting everyone innovative contribution.Continuous performance measurement matrices in terms of efficiency and effectiveness are proved to be appropriate methods for continuous evaluation of lean performance (Karim and Arif-Uz-Zaman, 2013).The Kaizen is activity which is performed by employees who is knowledgeable about task, involve team to perform task effectively and efficiently, show confidence in their capabilities and take ownership of the task so that process is raised to itshighest level (Karlssonand Ahlstrom, 1996). The objective of a Kaizen workshop is tomake people's jobs easier by taking innovative actions which makes a number of improvements in the industry premises. This message is distributed to everyone in the industry so that everyone plays a role of contributor (Shah and Ward, 2003). Thus an optimum process is achieved by getting everyone innovative contribution (DorotaRymaszewska Anna, 2014)

## III. APPLICATION OF LEAN MANUFACTURING METHODLOGY

Kaizen is the base of Lean Manufacturing that identifies the waste and directs towards continuous improvement to sustain growth and profitability. Henry Ford introduced Lean Manufacturing and Kaizen and observed that standardization and innovation as two sides of the same coin. He applied Lean Manufacturing and Kaizen to every opportunity and seeking constantly to reduce waste, reduce variability, reduce system cycle times, and improve overall performance. Continuous Improvement is the most important way to manage businessthrough 'zero defects' and 'do it better each time' strategies which continuously improve the qualityYeo et al. (1995). 'Zero defects' represents CIover quality by detection of defects. A phrase 'do it better each time' (DIBET) strategyis associated with constant, conscious and committed efforts to reduce process variation.Lean Manufacturing Methodology contains seven steps which will be done systematically to achieve

the defect free environment in small scale industry. In this Lean Manufacturing methodology, each step includes a Kaizen tool which is implemented to get the result and this result will become the input to the next step. Each Step must have key factors which describe a Kaizen tool which is used to get the output. These steps should be followed systematically to improve the quality of industry. These steps are discussed as follows in Figure 1.

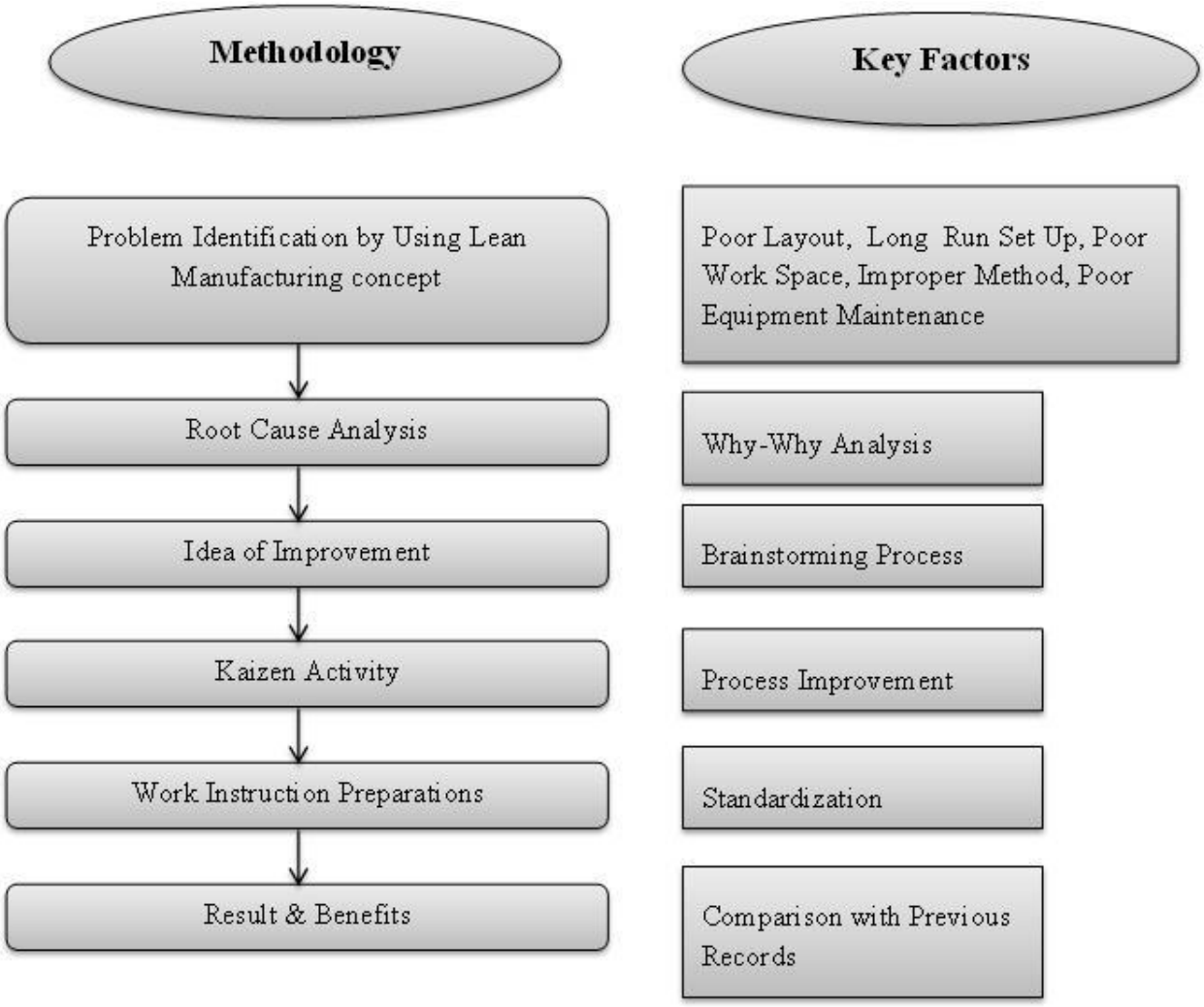


**Figure 1 Lean Manufacturing Methodology**

The Lean Manufacturing Methodology associated with Kaizen is introduced for improvement in quality of small scale industry in industry situated at Old IDC, Rohtak (Haryana), India. The industry is **ISO 9001:2010 certified**, renowned and reputed organization. The company focuses and believes in concept of lean manufacturing and dedication to achieve every single possibility of improvement through Kaizen which results in quality improvement of internal and external products. The case study is discussed as practical application of Lean Manufacturing Methodology which is discussed as follows.

## IV. CASE STUDY

It is obvious that many programs were installed in order to minimize this high level of PPM by the prominent level of management & employee. The management was ready to adopt any methodology to reduce the PPM Level to minimum level which affect the cost to the industry and affect the market value of the industry. Random Problem was selected for the solution of problem. No permanent system is present for reliable and permanent solution of the problem. No Focus was made on the customer complain and trivial efforts are applied to find the root cause of the problem. The solution of problem is done to fulfill the requirement of paper work and the corrective, preventive action is just for the name only.

**Case Study I:** The top secondand third products are taken as case study in this research work. The discussion of improvement is made through case studies which performed during the time of course work.

**Table 1 Contribution of Product in PPM (Three Months from Jan 15 to Mar 15)**

| Product wise PPM Contribution | | | | | |
|---|---|---|---|---|---|
| SR. NO. | Item name | Qty. | Cumm. Qty. | %age | cumm. %age |
| 1 | Spindle Kick Starter ( 284 )DH111012 | 334 | 334 | 39 | 39 |
| 2 | Plain Coller (606) (DS101336) | 183 | 517 | 21 | 60 |
| 3 | Axle front wheel ( 52DJ0105 ) | 117 | 634 | 14 | 73 |
| 4 | Axle rear wheel ( 52DJ0105 ) | 80 | 714 | 9 | 82 |
| 5 | Coller sprocket ( 695 ) (DK101245) | 48 | 762 | 6 | 88 |
| 6 | 59050008 | 45 | 807 | 5 | 93 |
| 7 | DK151008 | 29 | 836 | 3 | 97 |
| 8 | DK151009 | 8 | 844 | 1 | 97 |
| 9 | DK171003 | 7 | 851 | 1 | 98 |
| 10 | DK171006 | 6 | 857 | 1 | 99 |
| 11 | DH171012 | 6 | 863 | 1 | 100 |
| 12 | 59050002 | 3 | 866 | 0 | 100 |
| 13 | Rack ( 162 ) DH101141 | 0 | 866 | 0 | 100 |
| 14 | Assly. Tie rod ( DK 101180 ) | 0 | 866 | 0 | 100 |

The Case Study is carried out for case product Plain Coller which is shown in Figure 1.2.

**Figure 2: Burr in Plain Coller**

1. **Study of Process Flow Diagram:** A Process flow diagram (PFD) is a flow sheet which indicates the general flow of plant processes and equipment. Most of Products follows process flow diagram as shown in Figure 1.2. Study of each process is taken as case study in this research work. Plain Collar is considered for this research work as case product. It is comprised of nine processes which include Cutting, Turning, Milling, Deburring, Heat Treatment, Shot Blasting, Grinding, Final Inspection and Dispatch as shown in Figure 3.

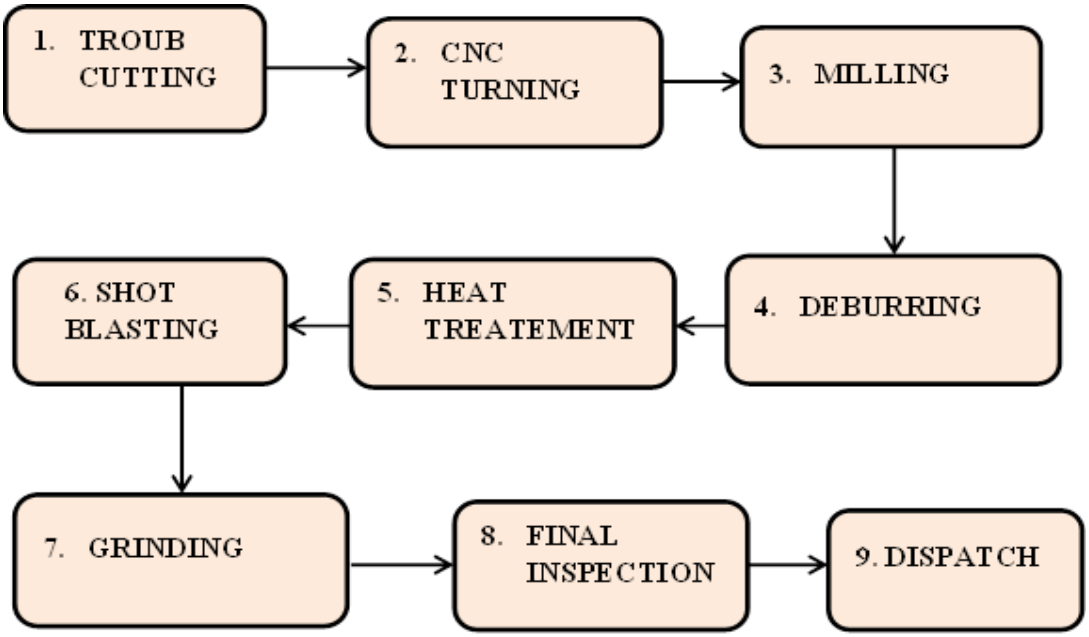


**Figure 3: Process Flow Diagram of Plain Collar**

**2. Improvement of Lean Manufacturing Methodology for Elimination of Deburring Process:** Deburring (Unwanted Burr on the surface) is done after milling process of case product Plain Collar as shown in Figure When milling cutter advances on the work piece and performs operation; it leaves a burr on the work piece which is not desirable for next operation. The Elimination process is done for the trial purpose to check whether it is possible to eliminate such process with a sample size of 5-10 pieces which is processed milling before CNC Turning process. The improvement is made by changing sequence of processes which is shown in Figure 4.5 in which Deburring process is eliminated.The concept is applied through Lean Manufacturing Methodology in which unwanted transportation and delay in work due to Deburring process can be eliminated.

**a) Problem Identification**

High cost rate on operation, Lack of manpower to perform operation and high load of next process (Heat Treatment Process) needs to eliminate of deburring process. The problem is identified by monitoring the in-process and final inspection Quality status.

**b) Idea of Improvement**

The ideas of improvement is achieved through Why-Why analysis which is done as follows.

**i. Why-Why analysis**

**Why 1:**Burr occurred during milling operation.

**Why 2:**This is the nature of process.

**ii. Root Cause**

Due to operator negligence, a quantity of products is milled before turning operation.

**c) Kaizen activity**

-Then experimental set up was done for turning process on that quantity of products which are milled before turning of the case product. An effective result was drawn that found the product satisfy the parameter of next process (Heat treatment) which indicate to eliminate deburring process from PFD of the case product. Thus this became a Kaizen activity that the PFD gets changed and process becomes standardized.

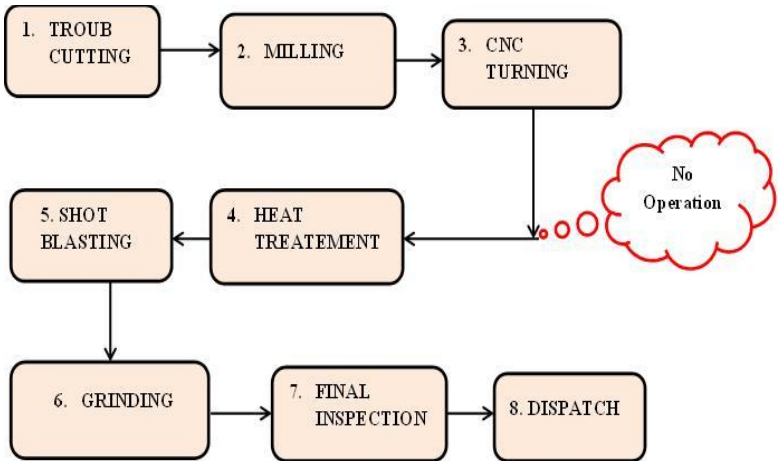


**Figure 4: Process Flow Diagram after Implementation of Lean Manufacturing Methodology**

**d) Work instructions**

These instructions are provided to engineering department as well as quality department to make adjustment in record relevant to milling operation of the case products as follows.

1) Revise the cutter drawing.
2) Cutter diameter and radius on cutter tip to be add in control plan.

**e) Benefits observed**

Following benefits are observed immediately after performing Kaizen Method.

1) Improved Productivity and quality by elimination of deburring process.
2) Reduction of cost of manpower.
3) Avoid accidents and improved on time delivery.

Rejection Quantity and cost per day result analysis of Plain Collar before and after Kaizen as shown in Chart 1 respectively.

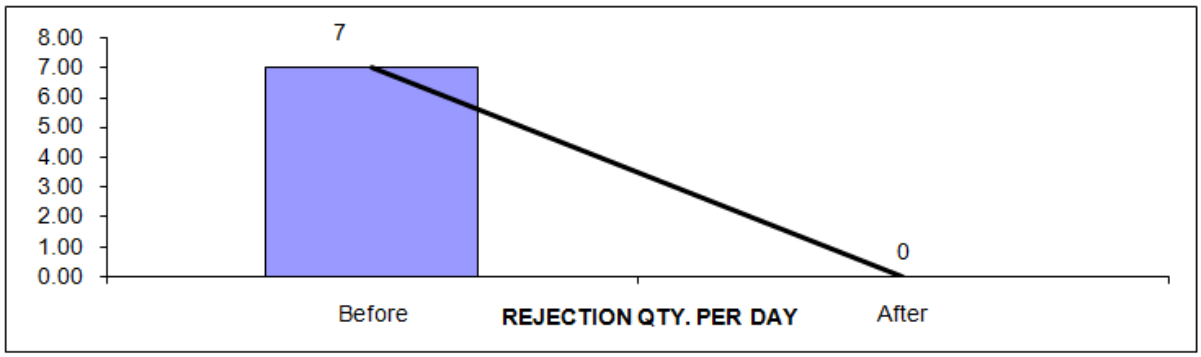


**Chart 1: Rejection Quantity per day of Plain Collar**

**f) Result Analysis**

Following results are analyzed immediately after performing Lean Methodology through Kaizen Method.

1) Eliminate the burr problem during performing milling process.
2) Eliminate the operator negligence during deburring operation.
3) Eliminate manpower cost and reduced per pieces cost.

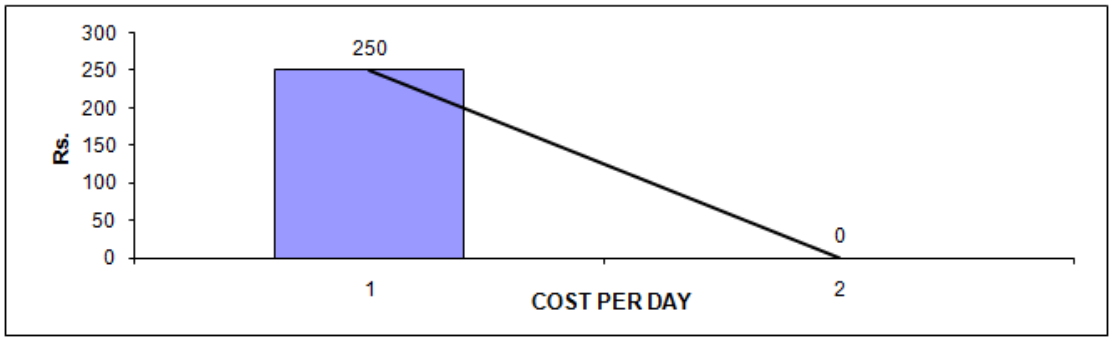


**Chart 2: Cost per day in Rupees of Plain Collar**

**Case Study II:** The final inspection data is studied and discussed in which three products were found prominently contributed in PPM which is taken as case study. The next product is Axle Front Wheel. The PPM Contribution for each month is discussed in Chart 3.

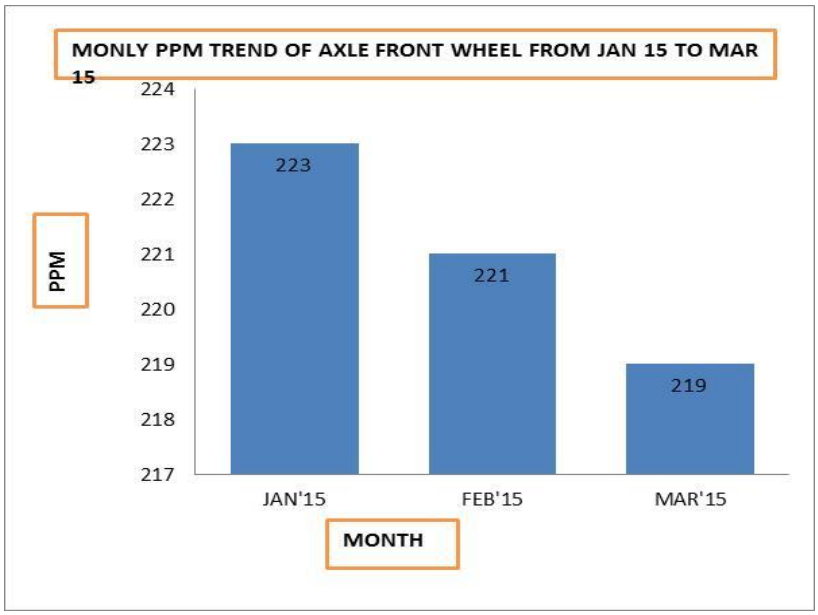


**Chart 3:Monthly PPM Trend of Axle Front Wheet (From Jan 15 to Mar 15)**

**1. Problem Discussion:** The Problem is identified by monitoring the Final inspection Quality status and In-process quality status. It is found that Steps on Outer Diameter of Axle front side is highly affecting quality of the product and increase the cost due to producing defective items in the production. The Problem Selection is made on the basis of defect wise monthly report of Axle Front wheel which is displayed in Table 2.

**Table 2: Defect Wise Monthly Report of Axle Front Wheel**

| DEFECT WISE MONTHLY REPORT OF SPINDLE KICK STARTER | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | MONTH NAME | | | Total | Comm. | Contribution | |
| SR. NO. | STANDARD DEFECT NAME | JAN'15 | FEB'15 | MAR'15 | Defects | Defects | in 100% | REMARKS |
| 1 | WIDTH U/SIZE | 85 | 95 | 85 | 265 | 265 | 80 | |
| 2 | OPERATION MISSING | 4 | 5 | 2 | 11 | 276 | 83 | |
| 3 | THREAD MISSING | 1 | 1 | 5 | 7 | 283 | 85 | |
| 4 | O.D U/SIZE | 2 | 3 | 3 | 8 | 291 | 87 | |
| 5 | THREAD DAMAGE | 8 | 2 | 13 | 23 | 314 | 94 | |
| 6 | DAMAGE | 12 | 12 | 12 | 36 | 350 | 105 | |
| 7 | FITMENT NOT O.K | 5 | 4 | 4 | 13 | 363 | 109 | |
| 8 | BEND/TWIST | 1 | 0 | 0 | 1 | 364 | 109 | |
| **9** | **STEP MARK / LINE MARK** | **132** | **139** | **127** | **398** | **762** | **229** | |
| 10 | BURR FOLDING | 4 | 4 | 2 | 10 | 772 | 232 | |
| 11 | RUST | 1 | 0 | 0 | 1 | 773 | 232 | |
| 12 | CUT MARKS | 2 | 3 | 4 | 9 | 782 | 235 | |
| 13 | THREAD N.G | 1 | 5 | 0 | 6 | 788 | 237 | |
| 14 | O.D O/SIZE | 2 | 2 | 0 | 4 | 792 | 238 | |
| 15 | MIX UP | 0 | 0 | 0 | 0 | 792 | 238 | |
| 16 | WRONG PART SUPPLIED | 1 | 5 | 5 | 11 | 803 | 241 | |
| 17 | PITTING MARK | 1 | 1 | 1 | 3 | 806 | 242 | |
| 18 | LEAK | 1 | 1 | 2 | 4 | 810 | 243 | |
| 19 | THREAD TIGHT | 1 | 1 | 1 | 3 | 813 | 244 | |
| 20 | LENGTH O/SIZE | 3 | 1 | | 4 | 817 | 245 | |
| 21 | LENGTH U/SIZE | 0 | 0 | 3 | 3 | 820 | 246 | |
| 22 | STEP ON O.D | 0 | 0 | 1 | 1 | 821 | 247 | |
| 23 | S.S.T NOT O.K | 0 | 0 | 0 | 0 | 821 | 247 | |
| 24 | HARDNESS NOT O.K | 0 | 0 | 0 | 0 | 821 | 247 | |
| 25 | HOLE BLOCKED | 1 | 0 | 0 | 1 | 822 | 247 | |
| 26 | WITHOUT GROOVE | | | | 0 | 822 | 247 | |
| | TOTAL INSPECTED QTY | 268 | 284 | 270 | | | | |

The centreless machine of case product Axle Front wheel is as shown in Figure 5. There is no work instruction provided on the shop floor for operator.

After dressing of grinding wheel , wheel location manually set by operator.

**Figure 5:Work Process on Centre Less Machine (Before LM Implementation)**

**2. Implementation of Lean Manufacturing Methodology for Improvement in Centreless Process:** During Centreless Operation, wheel touch problem is identified in petrol inspection of the product (when physically visit the machine). It is also identified that operator is struggling with setting of product immediately after the wheel dressing. This problem affects the quality as well as production of the case product and taken as case product. The Operation is studied in this research of case product Axle Front Wheel. Thus the process is found producing defective items in view of lean manufacturing.

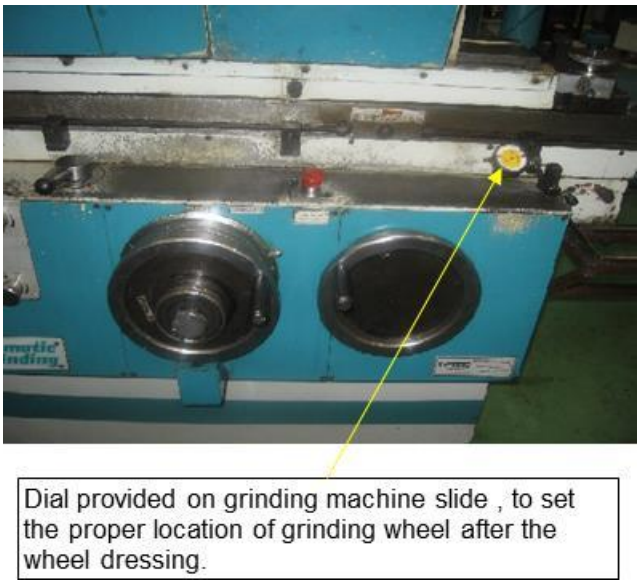


**Figure 6:Dial indicators on Centreless Machine to control Movement of Operation on Axle Front Wheel (After LM Implementation)**

**a) Problem Identification**

The Problem is identified by monitoring the Final inspection Quality status and In-process quality status.

**b) Idea of Improvement**

The ideas of improvement is achieved through Why-Why analysis which is done as follows.

**Why-Why analysis**

**Why 1:**1. Face touch & step on dia created due to uneven gap between grinding wheel face & component face.

**Why 2:**Gap uneven because the operator set the gap between grinding wheel face & component face by own judgement after the wheel dressing.

**Why 3:**No facility provided on machine.

**Why 4:**Because no idea on that time related to this problems.

**c) Root Cause**

Gap uneven because the operator set the gap between grinding wheel face & component face by own judgement after the wheel dressing, Because there was no facility provide on machine.

**d) Kaizen activity**

The problem can be solved by fixing dial indicator at the base which provides reading while resting of work piece on the fixture. The dial must be calibrated on monthly basis through proper calibration method. A master work piece is used for checking right location of drill and dial at the starting of work in each shift.

**e) Work instructions**

These are provided on the machine while performing drilling operation on the case products as follows.

1) One dial provided on machine to observe the over moment / in proper working of Machine.

**f) Benefits observed**

Following benefits are observed immediately after performing Kaizen Method.

Eliminate the wheel touch on face. Eliminate the step on dia. Reduce the setting time.

**g) Result Analysis**

The result analysis of case product immediately before and after Lean Manufacturing Methodology is shown in Chart 4. Followings are the result analyzed immediately after Kaizen method.

1. Eliminate Step mark / line mark on product.
2. Better finishing on the surface.
3. Improved Product Quality

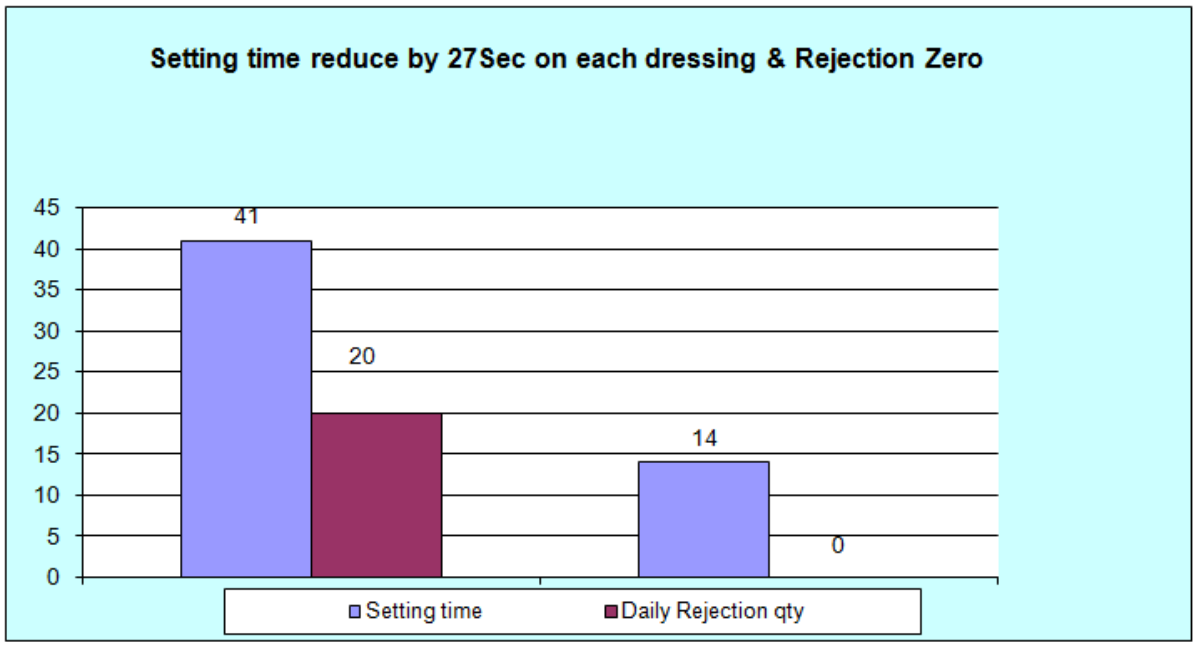


**Chart 4: Parts per million (PPM) Defects of Centreless Operation**

**Comparison of Both Case Studies:** Case study 1 derives out the benefits of eliminating the unnecessary process, burr problem along with others while case study 2 derives the benefits like reduced setting time, less rejection rate along with others.

## V. CONCLUSIONS

The implementation of Lean Manufacturing associated with Kaizen helps in achieving quality product by critical study of any processes. It also works in providing platform to individuals to implement self-suggestions for improvements in any concern area with an outstanding team helps in improving work and work culture.

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