Productivity Improvement and Zero Defect in Diff Case Sub Assy Line

M. Kumaran, V. Kandeeban, T. Premkumar

Abstract—The Differential case is considered as the very critical assembly and it plays very important role in power distribution to the both axles i.e. LH axle housing and RH axle housing. In this assembly line there is lot of internal quality issues and bottleneck areas, this leads to pulling down the overall productivity and Right at First time. Hence I take this as a project to improve the productivity and to reduce quality defects to zero. Here I used the tool as lean principles of eliminating the waste for productivity improvement and six sigma tool for quality improvements. This two are the highly efficient tool which is used nowadays for all the analysis.

I. INTRODUCTION
In TAFE organization we follow lean principles in a major role. Based on this unique practice we the team implement all the improvements in the plant. This Lean tool used to reduce the waste in the whole plant in terms of OLE and OEE. OLE is Overall equipment Effectives and OEE is Overall equipment Efficiency.

II. PLEAN FOR PRODUCTOION AND SERVICES
In TAFE we follow all the improvements in the system of Lean tool, As the advanced process of Six sigma tool. Lean and six sigma focused to reduce the waste in all cells like rear transmission and transmission case and Chassis assembly and Post painting stage.

III. SEVEN TYPES OF WASTES
In our Factory, the seven wastes are captured in a systematic way of approach by using standard principles.

A. T - Transportation
Transportation waste leads to more distance for transportation of material. In this project the material movement from stores to assembly line take more time, here we take special initiation to reduce the distance.

B. I - Inventory
Inventory more inventory leads to wastage of money

in the plant. In this project the current practice is holding inventory of ten tractors in every area. These parts are supplied as batch and stored as bulk. Hence this requires more inventory and inventory cost also very high. We take a special initiatives like kitting supply to the sub assembly and then to the main line. This process considerably reduced the line side inventory and inventory cost.

C. M – Motion waste
More cycle time leads to the increase in operating cost and leads to reduction in productivity. Here in the diff case assembly line assy line all the parts are placed around two meters away from the operator. Hence the operator has to move more distance from the work place, we focused to reduce the operator motion by implementation the point of usage concept. This will be briefly described as following chapter.

D. W – Waiting waste
In the diff case assembly process the operator has to wait for the machine for the further planetary gears assembly operation. Because the machine time is very high about ninety five seconds, this leads to the major bottleneck for the operation. For that the machine reduced and balanced with the man time by implementing some improvements, that will described in the below title.

E. O – Over processing
In cell 1 assembly process, there may more non value added activities carried out to complete the assembly operation. Hence the flow diagram concept is implemented in the assy line, so that non value added activities are converted in to value added activities.

F. O – Over production
Producing components or parts more than the required quantity is leads waste of investment, it comes under seven waste category. Here in TAFE we control the production by optimized way.

G. D – Rework and Defect waste
More cycle time leads to the rework and scraping of components. If there is defect in the rear transmission assembly, it takes more time for rectification, because for that the entire tractor has to dismantled and do the correction in the part. Hence this is considered as a much critical process for tractor assembly, we take much more concentration on this process.
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IV. PROBLEM DEFINITION

The problem definition is the chapter, where the description of the problem is given in detailed manner. The brief introductions of the problem with some details are to be provided the table format.

Table 1.1- description of the problem

<table>
<thead>
<tr>
<th>SL.no</th>
<th>Critical Process - Cell 123</th>
<th>Internal complaints (Aug’13 to May’14)</th>
<th>External complaints</th>
<th>Total Defects</th>
<th>6 Sigma Level (PPM)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>CQA</td>
<td>CRA</td>
<td>YARD</td>
<td>Sick</td>
</tr>
<tr>
<td>1</td>
<td>Cell 1 - Diffcase, Pinion sub &amp; R.T main assembly</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>38</td>
</tr>
<tr>
<td>2</td>
<td>IDB sub assembly</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>Hydraulic setting</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>15</td>
</tr>
<tr>
<td>4</td>
<td>Housing main drive sub &amp; main assembly</td>
<td>5</td>
<td>1</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>5</td>
<td>Hub front wheel pre-loading</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>6</td>
<td>PTO Sub assy</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>7</td>
<td>OIB Sub assy</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

In diff case assembly line the PPM level is 1388PPM with 4 sigma level. Hence the severity is high when compared to the other assembly line. In addition cell 1 is considered as the heart of Tractor assembly process. Hence this project is reduce the PPM level and to achieve 6 sigma in parallel productivity also increased.

Table 1.2- process failure mode effect analysis

This project supports establishment of six- sigma level processes in critical stages. Diffcase & Pinion sub assembly from 4Sigma level to 6Sigma level and there is an opportunity to Create Zero defect Stage at Diffcase & Pinion sub assembly. Create 6 Sigma Level Stage at Diffcase & Pinion sub assembly
V. ANALYSIS

A. PFMEA

Here in this project to find the potential failure in the process, we did a detailed analysis on the failure and its mode. Which is explained detailed in the below table.

B. Cause and Effect chart

For the diff case assembly process there may more number of causes and effects for the process, hence to analysis this we need the chart it is done in two levels. Here We show the detailed level 2 chart for ease of understanding. This fish bone shows the linkage between all the factors like man, method and machine and environment related issues.

C. Prioritized Causes for the defects

In this project, the causes and the measures and the measures are done by using the Japanese technology as below.

<table>
<thead>
<tr>
<th>S. No</th>
<th>Causes</th>
<th>Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Difficultightening of minus bolt</td>
<td>No future available</td>
</tr>
<tr>
<td>2</td>
<td>Difficult oto intenser minus bolts</td>
<td>No proper height of bolts</td>
</tr>
<tr>
<td>3</td>
<td>Crank shaft misaligning</td>
<td>Similar parts</td>
</tr>
<tr>
<td>4</td>
<td>Copper washer missing</td>
<td>Child parts</td>
</tr>
<tr>
<td>5</td>
<td>Missing of tenser for bolts</td>
<td>Human error</td>
</tr>
<tr>
<td>6</td>
<td>Man cycle time</td>
<td>1:4:6 not been cycle</td>
</tr>
<tr>
<td>7</td>
<td>Operator fatigues high</td>
<td>Handling of weight parts</td>
</tr>
</tbody>
</table>

D. Process analysis between old and new

The difference in process assembly between old and the new process are explained by using the exploded view as below and the difference for the two process also explained clearly in the below diagram.
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1. Backlash checking method

**DIFFERENCE IN PROCESS SEQUENCE**

**Fig. 1.3 Difference in process sequence**

**Fig 1.4 Backlash checking method**

Gage R&R

<table>
<thead>
<tr>
<th>Source</th>
<th>Component</th>
<th>% Contribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total reading</td>
<td>0.0000027</td>
<td>100.00</td>
</tr>
<tr>
<td>Reproducibility</td>
<td>0.0000024</td>
<td>89.94</td>
</tr>
<tr>
<td>Operators_1</td>
<td>0.00000003</td>
<td>10.06</td>
</tr>
<tr>
<td>Part-To-Part</td>
<td>0.00000000</td>
<td>0.00</td>
</tr>
<tr>
<td>Total Variation</td>
<td>0.0000027</td>
<td>100.00</td>
</tr>
</tbody>
</table>

Process tolerance = 0.017

Source: StdDev (SD) (6 * SD) (%$\sigma$) (SV/Toler)
- Total Gage R&R: 0.0016428, 0.0098567, 100.00, 57.58
- Reproducibility: 0.0055580, 0.0031256, 31.71, 18.39
- Operators_1: 0.005289, 0.0031256, 31.71, 18.29
- Part-To-Part: 0.0000000, 0.0000000, 0.00, 0.00
- Total Variation: 0.0016428, 0.0098567, 100.00, 57.98

Number of Distinct Categories = 1

Gage R&R for Backlash

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1. Diff case Stress analysis

2. Planetary gear stress analysis

E. Actions taken for causes
The main actions taken to avoid the cause one and two as detailed explain below.

1. Diff case improvement

Fig 1.5 Anova

Fig 1.6 Stress analysis

Fig 1.7 Stress analysis

Fig 1.8 Stress distribution

Fig 1.9 Stress distribution

Fig 1.10 Type of diff case
Productivity Improvement and Zero Defect in Diff Case Sub Assy Line

Fig 1.11 Models
CURRENT CONDITION

Fig 1.12 Current condition
PNEUMATIC/FIUTURE DEVELOPED

Fig 1.13 Pneumatic developed
2. Planetary gear design improvement

Fig 1.14 Cutting cycle
F. Testing results for improvements
Here I have shown the testing results for all the improvements with the test report from FEA and stress analysis.

1. Diff case testing

Fig 1.15 Test result
2. Planetary gear testing
Testing condition and Results

<table>
<thead>
<tr>
<th>Testing condition:</th>
<th>Width of testing</th>
<th>Tension configuration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample, Non (sample)</td>
<td>800</td>
<td>895</td>
</tr>
<tr>
<td>Tension</td>
<td>20</td>
<td></td>
</tr>
</tbody>
</table>

Fig 1.16 Testing condition

Durability Test Results and Comparison

<table>
<thead>
<tr>
<th>Life (HR)</th>
<th>Non-NF forged</th>
<th>NF forged</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample 1</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>Sample 2</td>
<td>10</td>
<td>15</td>
</tr>
<tr>
<td>Sample 3</td>
<td>12</td>
<td>15</td>
</tr>
</tbody>
</table>

Material: ZM6.12M6.1

Fig 1.17 Durability test results and comparison

VI. RESULTS AND BENEFITS

In diff case assembly line the overall PPM, should down to 60PPM as shown in the below graph. Here from the past financial year the parts per million is 1488 and by implementing all the improvements in quality by implementing poka yoke in the line PPM come down.

Fig 1.19 Diffcase washing – stainless steel washing tray

Nylon with rubber sheet for sleeve pinion assembly table

Fig 1.20 Nylon with rubber sheet for sleeve pinion assembly

Diffcase assembly bolts tightening – Locator modification

Fig 1.21 Diffcase assembly

In diff case assembly line the overall PPM, should down to 60PPM as shown in the below graph. Here from the past financial year the parts per million is 1488 and by implementing all the improvements in quality by implementing poka yoke in the line PPM come down.

Fig 6.1 Diff case assembly line the overall PPM

G. Other Improvements done in line

Diffcase washing – stainless steel washing tray with partition

Fig 1.8 Test report for axle shaft spline

Note: Knowledge got from welding and testing paper - Fifth semester

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In this process around 50% of the non-value added activities are converted into value added activities and the required table is shown below.

![Fig 6.2 Rejection](image)

In this process, the overall cycle time is 1248 seconds, for that we have set the target of 624 seconds but as the end result we achieved as the savings of 800 seconds. This shows the result of 95% of cycle time savings from the existing process, this is clearly shown in the below figure.

![Fig 6.3 NVA vs VA](image)

![Fig 6.4 Cycle time improvement](image)

In the below table, the overall result achieved by this project, through Inventory, Man movement, space utilization and quality improvement as shown. In words the Inventory is reduced from 20 tractors to 5 tractors in line side. Man movement reduced from 2 meters per assembly to 1 meter for sub assembly that is 50% reduction. Quality improvement is achieved by 20%.

VII. CONCLUSION

In this project, Productivity of diff-case sub assembly has been improved and defect in the sub assembly has been reduced through various analyses and testing. Based on this improvements like cycle time reduction, man power elimination, non-value added activities has been reduced, defects has been completely eliminated and brought to zero, through this projects many kaizen were implemented which benefited the organization more so, I sincerely thank Mr.Premkumar for supporting me throughout the project. As a whole I thank both the TAFE and KALASALINGAM UNIVERSITY for providing me such a great opportunity where I can improve myself and make organization to gain benefit

REFERENCE

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