Modification of Manufacturing Process for Suspension Pin used in Commercial Vehicles and its analysis

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Abstract: Suspension pin is a component for chassis of commercial vehicle used for shifting fork mounting, during component assembly part get rejected due to cross hole found shifted from C slot. The current research envisages a manufacturing process of suspension pin by which part will not get rejected .The manufacturing process encompassed sequence of manufacturing process which includes MPI Testing, Induction Hardening testing (Pattern Testing), Material Testing, Hardness Testing, PFD, PFMEA, Control Plan, SPC & MSA Study and conducting VMC operation on fixture.

Keywords: Suspension pin, Manufacturing, Material testing.

I. INTRODUCTION

Commercial vehicles such as trucks, trailers and semi-trailers have ladder chassis. These are so called because of the configuration of their members. They generally consist of two beams arranged parallel to the longitudinal axis of the frame and several crossbeams placed laterally between the beams. Therefore, the axles, as well as the power plant, the driver's cab and platform or other superstructures, are easy to repair. While it must be said that the conventional ladder chassis is an ineffective structure to support bending and torsional loads, it is true that for historical and economic reasons, practically all commercial vehicles in the world are based on this structure. chassis. The demand for chassis-chassis vehicles continues to increase in the commercial vehicle sector where the current trend is for trucks and articulated vehicles carrying large loads.

II. LITERATURE REVIEW

Madan Mohan Reddy and Lakshmi Kanta Reddy (2014) [1] studied the modeling and analysis of the container frame using the FEM to improve load capacity and reduce frame failure with bending by adding stiffeners. The rectangular stiffeners is positioned between the crosspieces and fixed to the chassis by bolts. The results of the Ansys-14 analysis show that there is a reduction in the von miss stress in the chassis with stiffening up to 37.11% compared to without stiffening, while the intensity of the stress is reduced to 36.23% and the reduction reduced by 36.16%.

Bhat KA, Untawale SP, Katore HV (2014) [2] has redesigned the tractor chassis. The existing trolley frame uses a "C" cross section and the material used is mild steel. The total capacity of the trolley is 60KN, but the dead weight of the trolley and other accessories is 13 KN. The redesign is carried out by changing the cross section from "C" to "I" without changing the material and dimensions. Modifying the section resulted in safer strains than the previous section and a weight reduction of 31.79 kg, which ultimately reduced the cost of the frame.

Ketan Gajanan Nalawade, Ashish Sabu and Baskar P (2014) [3] performed static structural analysis and modal analysis of a TATA 407 truck chassis. Modeling is conducted in CATIA and finite element analysis is performed using the ANSYS seminar. After carrying out the analysis on the ladder frame with structural steel and E-Glass composite, the results obtained show that the maximum shear stress and the equivalent stress generated in the E glass are lower than the acceptable limit and the total deformation is also within the limit.

Abhishek Sharma, Pramod Kumar, Abdul Jabbar and Mohammad Mamoon Khan (2014) [4], designed the chassis of heavy vehicles and analyzed using ANSYS-15.0. The size of the TATA LPS 2515 EX chassis is used for the structural analysis of the chassis of heavy vehicles with three different alloys subject to the same conditions as the steel chassis. The three materials used for the frame are gray cast iron, AISI 4130 alloy steel and ASTM A710 STEEL GRADE A (CLASS III). There are different forms of sections used in this work, for example type C, I and Box sections. A solid three-dimensional model was built in the parametric model CATIA V5. The results show that the steel alloy AISI 4130 exhibits better and lighter performance than all the other metal alloys also offering resistance.

Swami K.I. and Tuljapure S.B. (2014) [5] studied static structural analysis of the truck chassis using the ANSYS software. Here, the frame of the Eicher 20.16 is of the ladder frame type that has two beams or beams of cross section in C and seven beams called beams of cross section in C. The results of the graph show that as and As the thickness increases of the lateral element, initially there is a slight decrease in the maximum value of the von miss stress, but then it starts to increase. Speed decreases just before the end and increases again at the end.

III. PROPOSED WORK

Below given complaint report is for Suspension Pin, a component for chassis assembly of commercial vehicle, during component assembly part get rejected due to radius slot found shifted from cross hole as shown in report picture. Now we have to propose a full proof manufacturing process of Suspension Pin by which part will not get rejected.

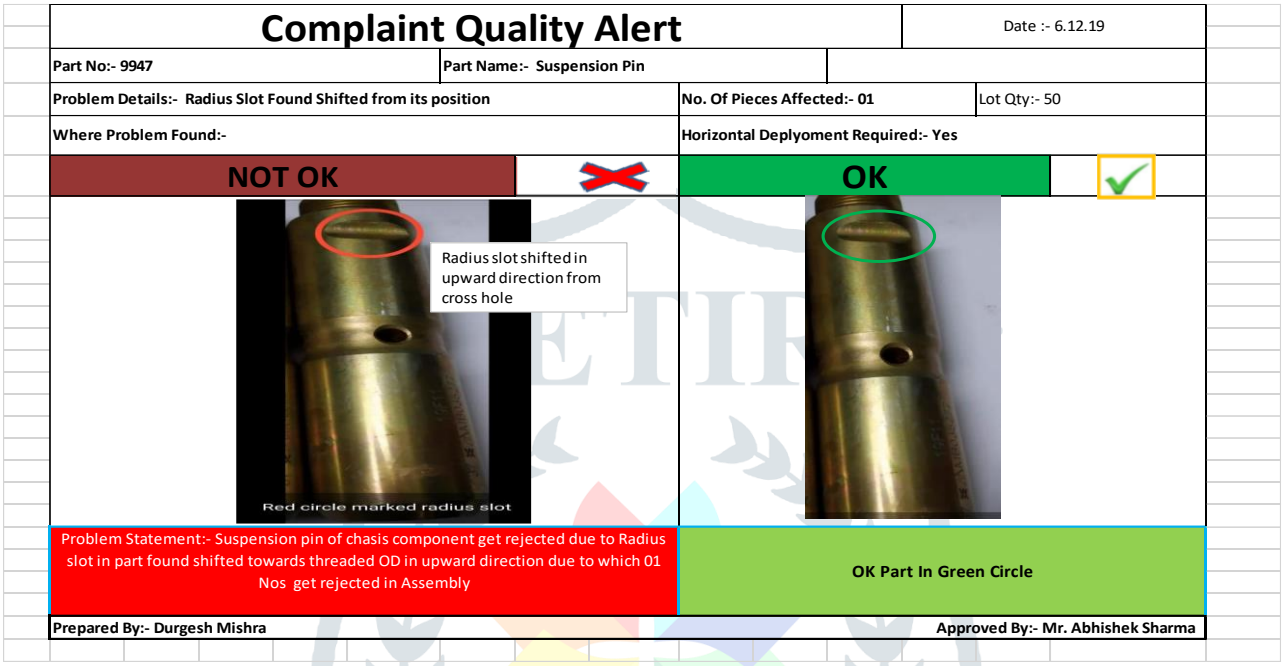

Figure 1: Customer complaint report

a) PFD
b) PFMEA
c) Control Plan
d) SPC
e) MSA
f) Fixture for Process
g) Part Dimensional Report
h) Part Analysis report

IV. MATERIALS AND METHODS

In this process original component is found with customer complaint being analyzed by Root Cause Analysis Method. On that basis new component drawing is made and comparison of old and new design are done on basis Met Lab Report. Now according to the new design, we have manufactured new component and performed experimental analysis on new component for determining dimensional aspects and material aspects. On getting satisfactory results according to optimized design experimental analysis by manufacturing new component is proceeded and comparing the results of new design results and experimental analysis for knowing the variations and parameters. The operations are discussed below in detail

OPN10 : In this operation checking of Raw material as per the requirement given in control plan held.

OPN 20: In this operation full length Bar of raw material cut on bandsaw machine with particular specification for reducing end piece scarp from the round bar.

OPN 30:- In this operation length of the pin maintained for removing tapper from the face, So this operation is said as facing operation.

OPN 40: - During this operation drilling operation will be conducted on pin with the help of CNC machine.

OPN 50:- In this process OD turning operation will be held on part with the help of CNC machine by turning operation.

OPN 60:- Total length & Chamfering is maintain during this operation as per specifications given in drawing.

OPN 70:- First Slotting will be done in this operation which will be maintain on SPM machine.

OPN 80:- This is the most important operation in which radius slot will be maintained on VMC machine with the new fixture which we have developed for reducing the radius slot shifting defects.

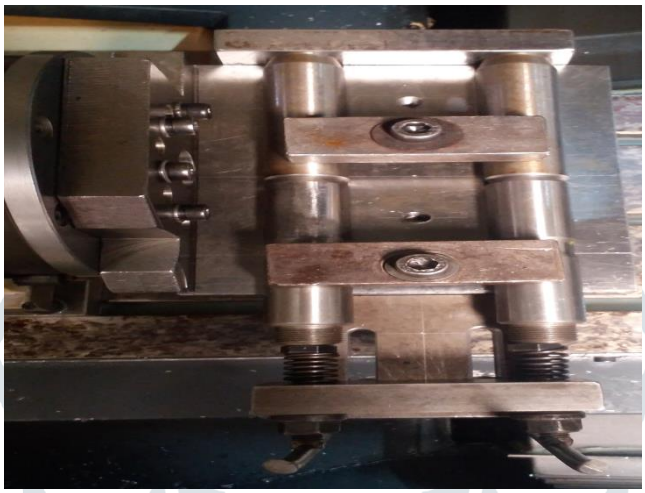

Figure 2: VMC machine operation

OPN 90:- Now side milling operation will be done on VMC machine with other setup.

OPN 100:- In this operation cross drilling will be done on pin on cross drilling machine .

OPN 110:- This operation is held for maintaining chamfer angle on the Pin by pillar drill machine.

OPN 120 :- Roll threading will be held on part for achieving threading operation on OD.

OPN 130:- Hardening & Quenching done in this operation for maintain the hardness & Case depth of the Suspension Pin as per the Drawing Specifications.

OPN 140:- Now Tempering will be done on Part for releasing stress generated during Hardening process.

OPN 150:- Induction Hardening process will be completed on part on specific Parameters.

OPN 160:- Now again Tempering will be done on Part for releasing stress generated during Induction Hardening process.

OPN 170:- Grinding operation done on Suspension Pin for maintaining outer Diameter of the Suspension Pin. OPN 180:- MPI Checking also did during the operation for detecting cracks in the parts.

OPN 190:- Zinc yellow plating will be held on machine by vendor support .

200:- After completing all the operations part moved to Final Inspection area for 100% Checking of the Parts as per the inspection plan, For Knowing Dimension Results on the part. If parts found not Ok, the parts get Rejected & putted in NCP area.100% parts checked for MPI for Crack Detection.

OPN 210 : In this operation Pre Dispatch Inspection process held for Inspecting parts Visually.

OPN 220: Storage will done of OK parts as per the standard procedure after packing of the material. Anti-rust oiling should be done on parts before packing in poly bag for eliminating rusting issue in parts as per customer specific requirement.

Process Manual	Ramakant Engineering Pvt. Ltd.				Section :- 15	
Proces Code : NPD	List Of Checking Aids				Revision No. / Date :-00	
Part Name : Suspension Pin			Doc. No. : LOCA/9947/01			
Part No. : 9947						
Sr. No.	Name Of Instrument / Gauge / Checking Fixture	Idendification No.	L.C. (in "mm")	Range (in "mm")	Calibration Date	Due Date	Remarks
1	Height Guage	REPL/HG/02	0.01	0~600	06-Dec-19	05-Dec-20	Calibrated
2	Vernier Caliper	REPL/VC/02	0.02	0~150	06-Dec-19	05-Dec-20	Calibrated
3	Trimos	REPL/EHG/01	0.0005	0~600	06-Dec-19	05-Dec-20	Calibrated
4	Hardness tester	REPL/RHT/01	1 HRC	-	06-Dec-19	05-Dec-20	Calibrated
5	Micro Vicker hardness teste	REPL/MVHT/01	1 Hv	1kg-1000kg	06-Dec-19	05-Dec-20	Calibrated
6	Microscope	REPL/MS/01	-	1000x	06-Dec-19	05-Dec-20	Calibrated
7	TPG	REPL/TRG/1/8/02	-	BSP 1/8	06-Dec-19	05-Dec-20	Calibrated
8	Ring Gauge	REPL/SRG/27.947/01	-	27.947	06-Dec-19	05-Dec-20	Calibrated
9	Ring Gauge	REPL/SRG/27.98/02	-	27.98	06-Dec-19	05-Dec-20	Calibrated
10	Setting Piece	REPL/28.03/01	-	28.030±0.050	06-Dec-19	05-Dec-20	Calibrated
11	Setting Piece	REPL/130.00/01	-	130.00±0.050	06-Dec-19	05-Dec-20	Calibrated
12	Micrometer	REPL/MM/02	0.001	25~50	06-Dec-19	05-Dec-20	Calibrated
Prepared By- Vikas Das			Approved By - Anand Rathor				

Figure 3: List of checking aids

Magnetic particle inspection is nondestructive type of testing for detecting cracks on part by use of circular coil 1250 on 1400 ampere under 3.15kat and oil concentration of 0.3ml . Checking cracks by generating magnetic field on Pin, applying oil flow and then visually detecting it in presence of uv rays.

m	M.P.I.Check Sheet	Format No.:-REPL/F/QC/110 Rev No. 00 Issue Date:- 10.03.17

Process Parameter details:-	1..Machine No. 01	3. Demagnetize :- Working	4. Defective Sample:-Checked	7. Circular coil:-Working
	2. Oil flow:- Yes	4. Bulb Intensitiy:- ok	2. Pie Testing:-Checked	8. L Coil :- Working
	9.Oil level:-Yes	10.Calibration Status:- Yes	11.No. of Strokes :- 1	12.Type of Magnatized:- Combined
	13. Coil knob setting:- 2+2High	14. L. Knob Setting:- 3	15.Copper bush avability:- N.A	OK

Part details	Part No. : 9947		Operator Name:
	Part Name :- Suspension Pin	Part Grade :- 45 C8	sawan
		Part Condition:-	Date:- 20.02.20
	Induction Batch No.-		Lot Qty.- 60 NOS

Required Current:-	Circular Coil:- 1250 ± 100	L. Coil :- 3.00 Kat Min.	Oil Concentrate :- 0.2~0.4 ml/ltr
Actual :-	1400 AMP	3.15 KAT	0.3 ml

Setup

Sl No.	Time	Quantity			Demagnetize
		Checked	OK	NOT OK	
1	8:00 PM	30	30	0	Yes
2	9:00 PM	30	30	0	Yes
Total		60	60	0	

Remarks:-

Checked By:-Mr. Radheshayam Approved By:-Mr Abhishek Sharma

Figure 4: MPI testing report of Suspension Pin

Process Manual	RAMAKANT ENGINEERING PVT.LTD.	Section: 03
Process Code: PMM	DIMENSION REPORT	Revision: 00

Machi 9947 Date: 18.02.20

Part Name: PIN SUSPENTION Shift: A

Operation: Facing,Drilling,Turning,Chamfering, Sloting,Threading,Grinding Part No.: 9947

S. No.	Parameteras	Specification	Measuring Equipement	Opertion No.	1	2	3	Remark
1	Length	130 ±0.3	Trimos/DHG/LHG	1st	130.24	130.12	130.1	OK
2	Drill Dia	8.8 ±0.2	VC	2nd	8.87	8.91	8.8	OK
3	Depth	14 ±0.5	VC		14.28	14.32	14.15	OK
4	Drill Dia	7 ±0.2	PPG		OK	OK	OK	OK
5	Depth	55 .+0.5	VC		55.02	55.21	55.18	OK
6	OD	28.25 ±0.05	Micrometer/DVC	3rd	28.26	28.22	28.24	OK
7	Chamfer	2X45°	Bevel Protector	4th	45°	45°	45°	OK
8	Angle	15° ±0.5°	Bevel Protector		15°	15°	15°	OK
9	Angle length	10 ±0.2	DHG/VC		10.15	10.08	10.12	OK
10	Side Cut Width	22 ±0.2	Trimos/VC/LHG	5th	22.08	22.05	22	OK
11	Ø28 to Dim.22 Center	0.2	Trimos/DHG/LHG		0.2	0.2	0.2	OK
12	C.D.Dim.	16 ±0.2	Trimos/DHG/LHG		16.15	16.18	16.12	OK
13	Depth	0.5 Typ	Trimos/DHG/LHG	7th	0.4	0.5	0.4	OK
14	Length	50 ±0.3	DHG/VC		50.15	50.18	50.12	OK
15	Dim.	40 ±0.3	DHG/VC		40.15	40.12	40.18	OK
16	Drill Dia	4 ±0.1	VC	8th	4.08	4.05	4.02	OK
17	Cross Hole Distance	50 ±0.3	Trimos/DHG/LHG		5.02	50.18	50.14	OK
18	Chamfer Ø8.8	1x45°	Visual	9th	45°	45°	45°	OK
19	Chamfer Ø4	1x45°	Visual		45°	45°	45°	OK
20	Threading	PS/ 1/8	TRG	10th	ok	ok	ok	OK
21	Heat Treatment In Core	250~ 300		11th	ok	ok	ok	OK
22	Induction Hardning	600~660 HV		12th	ok	ok	ok	OK
23	Induction Length	80 MM			ok	ok	ok	OK
24	Radius to Induction Distence	5~10			ok	ok	ok	OK
25	Tempring			13th	ok	ok	ok	OK
26	Dia	28 -0.02/-0.053	Micrometer	14th	27.968	27.951	27.982	OK
27	MPI			15th	ok	ok	ok	OK

Visually	Burr,Dent,Rust,Finish,Operation Missing	100% Checked - TRG
As per Sampling plan		
OK Qty :- 60	Rework Qty:- 0	Reject Qty:- 0
Remarks (if any) : 100% checked by vaibhav		
Checked By- Pawan Gupta		Approved By- Abhishek Sharma

Figure 5: Inspection report of Suspension Pin

Measurement System Analysis is for knowing & the measurement variations of the system. It gives us range of measurement variations between Appraisers to Appraiser. Bellow given is the report for 9947 MSA.

Process Manual	Ramakant Engineering Pvt. Ltd.	Section	: 07
		Origion	: 01.01.14
Process Code : IMTE	Gauge Repeatability and Reproducibility Data Collection Sheet	Revision No.	: 00

Job Details		Characteristic Details			GRR No.	6
					Date	
Model No.	Pin	Characteristic	ID	Unit	GRR Leader	
		Spec.Nominal Value	16.000		Appraiser 1	Vijay
Part No..	9947	Spec. Upper Limit	16.200	mm	Appraiser 2	Radheshyam
Part Name	Suspension Pin	Spec. Lower Limit	15.800		Appraiser 3	Gurudev

Instrument Details							
Gauge Name	Bore Dial Gauge	Gauge No.	BDG/02	least Coun	0.001	Gauge Type	Digital, Variable

Appraiser 1	Trial	Sl. No. of Part										Average
		1	2	3	4	5	6	7	8	9	10	
Vijay	1	16.150	16.000	15.950	15.920	15.980	16.120	16.180	16.140	16.120	16.000	16.056
	2	16.000	15.950	15.980	15.920	16.150	15.980	16.150	16.000	15.950	15.920	16
	3	16.180	16.140	16.120	16.000	16.000	16.150	15.980	15.920	16.150	16.150	16.079
Average	X bar	16.110	16.030	16.017	15.947	16.043	16.083	16.103	16.020	16.073	16.023	16.0450
Range	R	0.18	0.19	0.17	0.08	0.17	0.17	0.20	0.22	0.20	0.23	0.181

Appraiser 2	Trial	Sl. No. of Part										Average
		1	2	3	4	5	6	7	8	9	10	
Radheshyam	1	16.180	16.140	16.120	16.000	16.000	16.150	15.980	15.920	16.150	16.150	16.079
	2	16.180	16.140	16.120	16.000	16.000	16.150	15.980	15.920	16.150	16.150	16.079
	3	16.150	16.000	15.950	15.920	15.980	16.120	16.180	16.140	16.120	16.000	16.056
Average	X bar	16.170	16.093	16.063	15.973	15.993	16.140	16.047	15.993	16.140	16.100	16.0713
Range	R	0.03	0.14	0.17	0.08	0.02	0.03	0.2	0.22	0.03	0.15	0.107

Appraiser 3	Trial	Sl. No. of Part										Average
		1	2	3	4	5	6	7	8	9	10	
Gurudev	1	16.140	16.000	16.150	15.920	16.150	16.180	15.980	16.180	16.140	16.120	16.096
	2	16.140	16.000	16.150	15.920	16.150	16.180	15.980	16.140	16.120	16.000	16.078
	3	16.000	15.920	16.120	16.140	16.120	16.150	16.180	16.120	16.180	16.140	16.107
Average	X bar	16.0933	15.9733	16.1400	15.9933	16.1400	16.1700	16.0467	16.1467	16.1467	16.0867	16.0937
Range	R	0.14	0.08	0.03	0.22	0.03	0.03	0.2	0.06	0.06	0.14	0.099
Part Average	X Db	16.124	16.032	16.073	15.971	16.059	16.131	16.066	16.053	16.120	16.070	16.0700
Range of	X Db											0.160
Part Range	R Db	=(R b1 + R b 2+ R b 3)/3										0.1290
Average Variance	X Db Diff	=MAX(X b1,X b2,X b3)-MINX b1,X b2,X b3)										0.0487
	UCL R	= R Db * D4 [D4 = 2.58]										0.3328

Process Manual	Ramakant Engineering Pvt. Ltd.	Section	: 07
Process Code : IMTE	Gauge Repeatability and Reproducibility Data Collection Sheet	Revision No. / Date	: 00

Job Details		Characteristic Details			GRR	6
Model No.	Pin	Characteristic	ID	Unit		
		Spec.Nominal Value	16		Appraiser 1	Vijay
Part No.	9947	Tol. Upper Limit	16.2	mm	Appraiser 2	Radheshyam
Part Name	Suspenion Pn	Tol. Lower Limit	15.8		Appraiser 3	Gurudev

Instrument Details							
Gauge Name	Bore Dial Gauge	Gauge No.	BDG/02	Least Coun	0.001	Gauge Type	Digital, Variable

From Data Sheet: R Db = 0.129, n = 10, X b Diff = 0.049, r = 3, Rp = 0.160

Measurement Unit Analysis

Repeatability - Equipment Variation (EV)

No of Trials	K1
2	0.8862
3	0.5908

EV = R Db X K1
= 0.129 X 0.5908
= 0.07621

Reproducibility - Appraiser Variation (AV)

Appraiser	K2
2	0.7071
3	0.5231

AV = $=SQRT((X\ b\ Diff\ xK2)^2-(EV^2/(nr)))$
= 0.021318

Repeatability & Reproducibility (GRR)

GRR = $=SQRT(AV^2+EV^2)$
= 0.079139

Part Variation (PV)

Part	K3
5	0.403
10	0.3146

PV = Rp X K3
= 0.160 X 0.3146
= 0.050336

Table Variation (Tol / 6)

Tol / 6 = pec. Upper Limit- Spec. Lower Limit = 0.32

%Total Variation

% EV = 100 (EV / TV)
= 100 (0.0762 / 0.32)
= **23.82**

% AV = 100 (AV / TV)
= 100 (0.02 / 0.32)
= **6.66**

% GRR = 100 (GRR / TV)
= 100 (0.08 / 0.32)
= **24.73**

% PV = 100 (PV / TV)
= 100 (0.05 / 0.32)
= **15.73**

ndc= 1.41 (PV / GRR)
= 1.41 (0.05 / 0.08)
= **0.8968** **1**

Remarks : -

1 *As % GRR > 10 % but < 30 % System may be acceptable based on application*

Figure 6: Measurement system analysis

On road Testing also had done for Suspension Pin, By Arranging four Suspension Pin 4 commercial vehicles Chassis assembly System. These Commercial Vehicles Runs 8000 Kilometres for Testing the Failure Mode & Knowing the Deformation in Suspension Pin. After completing 80000 Kilometres run. Again the Suspension Pin is disassembled from the Chassis Shock-up systems. These Suspension Pin then Sent To lab. Dimensional Analysis Conducted on Suspension Pin for knowing the deformation occurs in Suspension Pin.

V. CONCLUSION

After conducting dimensional Inspection for both Suspension Pin Manufactured Parts i.e. Old Part & New Fixture developed part we have obtained that to maintain the given specifications by New Fixture Manufactured Part can be achieved in Chassis assembly. Below is the comparison of customer complaint report found in the rejected Suspension Pin.

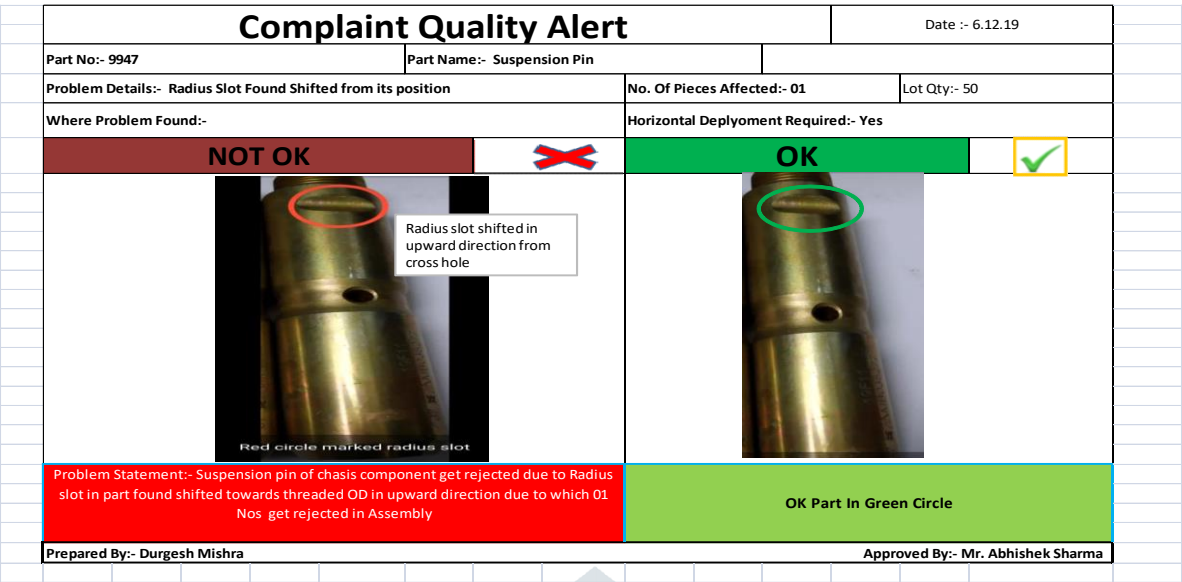

Figure 7: Complaint quality chart after new fixture development

During Inspection of Part all Specifications of part found ok as per given tolerance in drawing i.e CD from radius slot which found not Ok in customer complaint is also found Ok.

Table 6.1: Dimensional inspection report

C.D.Dim.	16 ±0.2	Trimos/DHG/LHG	16.15	16.18	16.12	OK
Length	50 ±0.3	DHG/VC	50.15	50.18	50.12	OK
Dim.	40 ±0.3	DHG/VC	40.15	40.12	40.18	ok
Depth	0.5 Typ	Trimos/DHG/LHG	0.4	0.5	0.4	OK

The Dimensional analysis is conducted on Suspension Pin by using Instrumental testing and results obtained shows that Pin manufactured by New Fixture Method performs better as compared with old method of manufactured Suspension Pin. Along with that the rejection rates which were higher in old method pin which is drastically reduced. Thus, high compactness is achieved which lead to better interference fit in assembly line and lower rejection rates during manufacturing. The experimental analysis is also conducted using on Road testing results obtained are in close agreement with dimensional results.

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