International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249-8958 (Online), Volume-9 Issue-1S4, December 2019

Productivity Improvement and Zero Defect in Diff Case Sub Assy Line

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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 bottlenecking 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.

Manuscript published on 30 December 2019.
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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

Sl.no	Critical Process - Cell 123	Internal complaints (Aug'13 to May'14)				External complaints		Total Defects	6Sigma Level (PPM)
		CQA	CRA	YARD	Sick	PDI	DEPOT		
1	Cell 1 - Diffcase, Pinion sub & R.T main assembly	0	0	0	38	0	0	38	1488 PPM – Internal NC
2	IDB sub assembly	0	0	0	0	0	0	0	0
3	Hydraulic setting	7	0	0		15	3	28	2268
4	Housing main drive sub & main assembly	5	1	1		5	0	12	972
5	Hub front wheel pre-loading	0	0	0		3	0	3	243
6	PTO Sub assy	0	0	0		4	0	4	324
7	OIB Sub assy	0	0	0		0	0	0	0

In diff case assembly line the PPM is 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

PROCESS FAILURE MODE EFFECTS ANALYSIS (Process FMEA)

System	100 hp	Process Responsibility	MDU-Team	FMEA No.	PFM031	Revision	1
Subsystem		Key Date	20.09.2016	Prepared by			
Component	---	Model		FMEA Date (Orig)	20.10.2016	FMEA date (modified)	

Crown wheel sub assy

Opn. seq. ref	Process Function	Requirements	Potential Failure Mode	Potential Failure Effects	SEV	Class	Potential Causes / Mechanism(s) of Failure	OCC	Current Process Controls Prevention	Current Process Controls Detection	DET	RPN	Recommended Action(s)	Resp. and target completion date	Actions Taken	SEV	OCC	DET	RPN
															Action Results				
10	Pressing of crown wheel and half casting	Appropriate crown wheel and casting to be pressed	Inappropriate matching	Functional failure	7		Similar component with slight modification	5	None	None	8	758	Parts lifting trolley	PED/17.10.2016		7	3	3	733
		Both to pressed uniformly	Improper pressing	Functional failure	7		Pressure not reached	5	None	Limit placed on the wall for ram movement	4	754							
60	Tighten the Minus bolt with nut	Tighten to the required torque	Not torque attained	Functional failure	7		Not able to hold	5	None	None	8	758	Providing fixture to hold the component	PED/17.10.2016		7	3	5	735
					7		Torque wrench not available	5	None	None	8	758	Torque wrench to be provided	PED/17.10.2016		7	3	5	735
70	Place the planetary gear thrust washer 11 on the case	Appropriate wahser to be placed	Inappropriate washer	star gear wear and heat generated	8		Similar component with slight modification	5	None	No changes in the wahser	1	851				8	3	1	831
		Presence of wahser	Missing of washer	Functional failure	8		Not available on the work spot	5	None	None	8	858	sensor to be placed to check and linked with nut runner	PED/17.10.2016		8	3	5	835

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.

Fig1.1- Causes and effects

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 1.3- causes and effects

S. No	Causes	Measures
1		
2	Difficult in tightening of minus bolt	No fixture available
3	Difficult in torque for minus bolts	No proper holding available
4	Cross shaft mismatching	Similar parts
5	Copper washer missing	Child parts
6	Missing of torque for bolts	Human error
7	More cycle time	1248 secs for one cycle
8	Operator fatigue high	Handling of weighted parts

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.

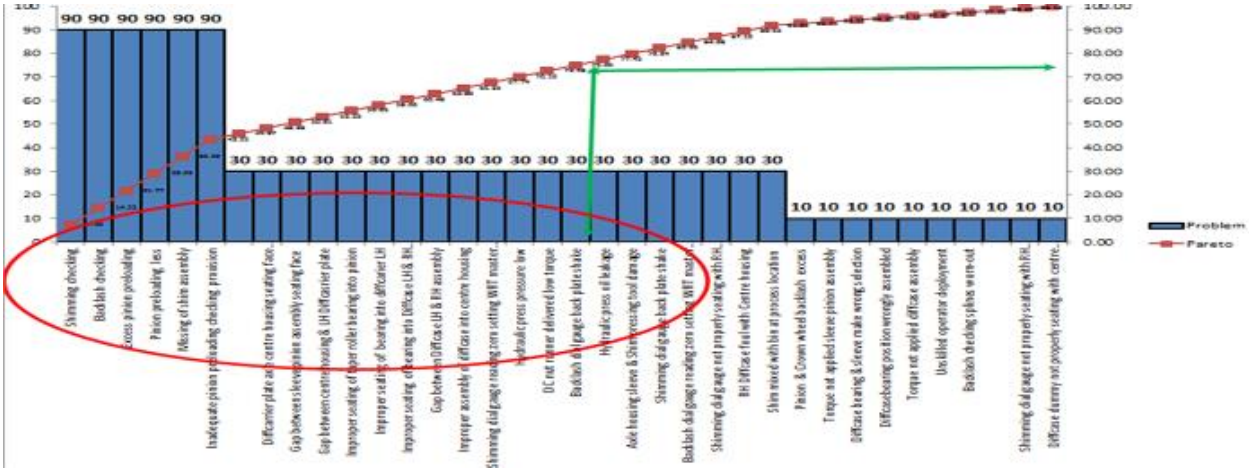
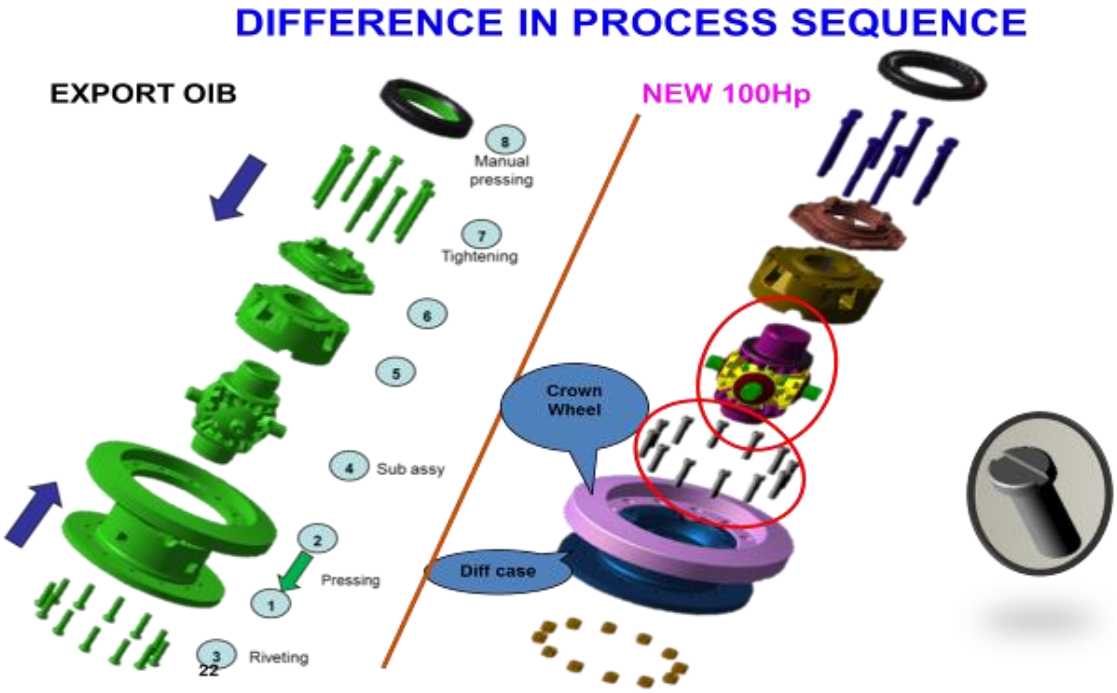


Fig. 1.3 Difference in process sequence

1. **Backlash checking method**



1

Backlash checking

Gage R&R

Source	%Contribution Component			
Total reading	0.0000027	100.00		
Repeatability	0.0000024	89.94		
Reproducibility			0.0000003	10.06
Operators_1	0.0000003	10.06		
Part-To-Part	0.0000000	0.00		
Total Variation	0.0000027	100.00		

Process tolerance = 0.017

Source	StdDev (SD)	(6 * SD)	(%SV)	(SV/Toler)
Total Gage R&R	0.0016428	0.0098567	100.00	57.98
Repeatability	0.0015580	0.0093480	94.84	54.99
Reproducibility	0.0005209	0.0031256	31.71	18.39
Operators_1	0.0005209	0.0031256	31.71	18.39
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

Fig 1.4 Backlash checking method

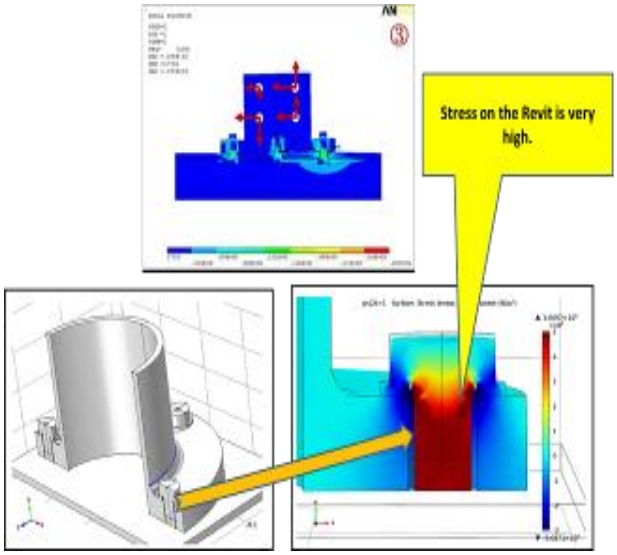


Fig 1.5 Anova

1. *Diff case Stress analysis*

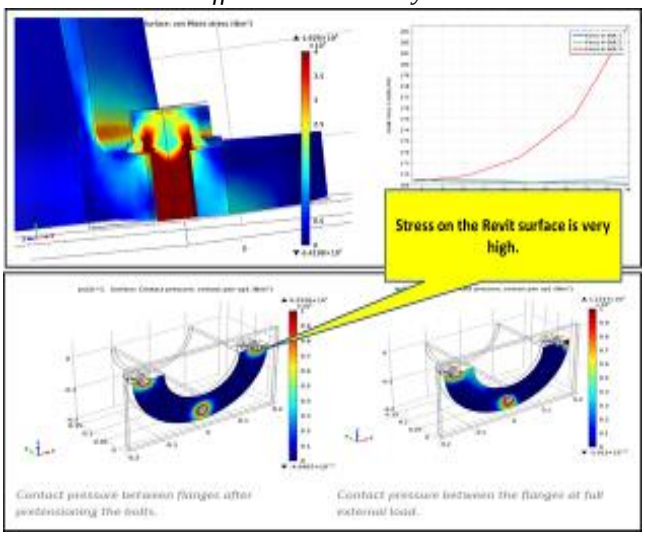


Fig 1.6 Stress analysis

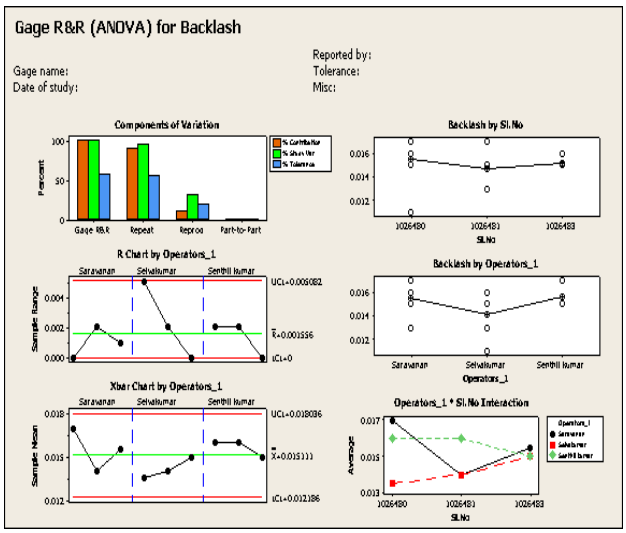


Fig 1.7 Stress analysis

2. *Planetary gear stress analysis*

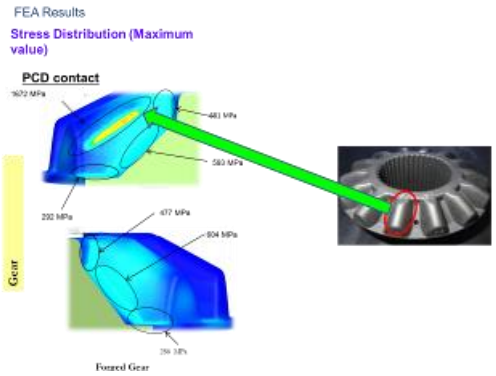


Fig 1.8 Stress distribution

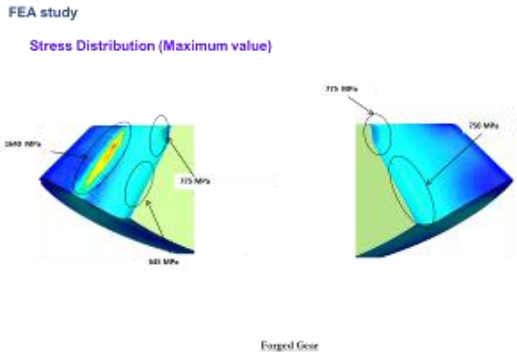


Fig 1.9 Stress distribution

E. Actions taken for causes

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

1. Diff case improvement

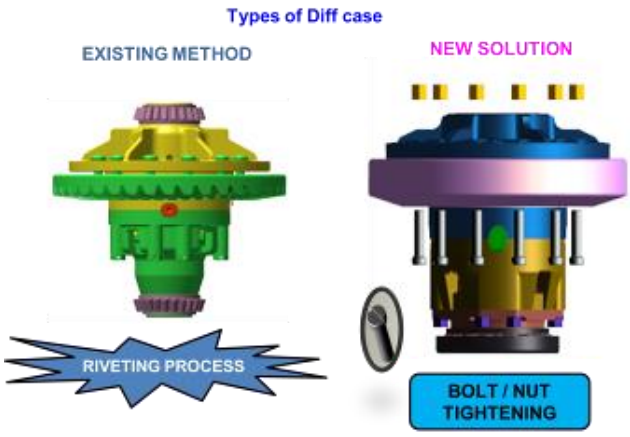


Fig 1.10 Type of diff case

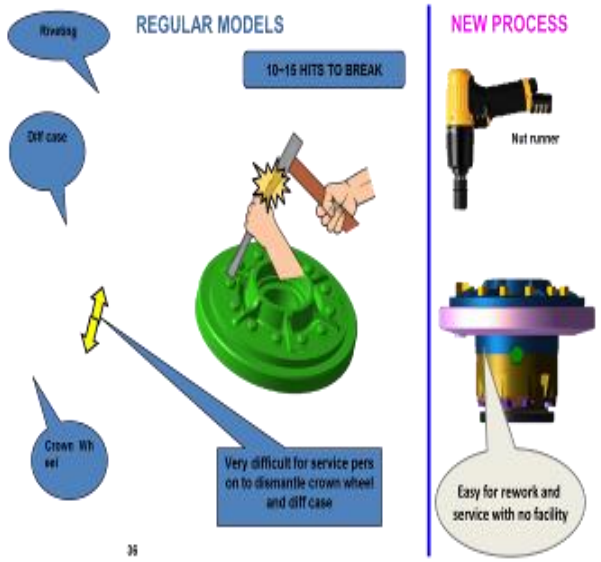


Fig 1.11 Models

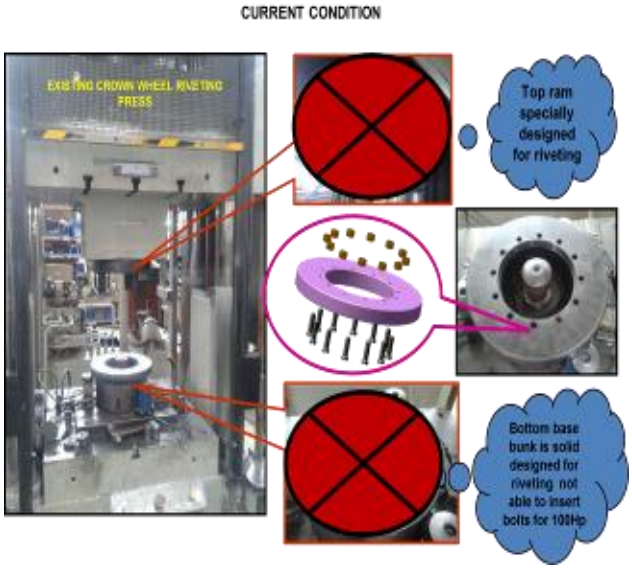


Fig 1.12 Current condition

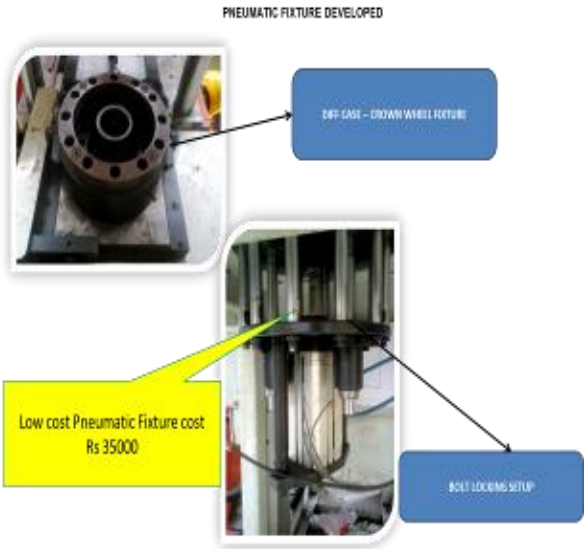


Fig 1.13 Pneumatic developed

2. *Planetary gear design improvement*

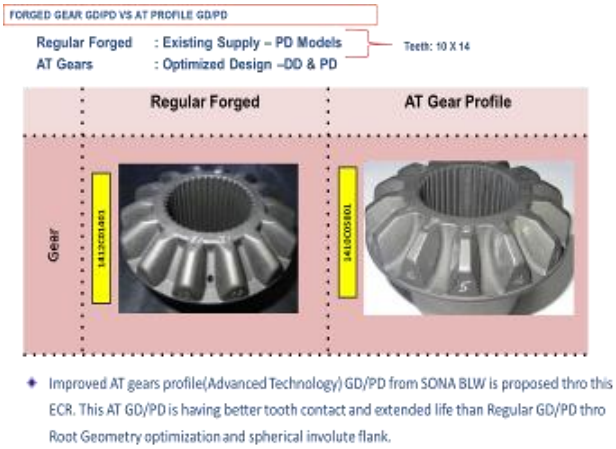


Fig 5.10 Improved designs

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*

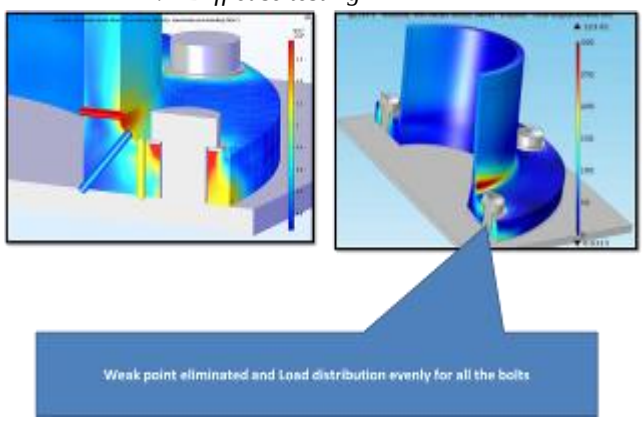


Fig 1.15 Test result

2. *Planetary gear testing*

Fig 1.16 Testing condition

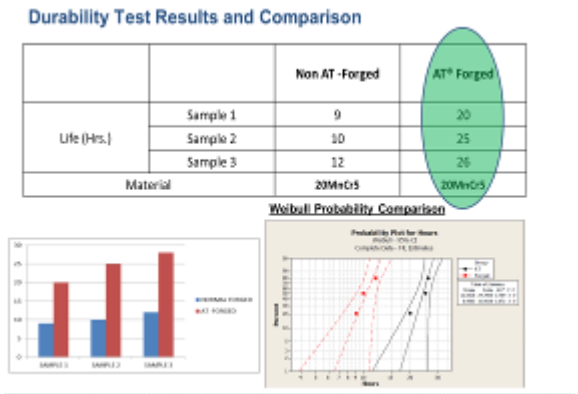


Fig 1.17 Durability test results and comparison

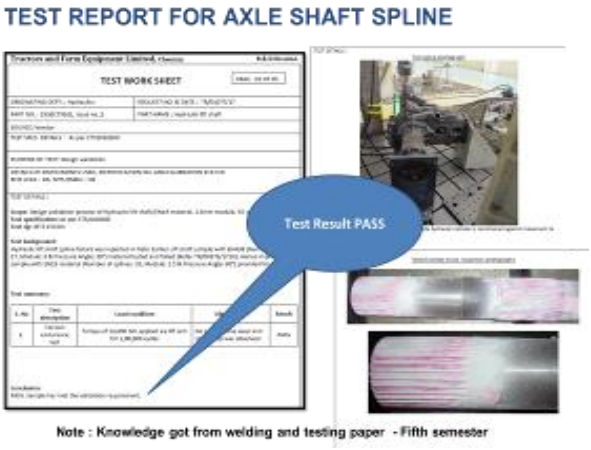


Fig 1.18 Test report for axle shaft spline

G. *Other Improvements done in line*

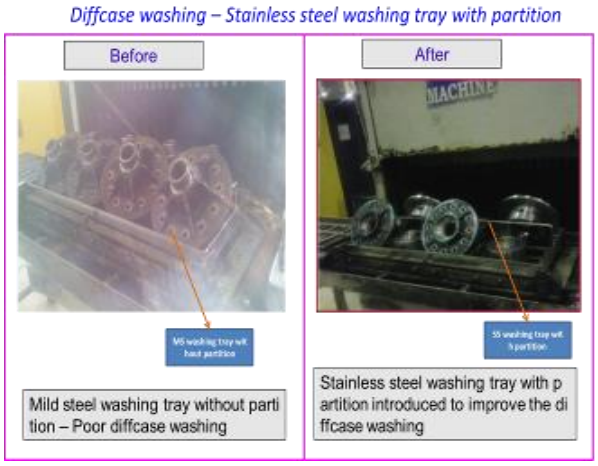


Fig 1.19 Diffcase washing – stainless steel washing tray

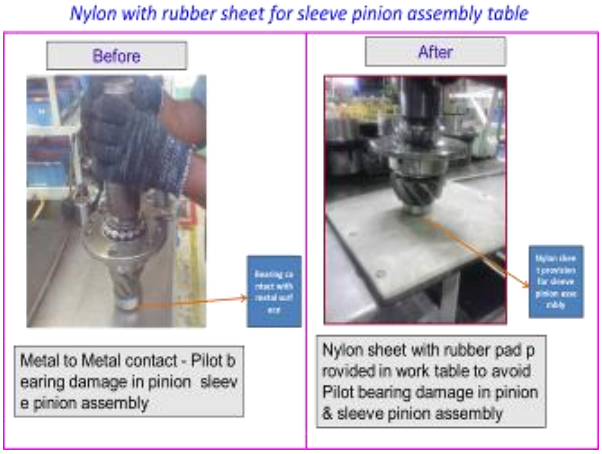


Fig 1.20 Nylon with rubber sheet for sleeve pinion assembly

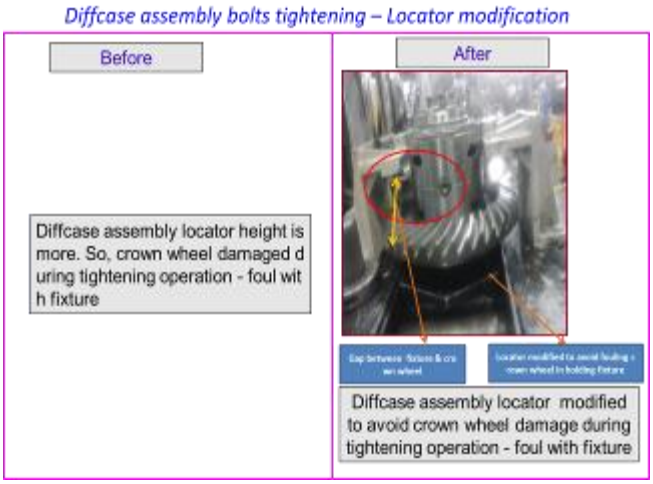


Fig 1.21 Diffcase assembly

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.

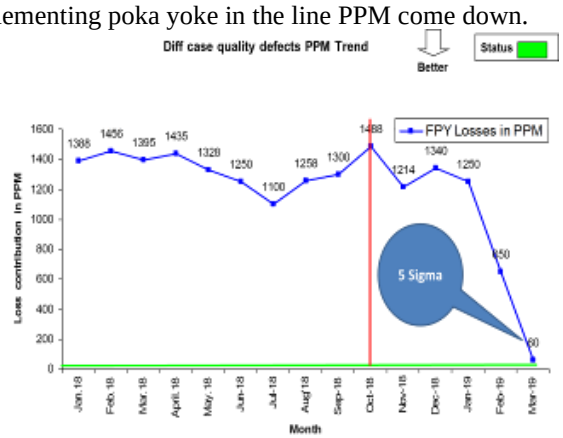


Fig 6.1 Diff case assembly line the overall PPM

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.

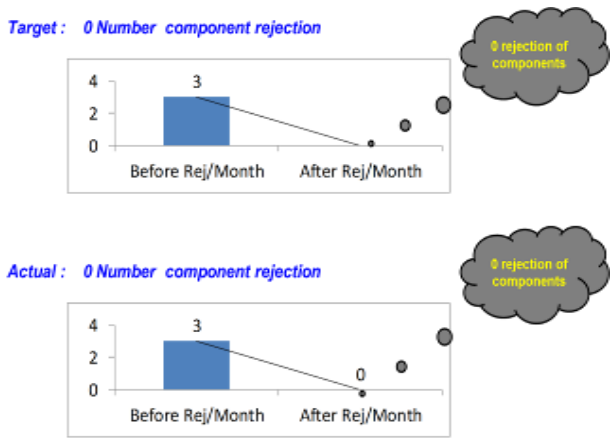


Fig 6.2 Rejection

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

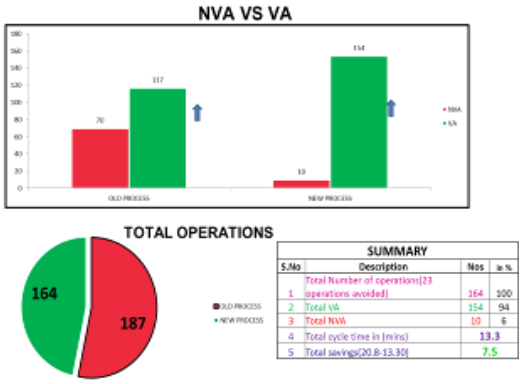


Fig 6.3 NVA vs VA

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.

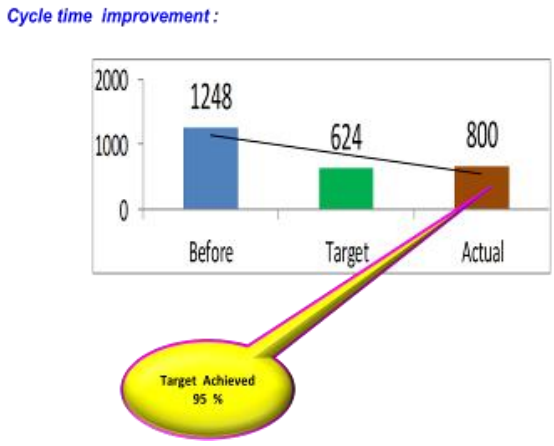


Fig 6.4 Cycle time improvement

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%.

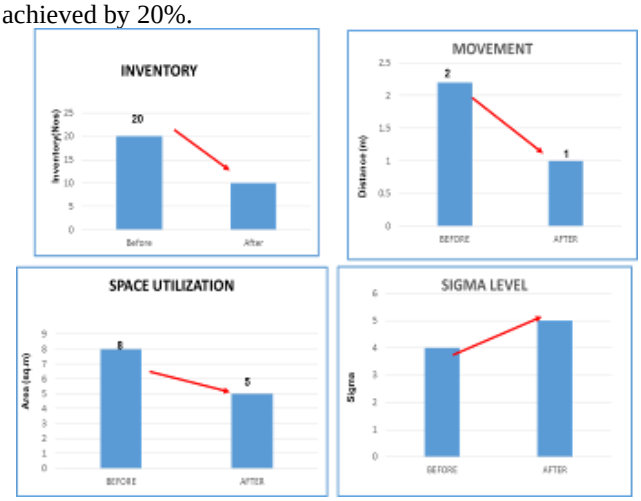


Fig 7.1 Overall result

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

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