Modification of Manufacturing Process for Companion Flange used in Commercial Vehicles and its Analysis

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Abstract: Companion flange is used as assembly part with universal drive shafts in vehicle transmission system. It allows connection of a flange yoke to another type of connection, for proper torque transfer. The existing design of companion flange incurred wobbling problem during transmission testing. After dimensional checking of part found spline or broaching shifted from its centre position as shown in report picture. Now we have to propose a full proof manufacturing process of companion flange by which part will not get rejected**.** The manufacturing process encompassed sequence of manufacturing process which includes CMM testing, 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: Flange, Manufacturing, Material testing.

INTRODUCTION

An automotive drive shaft transmits power from the engine to the differential gear of a rear wheel drive vehicle. The drive shaft is usually manufactured in two pieces to increase the fundamental bending natural frequency because the bending natural frequency of a shaft is inversely proportional to the square of beam length and proportional to the square root of specific modulus which increases the total weight of an automotive vehicle and decreases fuel efficiency. So, a single piece drive shaft is preferred here and the material considered is to be stainless steel because of its high strength. Drive shafts are carriers of torque and are subject to torsion and shear stress, equivalent to the difference between the input torque and the load. They must therefore be strong enough to bear the stress. Companion flanges can be supplied as individual components or as assemblies with universal drive shafts. It allows connection of a flange yoke to another type of connection, for proper torque transfer.

Figure 1: Companion Flange

LITERATURE REVIEW

Tan Dan Do et al. [1] proposed an analytical approach to determine the effect of bolt spacing and its impact on flange design based on the theory of circular beam. The model was tested for different bolted joints by varying number of bolts, flange and gasket stiffness. The analytical results were compared with FEA and suggested that the thickness of the flange and the stiffness of the gasket have a great effect on stress distribution. In this paper, a parametric study of the behavior of flanges and stresses in bolts are analysed and results were discussed.

Alkelani [2] proposed an elastic interaction model for clamp load loss of gasket flanged joint. The model can characterize the effects of gasket stiffness, gasket thickness, bolt spacing and tightening pattern on the clamp load loss of gasketed flange joint caused by elastic interaction.

Kumakura [3] studied the effect of tightening sequences for bolted joints using multiple bolts. The study showed that multi-pass tightening can make the bolt tension of each bolt more uniform.

P. M. Desai [4] discussed on design, analysis and optimization of body flange & cover flange by using FEM approach and its validation by analytical as per ASME Code. Numerical Simulation techniques are used for analysis of ring type flange. The result of numerical simulation overcomes the limitation of analytical approach which is observed from the results of suggested model. The optimum Value of thickness of Cover Flange and Body Flange are 48 mm and 90 mm respectively.

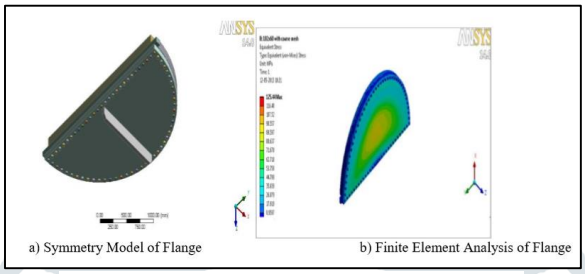

Fig.2 Modelling and Analysis of Flange [4]

D. H. Vardhan et al. [5] performed the java computation for mechanical design on dimensions of the various flange couplings. In the work they considered standard materials for the elements and also gave provision to change the material and stresses in the machine members. With the help of java they computed the couplings in shorter duration with precise values. With this program any one could compute the dimensions of the coupling with in fraction of seconds.

PROPOSED WORK

Bellow given complaint report is for companion flange, a component for transmission assembly of commercial vehicle, in which after assembly of the component found during transmission testing that companion flange is wobbling. After dimensional checking of part found spline or broaching shifted from its centre position as shown in report picture. Now we have to propose a full proof manufacturing process of companion flange by which part will not get rejected.

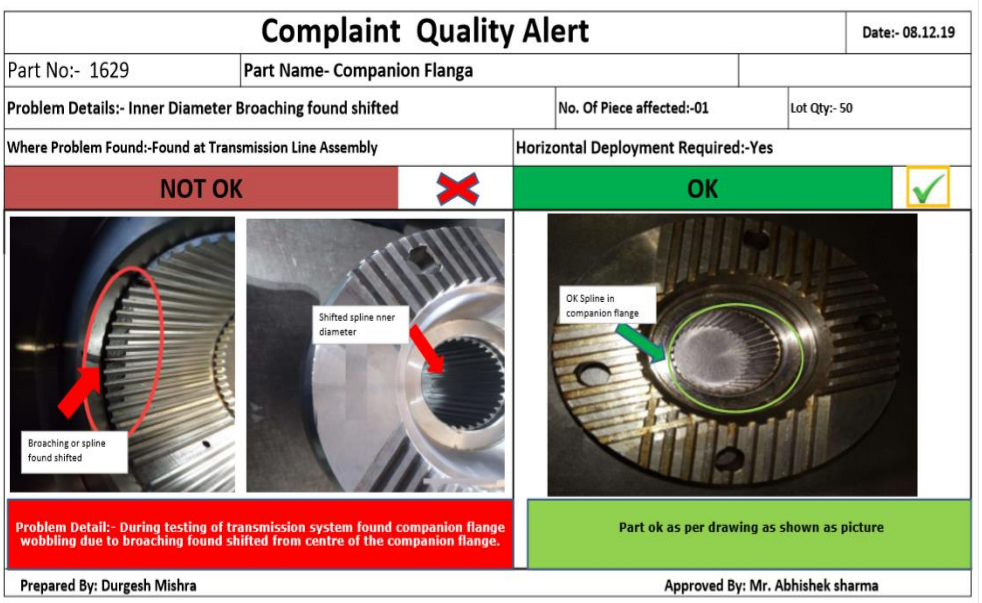

Figure 3: Companion Flange complaint report

This research is intended to rectify problems in existing design of companion flange.

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

VMC operation on fixture

MPI Testing

Induction Hardening testing (Pattern Testing)

Material Testing

Hardness Testing

PFD

PFMEA

Control Plan

SPC & MSA Study

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

OPN 10: In this operation checking of Raw material as per the requirement given in control plan held. Bellow given table is for knowing parameter to be checked in the Inspection.

S.N.	CHARACTERISTIC		SPL CHAR CLASS	PRODUCT/PROCESS SPECIFICATION	EVALUTION/ MEASURMENT TECHNIQUE	SAMPLE	
	PRODUCT	PROCESS				SIZE	FREQ.
1.	Surface			Smooth & Rustless	Visual	5 Per Lot	
2.	All Dimension			As per forging drawing	Respective gage	5 Per Lot	
3.	Material grade			EN8D / BS970	Lab report	1 Per Lot	
4.	Material grade			EN8D / BS970	Supplier report		

Figure 4: Checking of raw material and process parameters

OPN 20: During this Operation Outer Diameter & Face clean cut will be occurred in the companion flange on Lath Machine, Bellow is the process parameter table for this operation.

S.N.	CHARACTERISTIC		SPL CHAR CLASS	PRODUCT/PROCESS SPECIFICATION	EVALUTION/ MEASURMENT TECHNIQUE	SAMPLE	
	PRODUCT	PROCESS				SIZE	FREQ.
1	Outer Diameter			Ø124+0.5	DVC (LC-0.01)	2/Setup, 2/Hr, 2/End	
2	Collar Thickness			17.5 +0.5	DVC(LC-0.01)	2/Setup, 2/Hr, 2/End	
		Rpm		600-900	M/c Setting	1 time	Per Setup
		Feed		Manual	M/c Setting	1 time	Per Setup
		Tool Change/ Re-sharp		Wear Out	Visual	1 time	Per Setup
		Coolant Ph		8-10	Litmas Paper	1 time	Per day
		Coolant Concentration		3-5%	Refractometer	1 time	Per day

Figure 5: Face clean cut operation and process parameters

OPN 30: This Operation is also done on Lathe Machine for maintaining other side face clean cut & Outer Diameter, Bellow are the process Parameters for maintaining this operation.

S.N.	CHARACTERISTIC		SPL CHAR CLASS	PRODUCT/PROCESS SPECIFICATION	EVALUTION/ MEASURMENT TECHNIQUE	SAMPLE	
	PRODUCT	PROCESS				SIZE	FREQ.
1.	Inner Diameter			$Ø30^{\pm0.5}$	DVC(LC-0.01)	2/Setup, 2/Hr, 2/End	
		Rpm		600-900	M/c Setting	1 time	Per Setup
		Feed		Manual	M/c Setting	1 time	Per Setup
		Tool Change/ Re-sharp		Wear Out	Visual	1 time	Per Setup
		Coolant Ph		8-10	Litmas Paper	1 time	Per day
		Coolant Concentration		3-5%	Refractometer	1 time	Per day

Figure 6: Face clean cut operation and process parameters

OPN 40: CNC First setup will be held in this process of manufacturing for maintaining various dimensions .

S.N.	CHARACTERISTIC		SPL CHAR CLASS	PRODUCT/PROCESS SPECIFICATION	EVALUTION/ MEASURMENT TECHNIQUE	SAMPLE	
	PRODUCT	PROCESS				SIZE	FREQ.
1	Diameter			$Ø83^{\pm0.2}$	DVC(LC-0.01)	2 /Setup, 2/Hr, 2/End	
2	Diameter			$Ø72.85^{\pm0.1}$	DVC(LC-0.01)	2 /Setup	
3	Diameter			$Ø58.3^{\pm0.05}$	DVC(LC-0.01)	2 /Setup, 2/Hr, 2/End	
4	Inner Diameter			$Ø41^{\pm0.03}$	DVC(LC-0.01)	2 /Setup, 2/Hr, 2/End	
5	Length			$74.5^{\pm0.5}$	DVC/DHG(LC-0.01)	2 /Setup, 2/Hr, 2/End	
6	Collar Thickness			$15.25^{\pm0.5}$	DVC/DHG(LC-0.01)	2 /Setup, 2/Hr, 2/End	
7	Length			$24^{\pm0.1}$	DHG(LC-0.01)	2 /Setup, 2/Hr, 2/End	
8	Chamfer Length			6	DHG(LC-0.01)/PP	2 /Setup	
9	Counter Angle			$15^{+5'}_{0}$	Bevel Protector	2 /Setup	
10	Counter Diameter			$Ø50.5^{\pm0.3}$	DVC (LC-0.01)	2 /Setup, 2/Hr, 2/End	
11	Radius			R0.5-1.0	Radius Gauge	2 /Setup	
12	Angle			$13.4^{\pm0.5'}$	Not Feasible	-	
13	Length			4±0.1	DHG(LC-0.01)	2 /Setup	
14	Maintain Diameter			$Ø71.459^{\pm0.2}$	DVC(LC-0.01)	2 /Setup, 2/Hr, 2/End	
15	CD			8.4±0.1	H.M.(LC-0.0005)/PP	2 /Setup, 2/Hr, 2/End	
16	Radius			R2±0.2	Radius Gauge	2 /Setup	
17	Dimension			$2.0^{+0.2}$	DHG (LC-0.01)	2 /Setup	
18	Angle			13.40 ±0.5°	Not Feasible	-	
19	Chamfer Angle			$10^{\pm2°}$	P.P.(LC-5")	2 /Setup	
20	Radius			R0.8-1.0	Radius Gauge	2 /Setup	
21	Surface Finish			3.2	SRT/Comparatar Gauge	2 /Setup	
22	Perpendicularity			0.05 wrt X4	Not Feasible	-	
23	Concentricity			Ø0.2 wrt X4	Not Feasible	-	
24	Circularity			0.05	Not Feasible	-	
		Rpm (TNMG)		1500 - 2000	M/c Setting	1 time	Per Setup
		Feed (TNMG)		0.1 - 0.2	M/c Setting	1 time	Per Setup
		Rpm (VNMG)		1500 - 2000	M/c Setting	1 time	Per Setup
		Feed (VNMG)		0.1 - 0.2	M/c Setting	1 time	Per Setup
		Rpm (CNMG)		1500 - 2000	M/c Setting	1 time	Per Setup
		Feed (CNMG)		0.1 - 0.2	M/c Setting	1 time	Per Setup
		Rpm (WNMG)		1500 - 2000	M/c Setting	1 time	Per Setup
		Feed (WNMG)		0.1 - 0.2	M/c Setting	1 time	Per Setup
		Insert Change		Wear Out	Visual	1 time	Per Setup
		Chuck run out		0.02 max	Dial	1 time	Per Setup
		Coolant Ph		8-10	Litmus Paper	1 time	Per day
		Coolant Concentration		3-5%	Refractometer	1 time	Per day

Figure 7: CNC 1st setup operation process parameters

OPN 50: CNC Second setup machining will be done in this operation , Bellow are the process parameters maintained for the operation.

S.N	CHARACTERISTIC		SPL CHAR CLASS	PRODUCT/PROCESS SPECIFICATION	EVALUTION/ MEASURMENT TECHNIQUE
	PRODUCT	PROCESS			
1	Diameter			Ø122 $^{\pm 0.3}$	DVC(LC-0.01)
2	Inner Diameter			Ø64.4 $^{\pm 0.15}$	DVC(LC-0.01)
3	Inner Diameter			Ø61 $^{\pm 0.15}$	DVC(LC-0.01)
4	Inner Diameter			Ø46.5 $^{+0.05}_{0}$	DVC(LC-0.01)
5	Length			72.65 $^{\pm 0.1}$	DVC (LC-0.01) / H.G.
6	Dimension			50 $^{\pm 0.3}$	DHG (LC-0.01)
7	Collar Thickness			13.2 $^{\pm 0.02}$	DVC(LC-0.01)/MM(LC-0.01)
8	Chamfer Length			3.5 $^{\pm 0.1}$	DVC(LC-0.01)
9	Angle			20° $^{\pm 0.5°}$	Bevel Protector(LC-5")
10	Perpendicularity			0.03 wrt 'A'	Not Feasible
11	Dimension			10 $^{\pm 0.2}$	DHG(LC-0.01)
12	Dimension			2 $^{\pm 0.1}$	DHG(LC-0.01)
13	Dimension			5 $^{\pm 0.1}$	DHG(LC-0.01)
14	Counter			1x45°	Not Feasible
15	Counter			0.5x45°	Not Feasible
16	Radius			R1	Not Feasible
17	Radius			R0.5	Not Feasible
18	Angle			20° $^{\pm 0.5°}$	Bevel Protector(LC-5")
		Rpm (TNMG)		1500 - 2000	M/c Setting
		Feed (TNMG)		0.1 - 0.2	M/c Setting
		Rpm (VNMG)		1500 - 2000	M/c Setting
		Feed (VNMG)		0.1 - 0.2	M/c Setting
		Rpm (CNMG)		1500 - 2000	M/c Setting
		Feed (CNMG)		0.1 - 0.2	M/c Setting
		Rpm (WNMG)		1500 - 2000	M/c Setting
		Feed (WNMG)		0.1 - 0.2	M/c Setting
		Insert Change		Wear Out	Visual
		Chuck run out		0.02 max	Dial

Figure 8: CNC 2nd setup operation process parameters

OPN 60: Induction Hardening of the part will be occurred in this operation for achieving proper hardness in the part, So that part will not get wear in small time period as well as it gives strength to the assembly.

S.N.	CHARACTERISTIC		SPL CHAR CLASS	PRODUCT/PROCESS SPECIFICATION	EVALUTION/ MEASURMENT TECHNIQUE	SAMPLE	
	PRODUCT	PROCESS				SIZE	FREQ.
1.	Case Depth			0.7~2.5 at 42 HRc(400 Hv)	DVC(LC-0.01) +RHT	After Setting 1 nos.	
2.	Surface Hardness			54 HRc (570HV)	RHT	After Setting 1 nos.	
3.	I/H Length			20 Max	DVC(LC-0.01)	After Setting 1 nos.	

Figure 9: Induction hardening and process parameters

OPN 70: CNC Hard Turning will be occurred in this operation for maintaining the various dimensions after induction hardening process, Bellow are the process parameters maintained in this operation.

S.N.	CHARACTERISTIC		SPL CHAR CLASS	PRODUCT/PROCESS SPECIFICATION	EVALUTION/ MEASURMENT TECHNIQUE	SAMPLE	
	PRODUCT	PROCESS				SIZE	FREQ
1	Total Length			$72.5^{\pm 0.15}$	DVC/DHG(LC-0.01)	2 /Setup, 2/Hr, 2/End	
2	ID Diameter		⊕⊕	$Ø42.23^{+0.05}$	DVC(LC-0.01)/PPG	3 /Setup, 3 /Hr, 2/End & 100% checked by gauge	
3	OD Diameter			$Ø58.05^{\pm 0.03}$	DMM(LC-0.001)	2 /Setup, 2/Hr, 2/End	
4	Length			$20^{\pm 0.2}$	DVC(LC-0.01)	2 /Setup, 2/Hr, 2/End	
5	Perpendicularity			0.05 wrt 'X4'	Not Feasible	-	
6	Concentricity		⊕⊕	Ø0.1 wrt 'X4'	HM(LC-0.0005)	3 /Setup, 3 /Hr, 2/End	
7	Circularity			0.02	Not Feasible	-	
8	Surface Finish			3.2	SRT/Comparator Gauge	2 /Setup	
		Rpm (TNGA)		1200 - 1800	M/c Setting	1 time	Per Setup
		Feed (TNGA)		0.1 - 0.2	M/c Setting	1 time	Per Setup
		Rpm (CNMG)		1200 - 1800	M/c Setting	1 time	Per Setup
		Feed (CNMG)		0.1 - 0.2	M/c Setting	1 time	Per Setup
		Insert Change		Wear Out	Visual	1 time	Per Setup
		Chuck run out		0.02 max	Dial	1 time	Per Setup
		Coolant Ph		8-10	Litmus Paper	1 time	Per day

Figure 10: CNC hard turning process parameters

OPN 80: This is the most important operation which is called as Broaching operation, This operation we have to conduct in a controlled manner, For this operation we have introduced a fixture on Broaching So that the issue of broaching shifting will not occurred again, Bellow are the process parameters for this operation.

S.N.	CHARACTERISTIC		SPL CHAR CLASS	PRODUCT/PROCESS SPECIFICATION	EVALUTION/ MEASURMENT TECHNIQUE	SAMPLE		
	PRODUCT	PROCESS				SIZE	FREQ.	
1.	Major Diameter			Ø45.47 / Ø45.34	P.P./Go-No-go Gauge / As per Broach	2 /Setup, 2/Hr, 2/End	100% BY GO-NOGO GAUGE	
2.	Minor Diameter			Ø42.29 / Ø42.16				
3.	No. of teeth			34	Go-Nogo Gauge/ As per Broach	2 /Setup, 2/Hr, 2/End		
4.	MOP			40.230 / 40.157	Spline Go-No Go			
		Broach Pressure		$30kg/cm^2$	Dial	1 time	Per Setup	
		Feed		--	M/c Setting	1 time	Per Setup	
		Broach Change		Re-Sharp/ Change	As per re-sharpening frequency	1 time	Per Setup	
		Coolant Oil		Ilobroacn No-11		1 time	Per day	

Figure 11: Broaching process parameters

OPN 90: This operation is held on VMC machine for maintaining the PCD in the given component, Bellow are te process parameters for the operation.

S.N.	CHARACTERISTIC		SPL CHAR CLASS	PRODUCT/PROCESS SPECIFICATION	EVALUTION/ MEASURMENT TECHNIQUE	SAMPLE	
	PRODUCT	PROCESS				SIZE	FREQ.
1.	Drill Dia			4xØ10.3 $^{+0.05}$	DVC(LC-0.01)/PPG/PCDG	2 /Setup, 2/Hr, 2/End	100% BY GAUGE
2	PCD			Ø100 $^{\pm 0.1}$	H.M.(LC-0.0005)/PCDG	2 /Setup, 2/Hr, 2/End	
3	Angle			70°	H.M.(LC-0.0005)/PCDG	2 /Setup, 2/Hr, 2/End	
4	Position		⊕⊕	Ø0.05Ⓜwrt 'X4'	H.M.(LC-0.0005)/PCDG	3 /Setup, 3/Hr, 2/End	
5	Counter			0.5 X 45°	DVC(LC-0.01)	2 /Setup	
6	Angularity			0.03 wrt 'X4'	Not Feasible	-	
		Rpm/Feed(D Ø10.3)		1500-2000 / 180-220	M/c Setting	1 time	Per Setup
		Rpm/Feed(C Tool)		1000-100 / 180 - 220	M/c Setting	1 time	Per Setup
		Tool change		Wear Out	Visual	1 time	Per Setup
		Spindle run out		0.007 max	Dial	1 time	Per Setup
		Coolent Ph		8-10	Litmus Paper	1 time	Per day
		Coolant Concentration		3-5%	Refractometer	1 time	Per day

Figure 12: VMC Operation and process parameters

OPN 100: Counter operation occurred on PDM Machine for applying Chamfer on the PCD in Back side of the part.

S.N.	CHARACTERISTIC		SPL CHAR CLASS	PRODUCT/PROCESS SPECIFICATION	EVALUTION/ MEASURMENT TECHNIQUE	SAMPLE	
	PRODUCT	PROCESS				SIZE	FREQ.
1.	Counter			0.5x45°	DVC(LC-0.01)+BP	2	Per lot
		RPM		250-300	M/c Setting	1 time	Per Setup
		Feed		MANUAL	M/c Setting	1 time	Per Setup
		Tool Change		WEAR OUT	Visual	1 time	Per Setup

Figure 13: Counter Operation process parameters

OPN 110: In this operation Face Spline will be done on Part by Milling cutter on Milling Machine , Bellow are the process parameters .

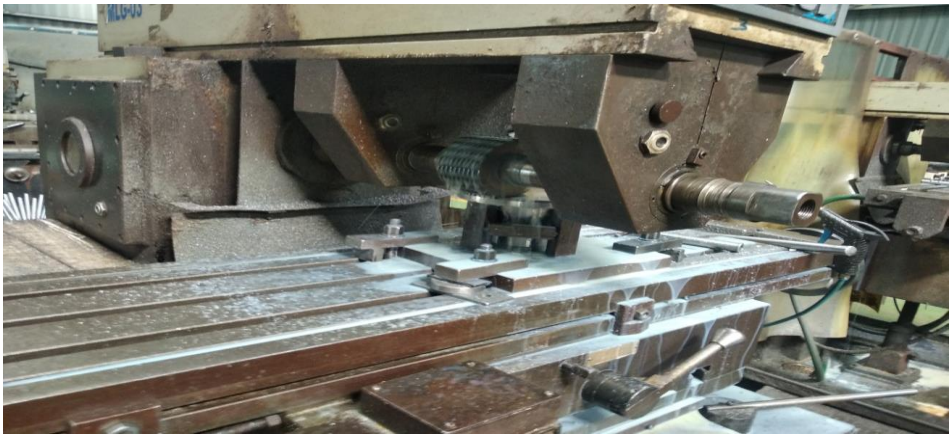

Figure 14: Milling Operation

OPN 120: Plunge Grinding during this operation for maintaining Outer diameter of the part as per specification for proper fitment in assembly, Bellow are the process parameters.

S N	CHARACTERISTIC		SPL CHAR CLASS	PRODUCT/PROCESS SPECIFICATION	EVALUTION/ MEASURMENT TECHNIQUE	SAMPLE	
	PRODUCT	PROCESS				SIZE	FREQ.
1	OD Diameter			Ø58 $^{-0.074}$ h9	DMM(LC-0.01) / SG	2/Setup, 2/Hrs, 2/End 100% by Gauge	
2	Length			20+2	DVC (LC-0.01)	2/Setup, 2/Hrs, 2/End	
3	Concentricity		⌖	Ø0.1 wrt 'X4'	Not Feasible	-	
4	Circularity			0.02	Not Feasible	-	
5	Surface Finish			0.8	SRT	1/Setup	

Figure 15: Plunge grinding process parameters

Table 1: Material Testing report

MATERIAL SPEC. EN8D						HEAT CODE(I/H):-AF	
ELEMENT		**C%**	**Mn%**	**Si%**	**P%**	**S%**	REMARKS
SPECIFD.	**Min.**	0.40	0.60	0.15	--	--	OK
	Max.	0.50	0.90	0.35	0.06	0.06	
ACTUAL		0.45	0.76	0.23	0.031	0.023	
METALLOGRAPHIC OBSERVATIONS:-							
TEST		**SPECIFICATIONS**			**OBSERVATIONS**		**REMARKS**
Case microstructure		Fine Tempered martensite			Fine tempered martensite without ferrite		OK
Core microstructure		Hardened and tempered			Tempered martensite		OK
Inclusion Rating		≤ 2 ABCD IS: 4163			1.0 A,0.5B,0.5C,1.0D		OK
Grain size		ASTM- 5 to 8			6 .5– 7 ASTM		OK
MECHANICAL PROPERTIES:-							
TEST		**SPECIFICATIONS**			**OBSERVATIONS**		**REMARKS**
Surf. hardness		500-570Hv			'560-565 Hv(53/54 HRC)		'OK
Core hardness		300-400HV			370-380 HV		OK
Effective case depth		1.5±1mm			1.7-2.0mm		OK

Effective case depth at oil groove	1.5±1mm	0.8mm-1.0mm	'OK
Magnafluxing/ acid etching/ visual	Shall be free from cracks, fold, seams etc.	No Cracks and free from other defects	OK

CONCLUSION- ACCEPTED.

Magnetic Particle Testing 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 companion Flange , applying oil flow and then visually detecting it in presence of uv rays.

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 Length:- 72.5	Operator Name:
	Part Name: Companion Flange	Part Grade :- EN8D	sawan
	Part Max. Dia :- 122.3	Part Condition:- Forged	Date:- 20.02.20
	Induction Batch No.-	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

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 16: MPI testing report of Companion flange

Dimensional inspection done for checking the Companion Flange made in define manufacturing process should have dimensions as per requirement or not. So, dimension checking of flange have been done by the use of several Instruments like Trimos, height gauge, DVC etc.

CONCLUSION

After conducting dimensional Inspection for both Companion Flange Manufactured Parts i.e. Old Part & New Fixture developed part we have obtained that to maintain the given broaching specifications by New Fixture Manufactured Part can be achieved in Transmission assembly. Bellow is the comparison of customer complaint report found in the rejected companion flange.

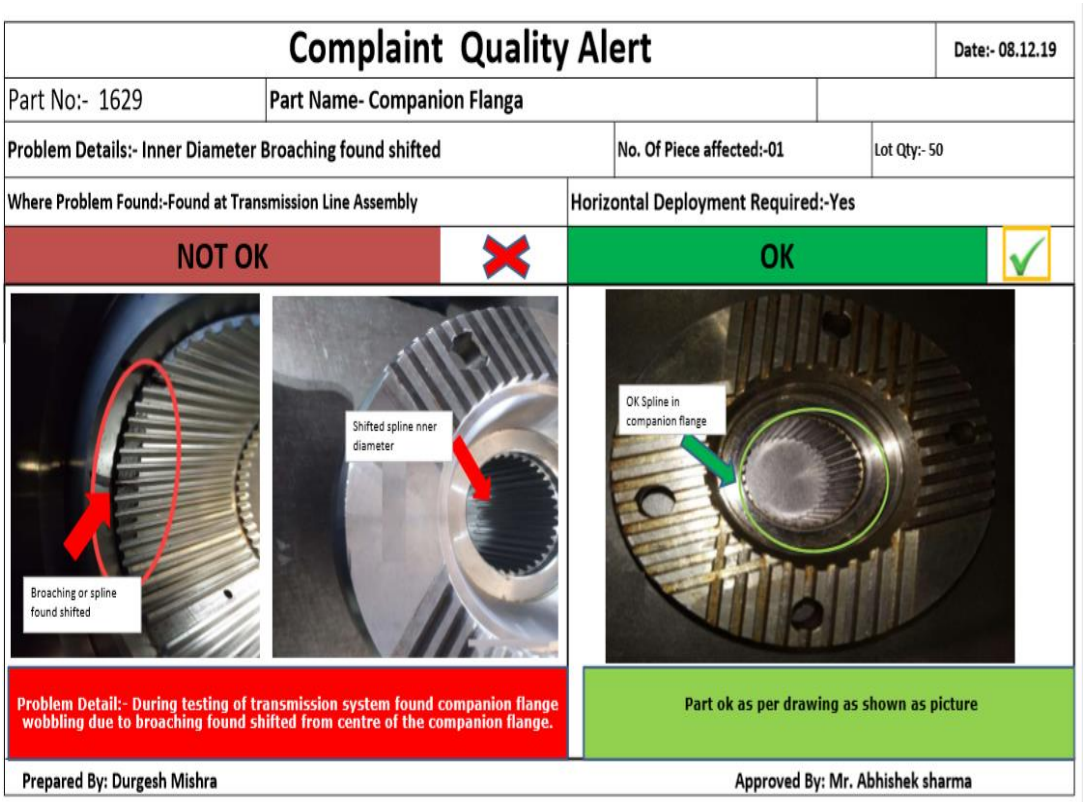

Figure 17: Final Quality report

During Inspection of Part no damage found in broaching of companion flange. Spline of the part checked by spline gauge as per the specifications given in drawing & control plan.

Figure 18: Final Quality report

Table 2: Dimensional analysis report

Major Diameter	45.7	45.34	PPG GO/NO GO	ok	ok	ok	ok	ok
Minor Diameter	42.29	42.16	PPG GO/NO GO	ok	ok	ok	ok	ok
No. of Teeth	34		PPG GO/NO GO	ok	ok	ok	ok	ok
MOP	40.230/40.157		Spline Go -No Go	ok	ok	ok	ok	ok

The Dimensional analysis is conducted on Companion Flange by using Instrumental testing and results obtained shows that Flange manufactured by New Fixture Method performs better as compared with old method of manufactured companion flange . Along with that the rejection rates which were higher in old method flange 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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