Modification of Manufacturing Process of Kingpin for Steering Assembly of Heavy Motor Vehicles and its Analysis

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Abstract: Conventional design of kingpin comes with a cross hole in the center of pin. But when the vehicle got loaded and travelled across hilly areas it was found that vehicle developed field failure from the center of kingpin. This was due to low core hardness required in the cross-hole area. In the proposed design this cross hole is eliminated which was used only for greasing. By eliminating this cross-hole manufacturing cost also got reduced and improved lead of manufacturing also. New kingpin without cross-hole is manufactured using standard manufacturing techniques which includes process flow diagrams and PFMEA. Nondestructive testing of new design of kingpin is also conducted using MPI testing

Keywords: Kingpin, MPI testing, PFD, PFMEA.

I. INTRODUCTION

The kingpin, is the main pivot in the steering mechanism of a *car* or other *vehicle*. The suspension design is crucial in the development of vehicle behaviour to optimize vehicle performance, handling and comfort. There are a multitude of possible adjustments depending on the vehicle . These settings play a important role in passengers safety in all phases of driving. The design of the steering system plays a vital role in stability and control of an automobile.

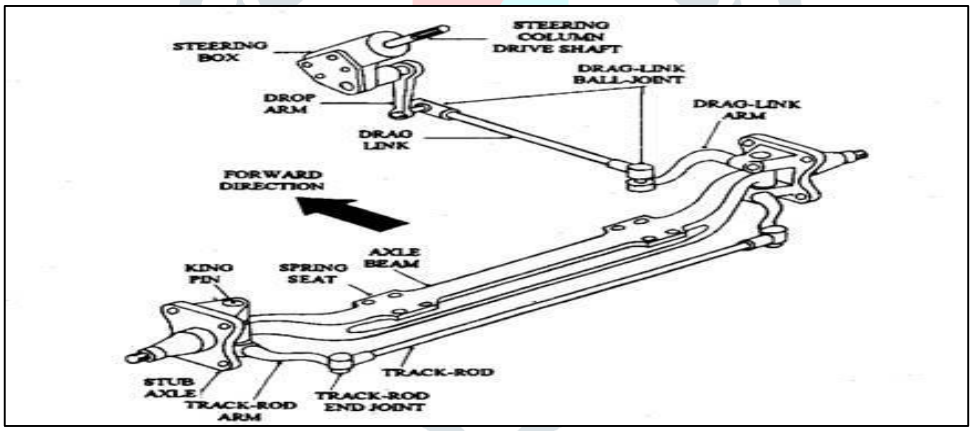

Figure 1: Kingpin location on front axle

II. LITERATURE REVIEW

Min Jhang, Lijun Li (2015) [1] analyzed stress and fatigue life of front axle beam by finite element analysis and experimental method. Also, investigate the effect of crack parameters like length and depth on fatigue life.

Topac (2008) [2] evaluated the fatigue failure prediction and fatigue life of a rear axle housing prototype by using Finite element analysis of heavy-duty truck. The expected load cycles required to fail during the vertical fatigue tests of a rear axle housing prototype is studied and mechanical properties were determined of housing material

A.K. Acharya et al. [3] described the failure analysis of the rear axle at the root of the spline of a tractor with a loaded trolley used for haulage. The front wheel lifting and the failure of the rear axle at the root of the spline though mainly due to the transfer of weight, not sufficient attention. By reducing the hitching height and it was observed that by reducing the hitching height to 16.00 inches (which is normally taken as 19 to 20 inches) with reduction in the weight transfer factor by nearly 20%.

Sanjay Aloni et al. [4] Studied on Evaluation of Tractor Trolley Axle by Using Finite Element Analysis to modify existing rear axle of 6.0-ton tractor trolley. Fatigue failure of the rear axle finite element model was predicted after the dynamic load was imposed on it. Spectrum analysis revealed that the failed axle shaft material is SAE 1020 steel. Fractographic features indicated that fatigue

was the main cause of failure of the axle shaft. It was observed that the fatigue cracks originated from transition areas due to sharp corners.

Osman Asi et al.[5] described the failure analysis of a rear axle shaft used in an automobile which had been involved in an accident. The failure zones were examined with the help of a scanning electron microscope equipped with EDX facility. Spectrum analysis and micro-hardness measurement show that the failed axle shaft material was AISI 4140 steel as hardened and tempered condition. Fractographic features indicated that fatigue was the main cause of failure of the axle shaft. It was observed that the fatigue cracks originated from welded areas. Due to the improper welding. So improper welding of hardened materials involves low ductility in the HAZ, stress concentration points, and inclusions in the structure that served as responsible for the fatigue cracks.

III. PROPOSED WORK

Manufacturing & Machining of kingpin using process plan as described in next following steps

1. VMC operation on fixture
2. MPI Testing
3. Induction Hardening testing (Pattern Testing)
4. Material Testing
5. Hardness Testing
6. PFD
7. PFMEA
8. Control Plan

IV. MATERIALS AND METHODS

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. Below is the table for defining Process parameters & checking Method for reducing rejection & method for cutting the part on bandsaw.

OPN 30: In this operation length of the pin maintained for removing tapper from the face, So this operation is said as facing operation. Bellow are the process specifications for maintaining the dimension in part.

Table 1: Operation no. 30 details

OPN No.-30	TOOL	SPEED (rpm)	FEED (mm/min)	CHECK & CHANGE QTY..	NECESSARY ACTION	**PART ID**	**DIMENSION**	**GAUGE NAME AND NO.**	**CHECK FREQUENCY**	**NECESSARY ACTION**
951 KP	TNMG16	930~980	165~175	500	ACTION SHOULD BE A PART COUNT& TOOL WEAR	951 KP	138.5±0.5	**DIAL TYPE HIGHT GAUGE**	1in 10 check by op. in self inspection report	**RESET/KEEP IN NCP AREA**

OPN 40: In operation 40 drilling done on RDM machine for maintaining below specifications.

Table 2: Operation no. 40 details

OPN No.-40	TOOL	SPEED (rpm)	FEED (mm/min)	CHECK & CHANGE QTY..	NECESSARY ACTION	PART ID	DIMENSION	GAUGE NAME AND NO.	CHECK FREQUENCY	NECESSARY ACTION
951 KP	8 MM CHF TOOL	150	MANUALY	1200	Action should be a part count &tool wear	951 KP	Ø 8.0 ±0.2	Vernier	1in 10 check by op. in self inspection report	RESET/KEEP IN NCP AREA
951 KP	8 MM CHF TOOL	150	MANUALY	1200	Action should be a part count &tool wear	951 KP	20+2	Vernier	1in 10 check by op. in self inspection report	RESET/KEEP IN NCP AREA

OPPN 50: proceed on lathe machine for turning the diameter of king pin. Below are the specifications for maintaining the process parameters on machine.

Table 2: Operation no. 50 details

OPN No.-50	TOOL	SPEED (rpm)	FEED (mm/min)	CHECK & CHANGE QTY..	NECESSARY ACTION	PART ID	DIMENSION	GAUGE NAME AND NO.	CHECK FREQUENCY	NECESSARY ACTION
951 KP	TNMG16	930~980	165~175	500	ACTION SHOULD BE A PART COUNT& TOOL WEAR	951 KP	28.25 ± 0.05	Micrometer	1in 10 check by op. in self inspection report	RESET/KEEP IN NCP AREA

OPPN 60: This operation held on Lathe machine for maintaining chamfer of the pin. Below are the process parameter specifications for manufacturing the part.

Table 2: Operation no. 60 details

OPN No.-60	TOOL	SPEED (rpm)	FEED (mm/min)	CHECK & CHANGE QTY..	NECESSARY ACTION	PART ID	DIMENSION	GAUGE NAME AND NO.	CHECK FREQUENCY	NECESSARY ACTION
951 KP	TNMG16	930~980	165~175	600	ACTION SHOULD BE A PART COUNT& TOOL WEAR	951 KP	2 ± 0.1	Part to be confirm with QC Inspection and check for Operation complete.	non recorded 100% Visual Inspection (Comparison with master)	RESET/KEEP IN NCP AREA

OPPN 70: In this operation slotting operation have been done on slotting machine. Below are the process parameters maintain for this operation

Table 3: Operation no. 70 details

OPN No.-70	**TOOL**	**SPEED (rpm)**	**FEED (mm/min)**	**CHECK & CHANGE QTY..**	**NECESSARY ACTION**	**PART ID**	**DIMENSION**	**GAUGE NAME AND NO.**	**CHECK FREQUENCY**	**NECESSARY ACTION**
951 KP	**SPMG 11**	**190`~210**	**145~155**	**600**	**Action should be a part count &tool wear**	**951 KP**	**DIM. 25 ± 0.5**	**Dial type variable Slot Depth Gauge /Radius gauge/vernier**	**1in 10 check by op. in self inspection report**	**RESET/KEEP IN NCP AREA**

OPPN 80: This Operation done on RDM Machine for maintaining drill depth & diameter. Bellow are the process Parameter Specifications.

Table 4: Operation no. 80 details

OPN No.-80	TOOL	SPEED (rpm)	FEED (mm/min)	CHECK & CHANGE QTY..	NECESSARY ACTION	**PART ID**	**DIMENSION**	**GAUGE NAME AND NO.**	**CHECK FREQUENCY**	**NECESSARY ACTION**
951 KP	11 MM CHF TOOL	150	MANUALY	1200	Action should be a part count &tool wear	951 KP	Counter Drill 11 ±0.2	**VISUALY**	1in 10 check by op. in self inspection report	**RESET/KEEP IN NCP AREA**
951 KP	11 MM CHF TOOL	150	MANUALY	1200	Action should be a part count &tool wear	951 KP	6 ±0.2	**VISUALY**	1in 10 check by op. in self inspection report	**RESET/KEEP IN NCP AREA**

OPPN 90: This operation is held for maintaining chamfer angle on the Pin. Bellow are the process parameters for maintaining the specifications.

Table 5: Operation no. 90 details

OPN No.:- 90	TOOL	SPEED (rpm)	FEED (mm/min)	CHECK & CHANGE QTY..	NECESSARY ACTION	PART ID	DIMENSION	GAUGE NAME AND NO.	CHECK FREQUENCY	NECESSARY ACTION
951 KP	11 MM CHF TOOL	150	MANUALY	1200	Action should be a part count &tool wear	951 KP	60 ®±0.5®	VISUALY	1in 10 check by op. in self inspection report	RESET/KEEP IN NCP AREA
951 KP	11 MM CHF TOOL	150	MANUALY	1200	Action should be a part count &tool wear	951 KP	Dim. 2 ±0.5	VISUALY	1in 10 check by op. in self inspection report	RESET/KEEP IN NCP AREA

OPPN 100: In this Operation drilling & Tapping done on parts on RDM Machine for maintaining the dimensions as per the drawing, for achieving the dim. Below are the specifications of the process parameters

Table 6: Operation no. 100 details

OPN No.- 100	TOOL	SPEED (rpm)	FEED (mm/min)	CHECK & CHANGE QTY..	NECESSARY ACTION	PART ID	DIMENSION	GAUGE NAME AND NO.	CHECK FREQUENCY	NECESSARY ACTION
951 KP	6 mm Drill	150	MANUALY	1200	Action should be a part count &tool wear	951 KP	6 ± 0.2	VISUALY	1in 10 check by op. in self inspection report	RESET/KEEP IN NCP AREA
951 KP	6 mm Drill	150	MANUALY	1200	Action should be a part count &tool wear	951 KP	65 + 2	VISUALY	1in 10 check by op. in self inspection report	RESET/KEEP IN NCP AREA
951 KP	M10 X 1.25 TAP	150	MANUALY	1200	Action should be a part count &tool wear	951 KP	M10 X 1.25 mm	TPG	1in 10 check by op. in self inspection report	RESET/KEEP IN NCP AREA
951 KP	M10 X 1.25 TAP	150	MANUALY	1200	Action should be a part count &tool wear	951 KP	Depth 15 +2	VISUALY	1in 10 check by op. in self inspection report	RESET/KEEP IN NCP AREA

OPPN 110: Hardening & Quenching done in this operation for maintain the hardness & Case depth of the King Pin as per the Drawing Specifications. Below are the Process Parameters for maintaining the hardness. MPI Checking Also done during the operation for detecting cracks in the parts.

Table 7: Operation no. 110 details

PART NO.	CURRENT AMP.	FEED MM/MIN.	QRS PROCESS (IN Psi)	FLOW (ltr/min.)	% of VOLTAGE	% of Frequency	% of POWER	% of Current	REMARKS
951 KP	78 ± 3	225 ± 25	8+2	35 ±5	55-65	55-65	85-95	70-80	Polymer (AQUEAQUENCH-365) % SPECIFICATION :- 2-3%,MAKE-HOUGTOUN,PH VALUE 7-10,QUENCH TEMP. 25-40 ®c, TRANS NO. 15,CAPACITOR

OPPN 120: Grinding operation done on King pin for maintaining outer Diameter of the King Pin. Below are the specifications for King Pin for maintaining the process parameters.

Table 8: Operation no. 120 details

OPN No.-120	TOOL	SPEED (rpm)	FEED (mm/min)	CHECK & DRESSING QTY	NECESSARY ACTION	PART ID	DIMENSION	GAUGE NAME AND NO.	CHECK FREQUENCY	NECESSARY ACTION
951 KP	GRINDING WHEEL	250	MANUALY	100	ACTION SHOULD BE A PART COUNT& TOOL WEAR	951 KP	Ø 28-0.025/-0.064	Micrometer	1in 10 check by op. in self inspection report	RESET/KEEP IN NCP AREA
951 KP	GRINDING WHEEL	250	MANUALY	100	ACTION SHOULD BE A PART COUNT& TOOL WEAR	951 KP	Perpendicularity 0.015	VARIABLE DIAL HIGHT GAUGE	1in 10 check by op. in self inspection report	RESET/KEEP IN NCP AREA

OPPN 130: 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 the parts get Rejected & putted in NCP area.100% parts checked for MPI for Crack Detection.

OPPN 140: In this operation Pre Dispatch Inspection process held for Inspecting parts Visually.

OPPN 150: 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.

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 fork , applying oil flow and then visually detecting it in presence of uv rays.

METALMAN

M.P.I.Check Sheet

Format No.:- MAPL/F/QC/110
Rev No. 00
Issue Date:- 10.03.2017

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 Length:- 180.5 mm		Operator Name:
	Part Name: King Pin	Part Grade :- CK45		sawan
	Part Max. Dia :- 27.98mm	Part Condition:- Forged, Bright bar:- Forged		Date:- 18.12.18
	Induction Batch No.- 180301	Heat No.- THE FORGING		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

	Sl No.	Time	Quantity			Demagnetize	Loading pattern
			Checked	OK	NOT OK		
Setup	1	8:00 PM	30	30	0	Yes	Straight Fit to Coil
	2	9:00 PM	30	30	0	Yes	
							Location of Crack Pattern
	Total		60	60	0		

Remarks:-

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

Figure 2: MPI testing report of Kingpin

METALMAN AUTO PVT. LTD.										Form No:	MAPL/F/PROD/13
INSPECTION REPORT										Date:	16.12.18
										Lot Qty:	60
										Heat Code/Lot	S
Part No:	951KP										
Part Name:	King Pin									Θ Critical	• Major
Visual & Dim Inspection											
Sl.No.	Parameter	Spc	Tol.	Checking Aids	Observations 1	2	3	4	5	Result / Remarks	
1	Length	180	±0.5	Vernier	180.2	180.1	180.2	180.2	180.1	ok	
2	O.D. Θ	28	-0.020 -0.053	Micrometer	27.954	27.967	27.955	27.972	27.958	ok	
3	Chamfer	2X20°		Visual	ok	ok	ok	ok	ok	ok	
4	Roughness	0.8		Surface Tester	0.7	0.6	0.8	0.7	0.8	ok	
5	Straightness Θ	0.015		Ht. Gauge	0.010	0.012	0.014	0.011	0.015	ok	
6	Drill Depth	20	+2.0	Vernier	20.1	20.5	20.9	21	20.5	ok	
7	Thread Size	M10X1.25		T.P.G.	ok	ok	ok	ok	ok	ok	
8	Slot-1 Width	12	-0.5	Vernier	11.9	11.87	11.95	11.82	11.85	ok	
9	Slot-1 O.D. Θ	25	±0.1	Micrometer	25.05	25.03	25.02	25.06	25.02	ok	
10	Slot Distance •	112.5	±0.3	Trimos	112.7	112.5	112.2	112.4	112.5	ok	
11	Thread Size	M6X1.0		T.P.G.	ok	ok	ok	ok	ok	ok	
12	Visually	Burr,Dent,Rust,Finish,Operation Missing			100% Checked - TPG/Ring Gauge/Templet						
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 3: Inspection report of Kingpin

METALMAN	METALMAN AUTO PVT. LTD. Material Test Report	Form No.	MAPL/F/PROD/51
		Issue:	01
		Sheet No.	1/1

Report No.	180301	Date	15/04/2018
Part Name.	King Pin	Raw Material	
Part No./ Rev. No.	951KP	Raw Material Used	CK45
Material TC	Received Ok	Heat No.	08
Heat Treatment Process	Induction Hard. & Temp. (HT30T)	Quantity	60 Nos.
Induction Hardening Batch, done & date	MAPL180301 20.12.18	Chemical Composition Report No. & Date	

Induction Heat Treatment Process Parameters (as per Std.)

Machine no.	2	KW	100 KW	
Location	X	Location	X	OK
Power (kW)%	18 %	Rotation	no	
Start Heating Time	After2 secs	Frequency KHZ	30 khz	
Heat Dwell Time	1.65 Sec	Polymer% (Without factor)	2%	
Scan Speed (Feed)	150 mm/min	Total Cycle Time	14 Sec	
Total Heating Time	2 sec	Quenching Bath Temp.	27 °C	
Total Quenching Time	8 secs	Tempering Temp.	160°C @ 90 min.	

Quality requirements for induction hardening for 'X' (as per std.)

Test	Specification	Observation		Remark
Hardness	19 – 36 HRC	31 - 35 HRC		OK
Case Depth @ X Loc.	1± 0.2 @ 550HV	Sec.1	A = 1.1 mm	OK
			B = 1.08 mm	
		Sec.2	A = 1.01 mm	
			B = 1.05 mm	
MPI	No Crack	No Crack Found		OK

Metallographic Observation:

PARAMETERS	SPECIFICATIONS	OBSERVATIONS	REMARKS
Case Microstructure	Fine tempered martensite (RA < 5%, no Carbides)	Tempered martensite with RA ~5% , no Carbides	OK
Core Microstructure	Low carbon marten site / Bainite	Low carbon marten site no ferrite	OK
Inclusion Rating	≤ 2 ABCD	1.5A, 1.0 B, 1.0D	OK
Magnafluxing / acid etching /Visual	Shall be free from cracks, under cut, sharp edges etc	No Such defects observed	OK

Remark: No Crack Observed during inspection & As per Specifications Part Sample found Ok.

Checked By: Ashish **Approved By: Abhishek Sharma**

Figure 4: Material Testing report of Kingpin

Developing and verifying hybrid drives a new level of technology from driveline test rigs. The Driveline can test hybrid systems for the task using Secondary Control Technology. Secondary Control allows hydraulic systems to quickly switch from absorption to driving thus the rig can replicate realistic drive cycles in order to optimize hybrid drives. Manufacturers of hybrid drive systems will be able to work on their regenerative control strategies by using driveline rig in drive cycle replication mode. To allow energy management controller development, the drive cycle can be created manually or by using data previously recorded on an instrumented Commercial Vehicle. Thus, the efficiency of the hybrid drive system through the complete cycle is measured. This allows our customers to try different energy management strategies in the controllers to fully optimize their performance

V. CONCLUSION

The Induction hardening analysis is conducted on kingpin by using material destructive testing and results obtained shows that King Pin without cross Hole performs better as compared with King Pin with cross hole. Removal of Cross Hole has also helped in manufacturing process reduction. Along with that the rejection rates which were higher in Cross Hole which is drastically reduced. Thus, the removal of slots has aided in reducing manufacturing process and rejection and 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 driveline rig and results obtained are in close agreement with simulation results.

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