International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Impact Factor (2012): 3.358

Continuous Improvement Application in an Excavator Assembly Line

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Abstract: ***The study was focused on continuous improvement applications in an excavator assembly line of Tata Hitachi Construction Machinery Company Limited Dharwad, Karnataka. The plant builds hydraulic excavators and wheeled backhoe loaders. The purpose of the study is to impart continuous process improvement application to reduce quality defects and improve cost efficiency. The study solves the problem of quality defects using Pareto analysis and Ishikawa Cause and effect diagram. The study objectives were to minimize the various issues regarding quality defects and thereby increasing product quality and reducing waste. Kaizen has become a foundation for this study. Through constant study and revision of processes, a better product can result at reduced cost.***

Keywords: Continuous Process Improvement (CPI), KAIZEN, Lean production, Pareto Analysis, FIFO and Why- Why Analysis.

1. Introduction

Continuous improvement (CI) is a philosophy that Deming described simply as consisting of “Improvement initiatives that increase successes and reduce failures” (Juergensen, 2000). We define CI more generally as a culture of sustained improvement targeting the elimination of waste in all systems and processes of an organization. It involves everyone working together to make improvements without necessarily making huge capital investments. CI can occur through evolutionary improvement, in which case improvements are incremental, or though radical changes that take place as a result of an innovative idea or new technology. Often, major improvements take place over time as a result of numerous incremental improvements. On any scale, improvement is achieved through the use of a number of tools and techniques dedicated to searching for sources of problems, waste, and variation, and finding ways to minimize them. A number of CI methodologies have developed based on a basic concept of quality or process improvement, or both, in order to reduce waste, simplify the production line and improve quality. The best known of them are: lean manufacturing, six sigma, the balanced scorecard, and lean six sigma. In this paper, our objective is to minimize the quality defects by applying sophisticated CI methodologies.

2. Methodology and Tools used in Quality Improvement

2.1 Methodology

Main objective of this study is to eliminate the process of rework by utilizing KAIZEN methodologies and thereby reducing the wastes (Defects) on the shop floor.

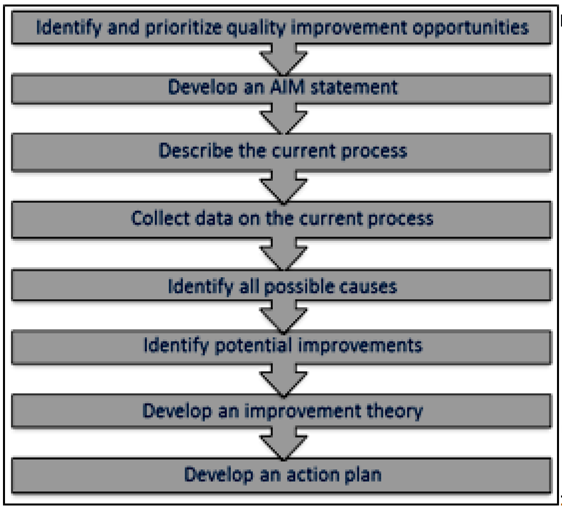

Figure 1: Problem Solving Method

2.2 Pareto Diagram

Pareto Diagram is a tool that arranges items in the order of the magnitude of their contribution, thereby identifying a few items exerting maximum influence. This tool is used in Statistical Process Control (SPC) and quality improvement for prioritizing projects for improvement, prioritizing setting up of corrective action teams to solve problems, identifying products on which most complaints are received, identifying the nature of complaints occurring most often, identifying most frequent causes for rejections or for other similar purposes. Dr. Juran suggested the use of this principle to quality control for separating the "vital few" problems from the "trivial many" now called the "useful many".

2.3 Ishikawa Cause and Effect Diagram

A Cause-and Effect Diagram is a tool that shows systematic relationship between a result or a symptom or an effect and its possible causes. It is an effective tool to systematically generate ideas about causes for problems and to present these in a structured form. This tool was devised by **Dr. Kouro Ishikawa** and as mentioned earlier is also known as Ishikawa Diagram. The symptom or result or effect for which one wants to find causes is put in the dark box on the right. The lighter boxes at the end of the large bones are main groups in which the ideas are classified. Usually four to six such groups are identified. In a typical manufacturing problem, the groups may consist of five M's - Men, Machines, Materials, Method and Measurement. The sixth M Money may be added if it is relevant. In some cases Environment is one of the main groups. Important subgroups in each of these main groups are represented on the middle bones and these branch off further into subsidiary causes represented as small bones. The arrows indicate the direction of the path from the cause to the effect.

3. Analysis and Findings

3.1 Pareto analysis of excavator main frame:

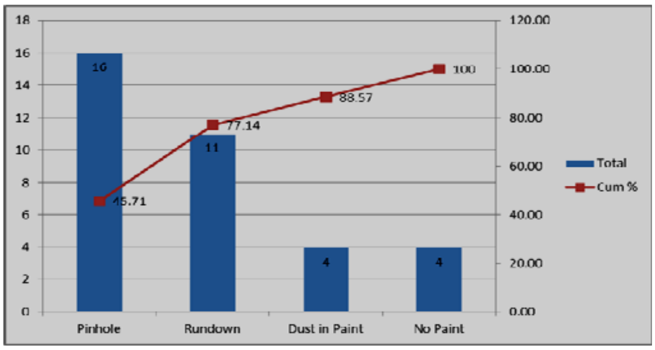

Figure 2: Pareto Analysis of Excavator Main Frame

Figure 3: Excavator Main Frame

3.2 Ishikawa Cause and Effect diagram for excavator main frame

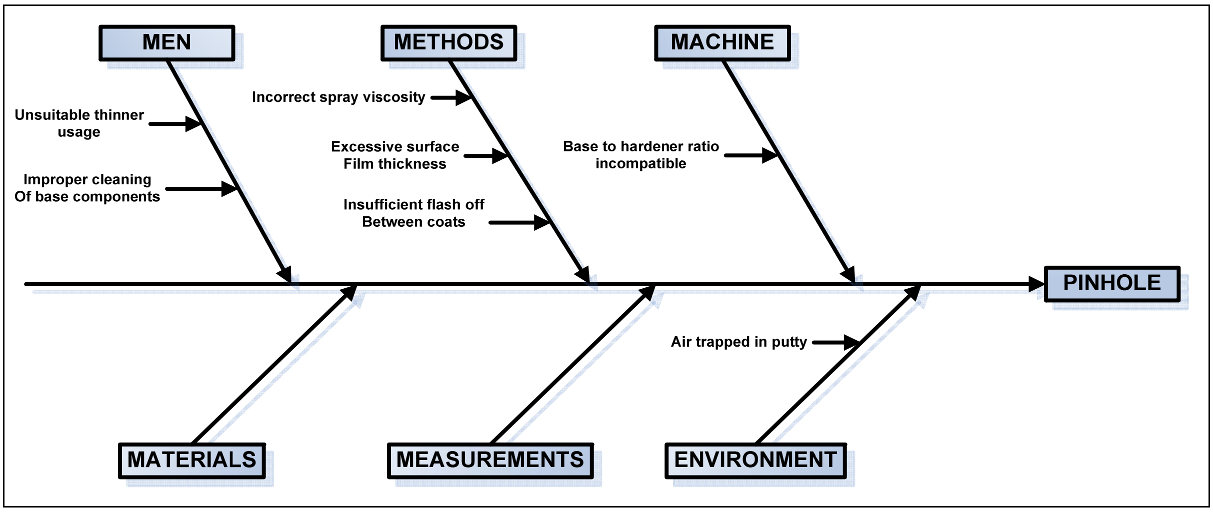

Figure 4: Ishikawa diagram for Pinhole

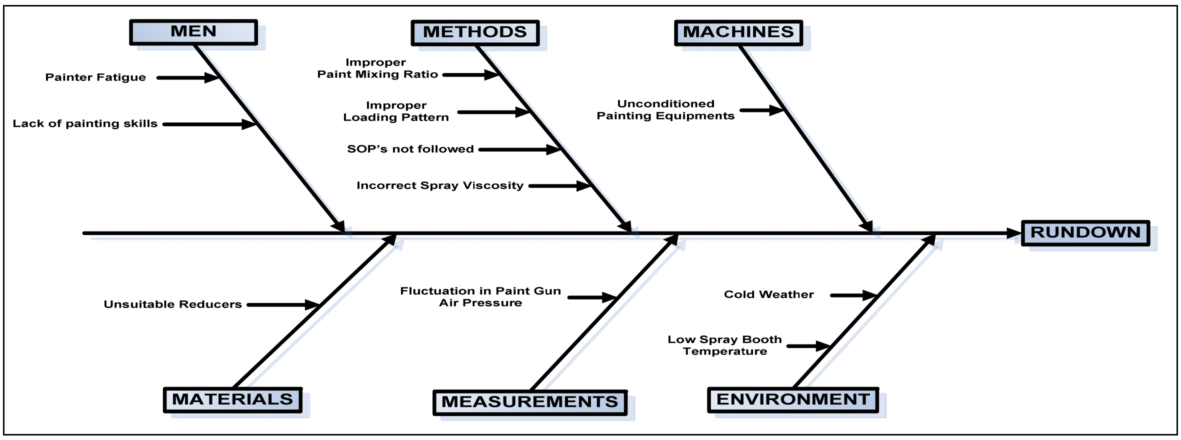

Figure 5: Ishikawa diagram for Rundown

3.3 Pareto analysis of excavator boom:

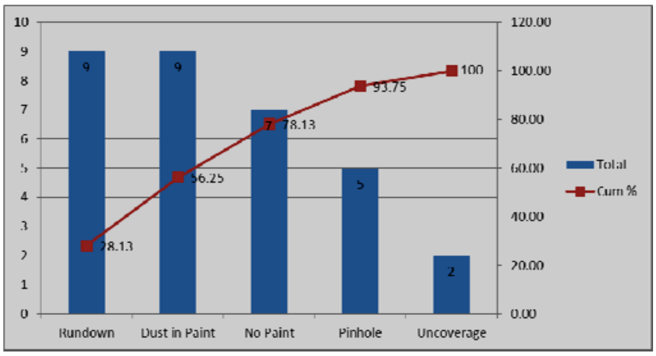

Figure 6: Pareto Analysis of Excavator Boom

Figure 7: Excavator Boom

3.4 Ishikawa Cause and Effect diagram for excavator boom:

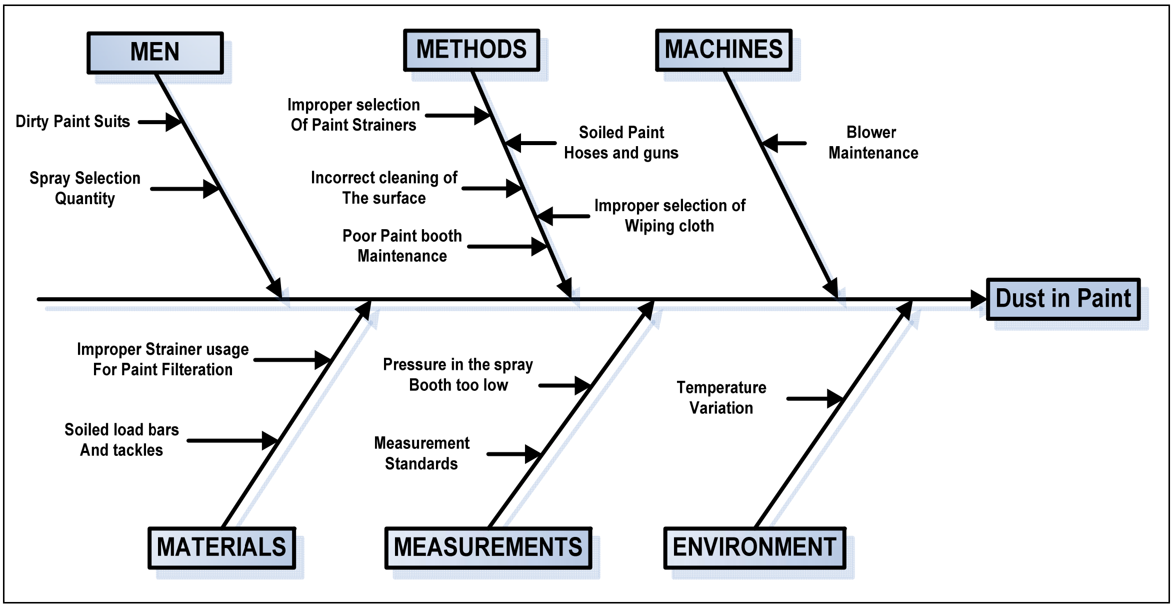

Figure 8: Ishikawa diagram for Dust in Paint

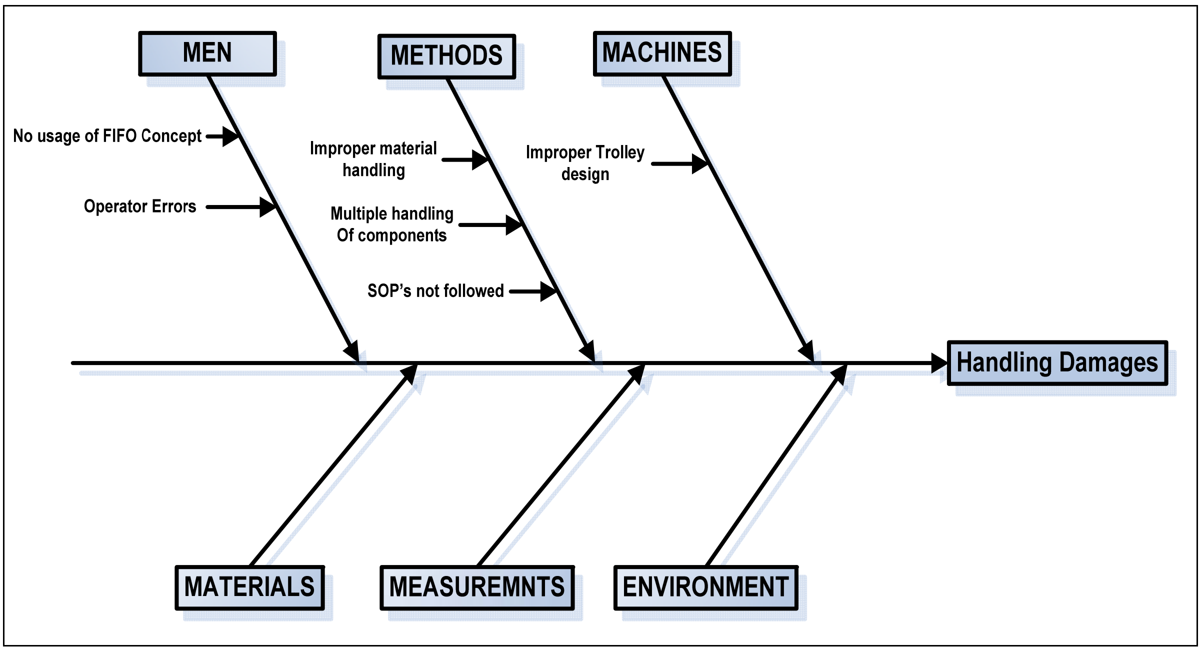

Figure 9: Ishikawa diagram for Handling Damages

By plotting Pareto charts and Ishikawa diagrams it is found that Pinhole, Rundown and Dust in Paint are the major quality problems before assembling the machine and during the assembly process handling damages contribute more errors.

4. KAIZENS Initiated for controlling Quality Defects

4.1 Sheet metal loading pattern:

Kaizen Theme: To reduce quality defects like un coverage & **rundowns.**

Countermeasure: Flat loading pattern is employed during painting.

Figure 10: Loading Pattern (Before KAIZEN)

Figure 11: Loading Pattern (After KAIZEN)

5. Results

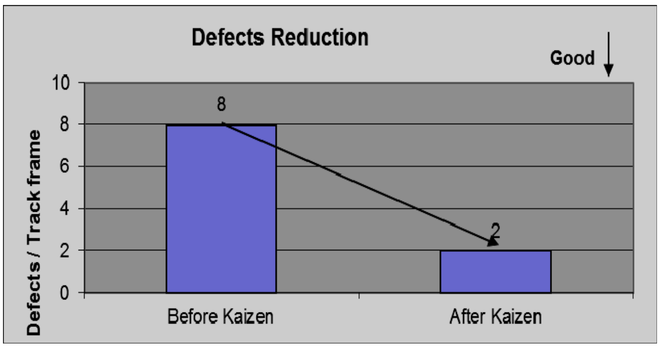

Figure 12: Graph of reduction in defects

1) Easy for painting as components per jig is less & flatter loading.

2) **Reduction in defects** like **un coverage & rundowns.**

4.2 Excavator Door

Kaizen Theme: To avoid paint damages & metal to metal contact while storing the excavator doors.

Problem/present status

Presently doors are storing on the floor it results metal to metal contact as well as paint scratches.

Countermeasure

Wooden rack is provided for storing doors.

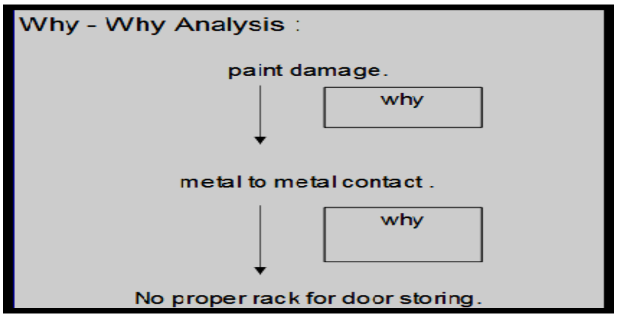

Figure 13: Why-Why Analysis

Figure 14: Storage (Before KAIZEN)

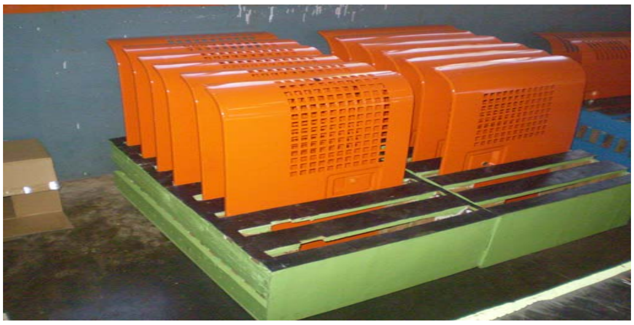

Figure 15: Storage (After KAIZEN)

Results:
Paint damages avoided.
Metal to metal contact is avoided.

4.3 Battery Box

Kaizen Theme: Quality Improvement & **Cost reduction.**

Problem/present status:

1) Paint damage due to handling. Painted components are stored one above the other on wooden pallets & then supplied to assembly line by fork lift.
2) Difficulty in storage. It may fall down during transportation.
3) Quantity per trip is only 02 no's.

Countermeasure

1. A dedicated trolley with HDPE with a capacity of 10 no's per trolley per trip.
2. 3T implemented.

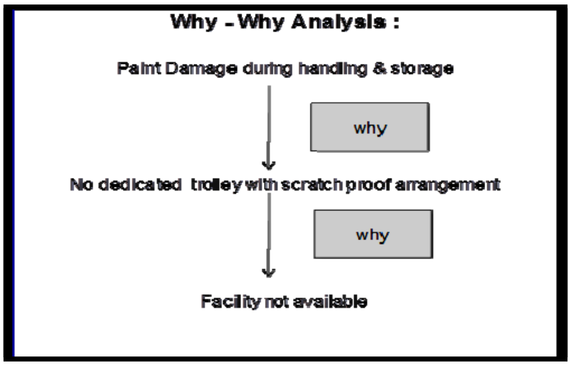

Figure 16: Why-Why Analysis

Figure 17: Storage (Before KAIZEN)

Figure 18: Storage (After KAIZEN)

Results

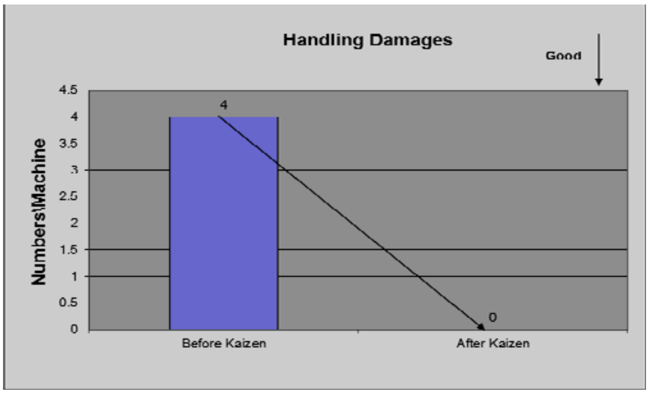

Figure 19: Graph showing zero defects on battery box

Benefits:

1) Achieved Zero handling damages.
2) Easy in storage.
3) Easy in identification, tracking & Retrieving.
4) Cost saving i.e. due to reduction in multiple trip as quantity per trip is 05 no's instead of 02 nos.
5) Time saving.

4.4 Painted Tanks

Kaizen Theme: Quality improvement – FIFO Implementation.

Problem/present status:

1) All painted tanks are stored on the floor.
2) No FIFO.
3) Chance of Handling paint damages.
4) Operator fatigue as handling is by crane.

Countermeasure:

1) Roller conveyor implemented.
2) Skids implemented as per size of the tank.

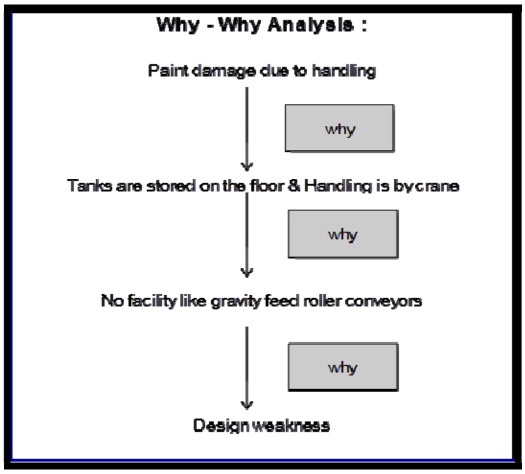

Figure 20: Why-Why Analysis

Figure 21: Storage (Before KAIZEN)

Figure 22: Storage (After KAIZEN)

Results:

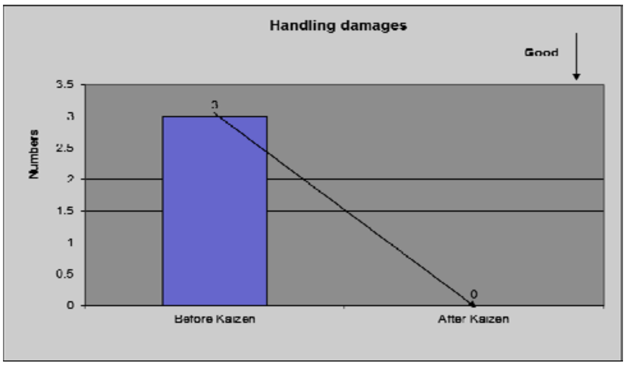

Figure 23: Graph showing zero defects on Painted Tanks

Benefits

1) 100% FIFO Implemented.
2) Improved productivity.
3) Time saving.
4) Crane usage completely avoided.
5) Power saving as no crane usage.
6) Achieved zero handling damages.
7) Operator fatigue avoided.

4.5 Excavator Track Frame

Kaizen Theme: Quality Improvement.

Problem/present status:
1. Paint damage during handling and storage.
2. Difficulty in storage.

Countermeasure:
A dedicated stand with **HDPE** arrangement to store the track frame.

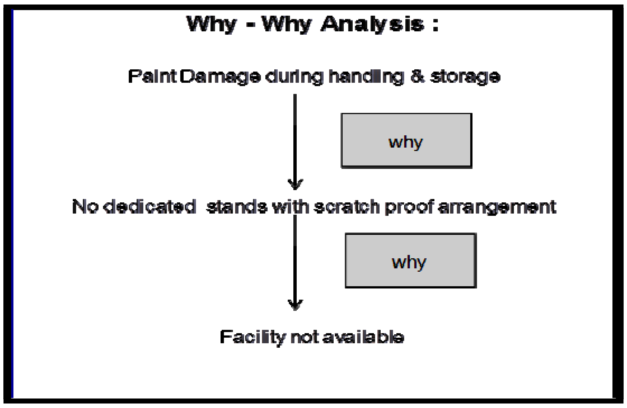

Figure 24: Why-Why Analysis

Figure 25: Storage (Before KAIZEN)

Figure 26: Storage (After KAIZEN)

Results

Figure 27: Graph showing zero defects on Track Frame

Benefits:
1) Achieved Zero handling damages.
2) Easy in storage.
3) Easy transportation to assembly line.
4) Time saving.
5) Handling is easy.

6. Results and Discussion

This chapter reports on the benefits of Continuous Process Improvement (CPI) to the excavator assembly line. The results of CPI implementation will be measured by considering the number of quality defects per machine (Excavator) before and after the assembly process.

Table 1: Production Volumes for two models

Production Volume in Month 1 and Month 2 (In No's)		
MODELS	Month 1	Month 2
MODEL - A	45	52
MODEL - B	28	36
Total Volume	73	88

Table 2: Total Defects observed in Month 1 & Month 2 (Before KAIZEN implementation)

Defect Category	Month 1	Month 2	Total
Pinhole	**5**	**5**	**10**
Rundown	**7**	**6**	**13**
Dust in Paint	**6**	**5**	**11**
Handling Damages	**4**	**3**	**07**
Uncoverage	14	11	25
No Paint	12	10	22
Vendor Defects	0	0	00

Table 3: Total Defects observed from Month 3 to Month 6 (After KAIZEN implementation)

Defect Category	Month 3	Month 4	Month 5	Month 6	Total
Pinhole	**4**	**2**	**0**	**0**	**06**
Rundown	**3**	**2**	**2**	**1**	**08**
Dust in Paint	**3**	**2**	**0**	**0**	**05**
Handling Damages	**2**	**1**	**0**	**0**	**03**
Uncoverage	4	2	3	3	12
No Paint	4	2	4	3	13
Vendor Defects	0	0	0	0	00

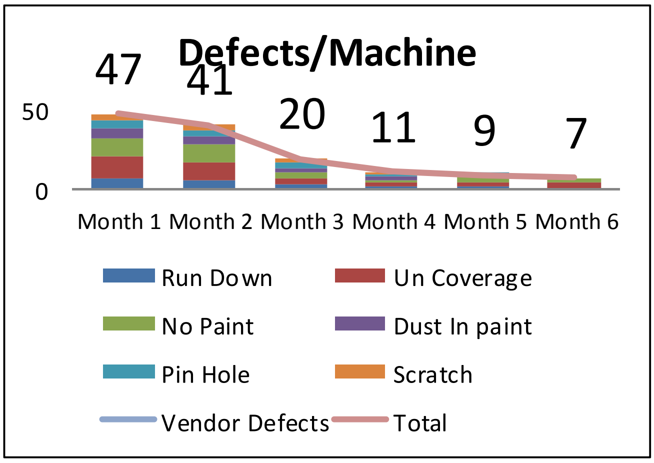

Figure 28: Graph showing Defects per Machine

7. Conclusions

- It has been found that there is a reduction in quality defects like Pinhole, Rundown, Dust in Paint and Handling damages by successful implementation of KAIZEN methodologies.
- The **Pareto analysis** helps to obtain the direct communication with customer and collect the problems regarding the product. It helps to organization minimize the chances of failure in the quality of the product and also continuous quality improvement.
- The paper gives the combination of lean to obtain the **continuous improvement** and the Pareto to obtain the **Quality improvement.**

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