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DESIGN AND ANALYSIS OF DIAPHRAGM HOT FORMING CYCLE TIME REDUCTION

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ABSTRACT

This project we have taken to increase productivity improvement in Model k diesel diaphragm hot forming by reducing cycle time. This convenience in increase the production rate per product and overall. A manufacturing method for a disk-like diaphragm spring for making a center hole at a center part, making rectangular holes on an outer peripheral part with specified spaces left between such holes in a circumferential direction. The diaphragm spring is a steel disc having a hole of at the centre, and the inner portion of the disc is radially slotted so that a number of actuating (release-lever) fingers is formed. The outer end of the slots are provided with enlarged blunting holes, which distribute the concentrate stresses created during deflection of the fingers, and also provide a means of locating the shouldered rivets, which restrain the fulcrum rings. Forming plural ligulated fingers radially by means of plural radial slits extending from such rectangular holes to the center hole and inner peripheral parts of the fingers to be pressed by a release bearing. The method comprises a step of punching such rectangular holes and slits out of a disc-like blank with a press and forming between the slits tapered ligulated fingers and a process of punching out a center hole by using a gear-shaped press die having circular tip portions at the same spacing as the slits for forming tapered openings at the slits extending radially outward from the center hole slits and circular ends on the fingers.

Keywords: Diaphragm Spring, blunting holes, forming, fingers, Stresses

INTRODUCTION

This invention relates to a manufacturing method for a diaphragm spring for use in a clutch for a vehicle. Conventionally, when manufacturing a diaphragm spring for use in a clutch cover assembly; plural holes 32 and slits 33 have been punched out from a disc-like metal blank 31 by a first press work as illustrated by and then a circular center hole 34 has been punched out as shown in by a second press work. Thereafter the blank has been bent to a specified shape as illustrated by. This diaphragm spring is elastically deformed by being pushed and pulled by a release bearing 36 at inner peripheral parts of fingers 35 formed of the slits 33 to cause a clutch disc to be pressed on and separated from a flywheel through, for instance, a pressure plate

In the conventional manufacturing method, it has been impossible to make a width of the slit 33 smaller than the plate thickness of the blank 31. Furthermore, contact area between an inner peripheral part of the finger 35 and a release bearing 36 is small because of the reduced inner peripheral width of the finger 35 causing a high bearing pressure. With the high bearing pressure the inner peripheral part of finger 35 has worn out quickly.

Diaphragm –spring clutch has similar construction to that of the multi-coil spring unit, but it uses a single dished diaphragm type spring to apply the clamping thrust. This spring also severs as a part of the release mechanism. The diaphragm spring is a steel disc having a hole of at the centre, and the inner portion of the disc is radially slotted so that a number of actuating (release-lever) fingers is formed.

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The diaphragm spring is placed between the pressure plate and the cover pressing. The outer edge of the dished spring bears against the pressure-plate, and two round-sectioned wire rings are positioned from a short distance from its outer edge, one on each side of the dished spring these two rings are located as well as held in position by shouldered rivets and these rivets in urn are supported by the cover pressing.

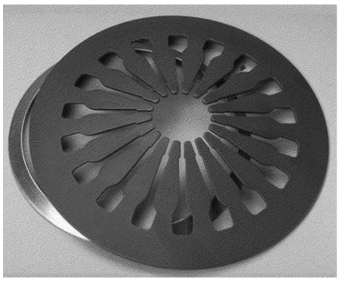

Fig.1.1 Diaphragm

During fastening of the cover-pressing to the flywheel, the dished spring is slightly flattened, which loads the pressure-plate against the driven friction discs, the spring reaction being taken through the outer ring to the cover-pressing. The inner ring acts as a pivot point for all the individual release-lever fingers and are located near the periphery of the diaphragm spring to increase the leverage

I. LITERAURE SURVEY

H.K.Dubey and Dr. D.V. Bhope (2012), Many researchers have carried out stress and deflection analysis of a Belleville spring. the stress and deflection analysis to prepare a CAD method for the checkout and design of the Belleville springs. The method eliminates the need to resort to conventional trial-and-error techniques. In a matter of seconds, it rapidly and accurately checks out and designs Belleville springs, outputting the load deflection characteristics in graphic and table formats and can generate a dimensioned drawing. the stress and deflection analysis of a slotted Belleville spring to develop a analytical relationship for deflection and stress of a slotted conical spring.

Abdullah and Schlattmann (2012) developed a two dimensional model to obtain the numerical simulation for band contact of disc clutch during slipping. In this study, three type of pressure application was used viz. constant pressure, linearly increasing pressure and parabolic ally increasing pressure. Finite element method was used to calculate the heat generated on the surfaces of friction clutch and temperature distribution for case of bands contact between flywheel and clutch disc, and between the clutch disc and pressure plate. They found that both slipping time and contact area ratio are intensely effect disc clutch temperature fields in the domain of time.

II. PROBLEM DEFINITION

3.1 Identification of Defects In Tool

- Between cooling jacket wall thickness is high (8 to 13 mm).
- ID ZONE Wall thickness is more (37 mm)
- Causes leads poor thermal conductivity which all are take the more Press time

3.2 Previous design of cooling jacket:

Ex: Belleville zone cooling jacket Thermal conductivity 1.91 W / m.K

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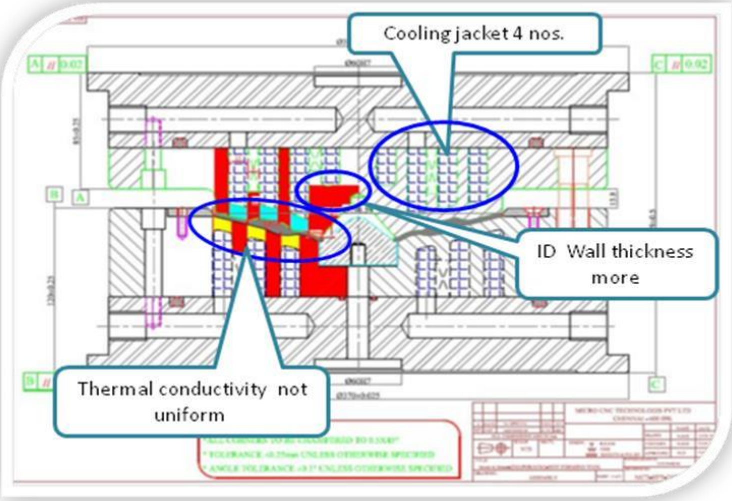

Fig 3.1 2D Design of cooling jacket

3.3 ***Before Improvement In Tool***

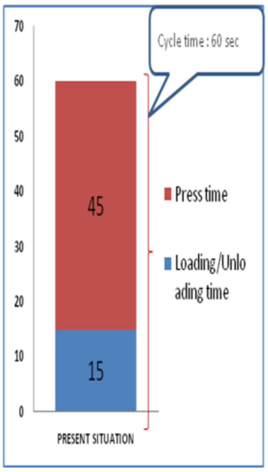

Fig 3.2 Old Tool

3.4 Description of problem:

- Water cooling jacket width low and cooling volume less

3.5 Causes of problem:

- Cooling rate is slow *3.6 Axial load test before:*

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Valeo	PPCA AXIAL FATIGUE TEST (M1)

Report N° M1. 491.15

Project number	-		Project name	MKD		Project phase	-
Customer	Maruthi	Car	Swift	Engine	DDIS Diesel	Gear box	MT5
Comment	Validation of cover assy:793754 for cycle time reduction from 60sec to 50sec at high temp M/C-8(backup)						

Tested products

Designation	215 CPoVE 5000	Reference	793754	Index	E
Origin of components				Quantity	3

Results	O (Ok)

Test conditions (according to procedure 400.150.001 rev B)

Results of visual criteria: O (Ok)

	Part n°	After	Comment	Criteria	Result
Diaphragm	491.15_CA_1	O (Ok)	No Breakage	No breakage or crack	O (Ok)
	491.15_CA_2	O (Ok)	No Breakage		
	491.15_CA_3	O (Ok)	No Breakage		
Straps	491.15_CA_1	O (Ok)	No Breakage		O (Ok)
	491.15_CA_2	O (Ok)	No Breakage		
	491.15_CA_3	O (Ok)	No Breakage		

Results of functional criteria: O (Ok)

	Part n°	Before test	After 1E6 cycles	Evolution	Criteria	Result
Mean Clamp Load (engaged new)	491.15_CA_1	5682	5743	1.07%	≥ -5%	O (Ok)
	491.15_CA_2	5840	5985	2.48%		O (Ok)
	491.15_CA_3	5739	5761	0.38%		O (Ok)
Mean clamp Load (wear)	491.15_CA_1	5809	5408	-6.90%	≥ -15%	O (Ok)
	491.15_CA_2	5849	5435	-7.08%		O (Ok)
	491.15_CA_3	5836	5414	-7.23%		O (Ok)
min. PP lift	491.15_CA_1	1.32	1.33	0.76%	≥ -5%	O (Ok)
	491.15_CA_2	1.28	1.30	1.56%		O (Ok)
	491.15_CA_3	1.32	1.29	-2.27%		O (Ok)

Indicators O (Ok)

	Part n°	Before test	After 1E6 cycles	Hysteresis/ PP load	Indicator	Result
PP load hysteresis (engaged new)	491.15_CA_1		889	15.5%	≤ 25%	O (Ok)
	491.15_CA_2		871	14.6%		O (Ok)
	491.15_CA_3		860	14.9%		O (Ok)
PP load hysteresis (wear)	491.15_CA_1		1361	25.2%	≤ 35%	O (Ok)
	491.15_CA_2		1353	24.9%		O (Ok)
	491.15_CA_3		1374	25.4%		O (Ok)

Conclusion

Cover assy 215 CPoVE 5000 with ref:793754 passed the validation on M1 test.

Reported by	M Arun kumar	Test end		Reviewed by	N Sathish kumar	Validated by	N Selvaraj
Signature	M. Arun			Signature		Signature	
Date							

Fig 3.3 Axial load test before

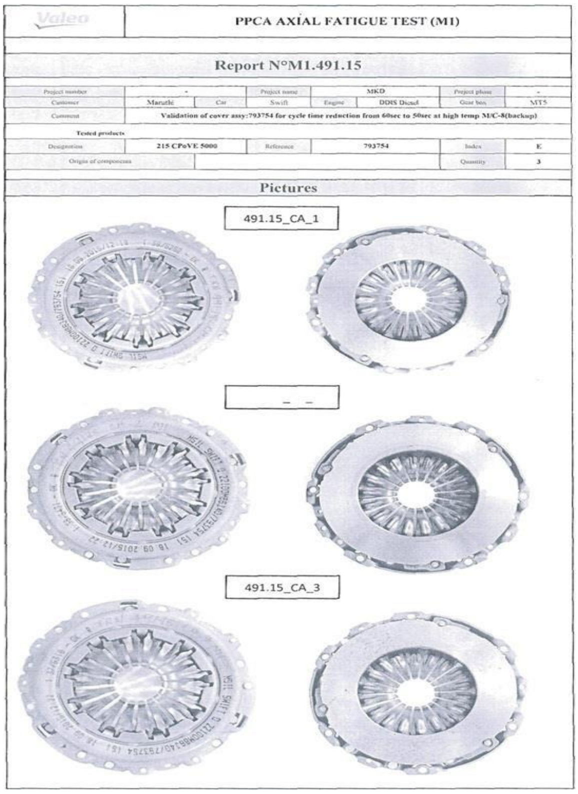

Fig 3.4 PPCA Axial Fatigue Test

3.7 Clamp Load & Bearing load

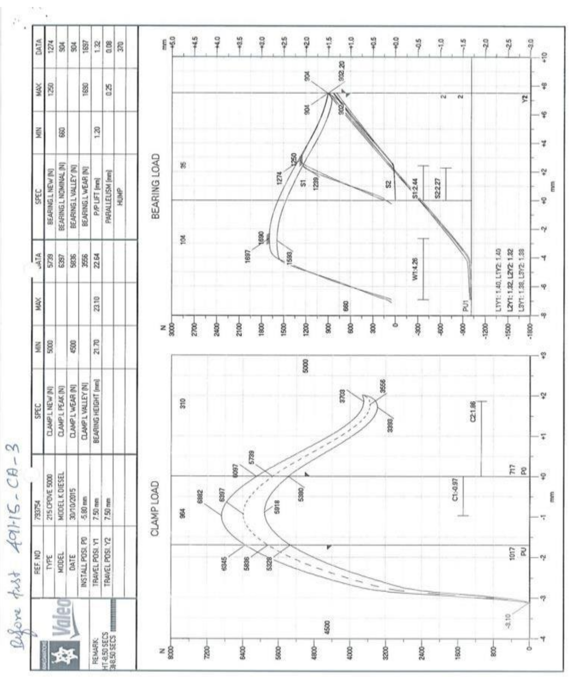

Fig 3.4 Before Test 491.15 CA-1

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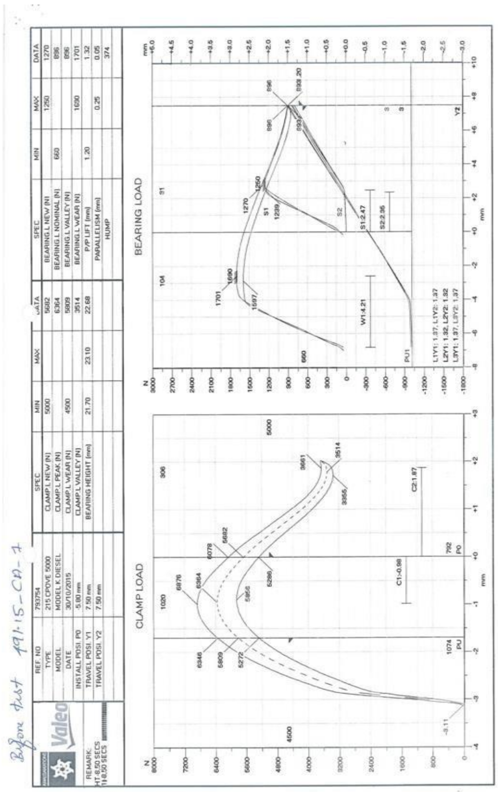

Fig 3.5 Before Test 491.15 CA-2

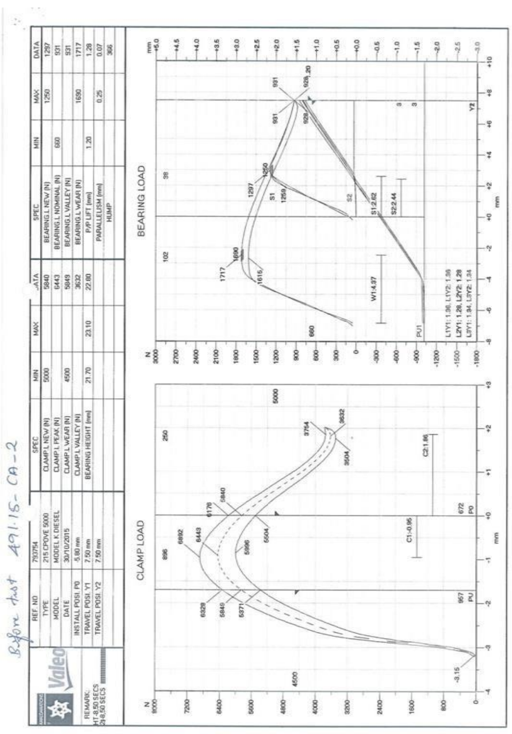

Fig 3.5 Before Test 491.15 CA-3

III. METHODOLOGY

4.1 Disclosure of The Invention:

In order to solve the foregoing problem, this invention provides a manufacturing method for a diaphragm spring in which, when making a center hole at a central part, making plural rectangular holes on an outer peripheral part with specified spaces left there between in a circumferential direction, forming plural ligulated fingers radially by means of plural radial slits extending from the rectangular holes to the center hole, and manufacturing the disc-like diaphragm spring wherein inner peripheral parts of these fingers are pressed by a release bearing.

4.2 Two Processes Are Involved:

A first process for punching the peripheral holes and slits out of a disc-like blank by a press work and a second process for punching out the center hole by using a gear-shaped press die having circular tip portions spaced at the same spacing as that of the slits. A blank inner peripheral side end of each slit, opposite, is formed into a tapered shape in punching out the rectangular holes and slits. An angular position of the circular tip portion of the press die is aligned with that of the tip ends of the tapered shape of the slits in the process.

According to the above-mentioned method, the blank inner peripheral side end of each slit along the longitudinal sides therefore, is formed into the tapered shape in the punching process for punching out the rectangular holes and slits.

The position of the circular tip portion of the press die is aligned with that of the tip ends of the tapered shape of the slits in the process for punching out the center hole. Therefore, the inner peripheral part of the finger formed between the slits has a large width so that the bearing pressure can be reduced because of the large contact area with the release bearing. Thus, the wear is reduced and the durability improved in the manufactured diaphragm spring.

4.3 *Hot forming process consists of the following steps:*

- Heat treatment in furnace
- Transfer from furnace to press and drawing tool
- Plastic hot forming
- Quenching in the closed, cooled die

Parts produced by hot forming are characterized by high strength, complex shapes and reduced spring back effects. Optimal material behaviour is achieved through the structural transformation of austenite into marten site. The most commonly used material in hot forming is Boron steel 22MnB5, which is available from many steel manufacturers. The direct hot forming phases: Blank – Heating–Drawing. In direct hot forming, the part is austenitized at a higher temperature, transferred to the cooled die and then deep-drawn. In this manner, complex shapes can be achieved as the material has excellent formability at high temperatures. In indirect hot forming, the part is first deep-drawn without heating. Before the final shape has been obtained, the part is heated to the austenitizing temperature and the final drawing is carried out. This additional step extends the forming capabilities and allows for very complex geometries to be attained.

Hot forming has recently become important for the automotive industry in meeting specific requirements for higher crash safety and lower overall weight. Numerous car manufacturers use these processes to produce structural car body parts such as A- and B-pillars, tunnels, front and rear bumper beams, door sills, door beams, side-rails, roof rails and roof frames.

Hot forming is more complex compared to conventional forming. By using the hot forming process, parts with higher strength, higher geometrical complexity and minimized spring back effects can be produced in a much shorter amount of time.

4.4 Present tool design of cooling jacket:

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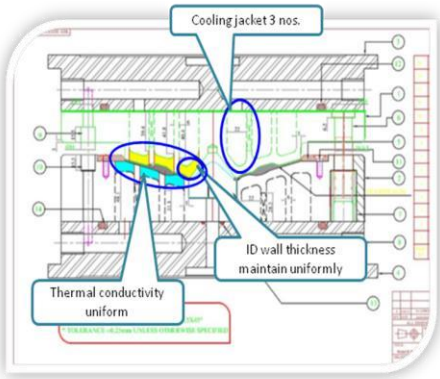

Fig.4.1 2D Design of cooling jacket

Ex: Belleville zone Cooling jacket Thermal conductivity 6.13 W / m.K

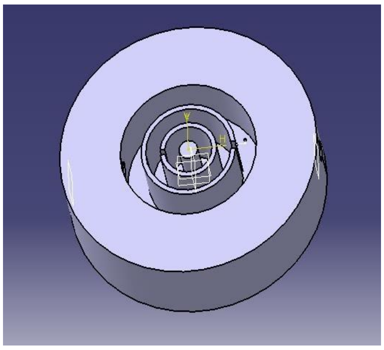

Fig.4.2 New Tool Present cycle time indication

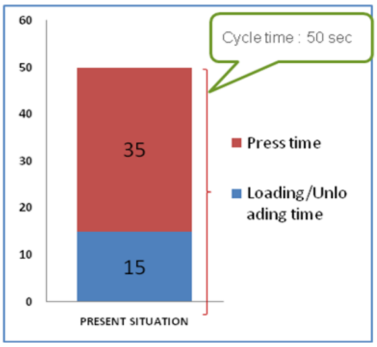

Fig.4.3 New Tool

IV. CALCULATION

5.1 Design calculation for old tool:

The design calculation is done for the thermal conductivity k.

Heat transfer Q:

Heat transfer can be defined as the transmission of energy from one region to another region due to temperature difference. *Dimension:*

ΔT = 1000°C+273= 1273 K, r1=0.070 m, r2=0.11 m, r3=0.15 m, Heat transfer Q=20 KW

Formula used:

Q= 2Πlk1ΔT/ln[r1/r2]

20,000 = 2*π*1*k1*1273/ln [0.11/0.070]

K1 = 1.130 W/mk

Q = 2Πlk1ΔT/ln[r3/r2]

20,000 = 2*π*1*k2*1273/ln [0.15/0.11]

K2 = 0.76 W/mk

Thermal conductivity k:

K=k1+k2, K=1.130+0.76

Thermal conductivity *K=1.91 W/mk*

5.2 Design calculation for new tool:

Dimension:

r1=0.048 m, r2=0.088 m, r3=0.128 m, ΔT=1273 k

Q= 20KW = 20,000 W

Formula used:

Q=2πlk1ΔT/ln[r2/r1]

20,000=2*π*0.37*k1*1273/ln[0.088/0.128]

K1=3.789 W/mk

Q = 2πlk2ΔT/ln [r3/r2]

20,000 = 2*π*k2*1273/ln [0.128/0.088]

K2 = 2.34 W/mk

Thermal conductivity k:

K = 3.789+2.34

Thermal conductivity *K = 6.13* W/mk

V. TEST REPORT

6.1 After Test 491.5-Ca-1:

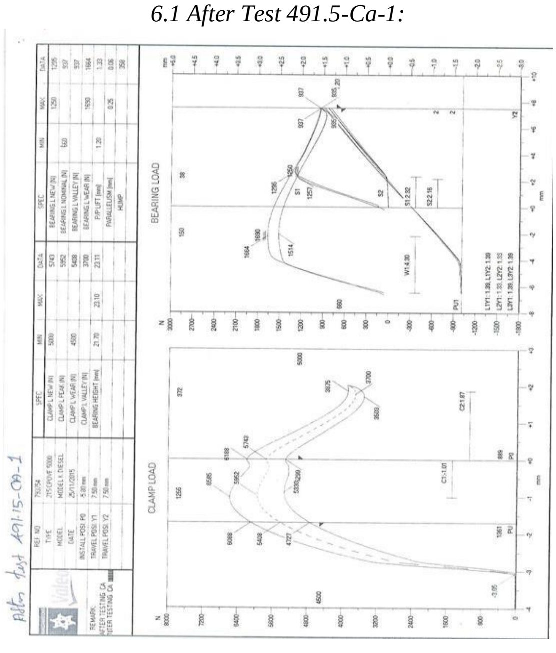

Fig 6.1 After Test 491.15 CA-1

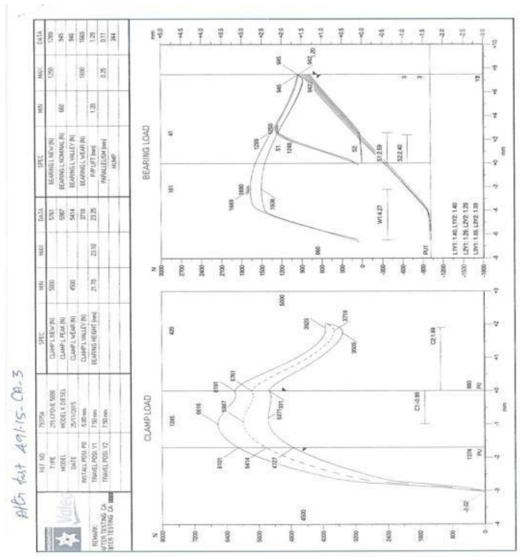

Fig 6.2 After Test 491.15 CA-2

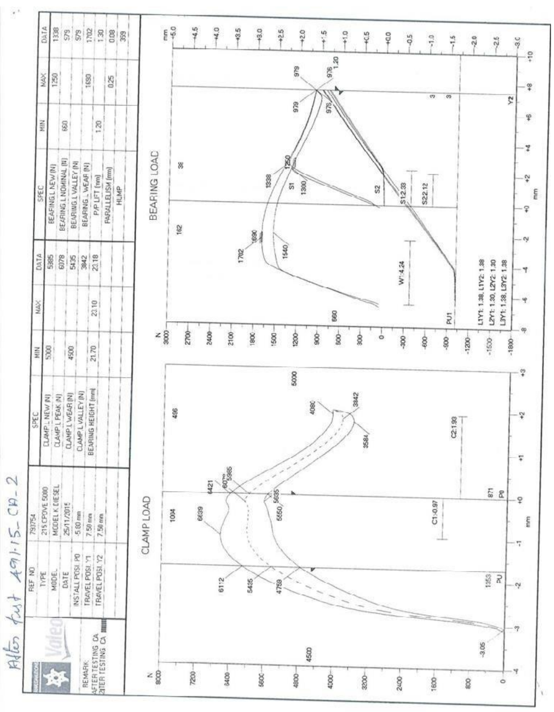

Fig 6.3 After Test 491.15 CA-3

6.2 Hot Axial Fatigue Test (M7):

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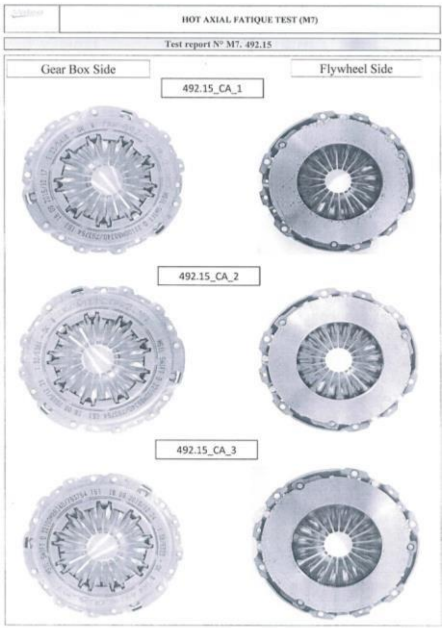


Fig 6.4 Hot Axial Fatigue Test

6.3 Fatigue life:

Fatigue life for a disc spring is defined by the effective number of stress cycles that can be sustained prior to failure under certain conditions. This depends on the minimum stress, maximum stress and stress range.

The diagrams presented here are for evaluating fatigue life of single disc springs or series stacks not more than6 springs. There are three basic groups, depending on thickness (see legend under each diagram).The horizontal border line enclosing the top portion of the graph (zone) represents the yield strength of the spring steel material. Intersection points of min/max stress limits which fall outside the graph/zone boundaries are to be avoided as they indicate spring failure is likely at an early stage. The graphs were developed based on empirical test data. The test loads were sinusoidal execute.

6.4 Material test report:

AMALGAMATIONSVALEOCLUTCHPRIVATELIMITED
MATERIAL TEST REPORT

Valeo

PartNo :793794

Customer/Model :MSIL/MKD MTRNo:MFEB/26/2016

Description :Diaphragm(CycleTimeOptimization) Qty:40No's

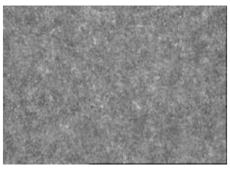
MaterialSpecification:50CrV4

Process:Tempering
HotformingMachineno:7

Sl.no	Parameter	Specification	Actual	Remarks
10	Hardness	44-50HRC	47-48	Ok
20			47-48	Ok
30			48-49	Ok
40			47-48	Ok

Microstructure

SampleNo!



Mag:400X
Etchant2% NITAL

CheckedBy **ApprovedBy**

(C.Logeshkumar) **(S.Saravanaperumal)**

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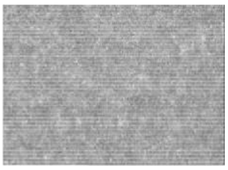
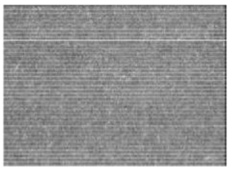
Fig 6.5 Material test report for tempering

AMALGAMATIONS VALEO CLUTCH PRIVATE LIMITED MATERIAL TEST REPORT		Valeo
Part No	: 793794	
Customer / Model	: MSIL / MKD	MTR No: MFEB/26/2016
Description	: Diaphragm (Cycle Time Optimization)	Qty : 40 No's
Material Specification : 50CrV4		

Sample No. 20



Sample No. 40



Mag: 400X
Etchant 2% NITAL

Micro structure analysis:
Micro structure analysis of specimens has revealed tempered martensite at case and core.

Remarks:
Trial results conforms hardness and microstructure specification.

Checked By	Approved By
(C.Logeshkumar)	(S.Saravanaperumal)

Fig 6.6 Micro Structure Analysis

AMALGAMATIONSVALEOCLUTCHPRIVATELIMITED MATERIALTESTREPORT		Valeo
PartNo	:793794	
Customer/Model	:MSIL/MKD	MTRNo:MFEB/26/2016
Description	:Diaphragm(CycleTimeOptimization)	Qty:40No's
MaterialSpecification:50CrV4		

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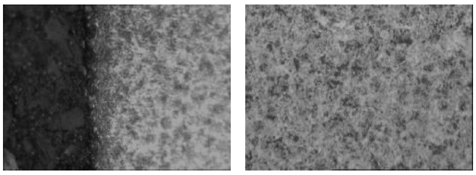
Process:Hotforming
HotformingMachineno:7

SampleID	Hardness(Hotformed)		Remarks
	Hardness(Body) (Spec.54-62HRC)	Hardness(Surface) (Spec.550-700HV5)	
10	59-60HRC	587-601	Ok
20	59-60HRC	593-603	Ok
30	60-61HRC	609-619	Ok
40	59-60HRC	596-602	Ok

Microstructure

Surface Core

SampleNo.1



Mag:400X
Etchant2%NITAL

CheckedBy ApprovedBy

(C.Logeshkumar) (S.Saravanaperumal)

Fig 6.6 Material test report for hot forming

AMALGAMATIONSVALEOCLUTCHPRIVATELIMITED
MATERIALTESTREPORT

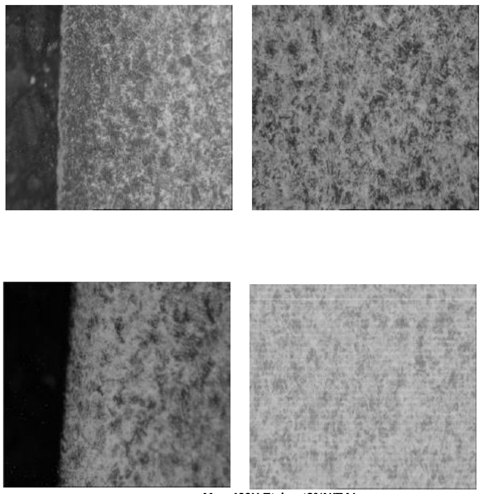
PartNo :793794

Customer/Model :MSIL/MKD	MTRNo:MFEB/26/2016
Description :Diaphragm(CycleTimeOptimization)	Qty:40No's
MaterialSpecification:50CrV4	

Surface
Core

SampleNo.20

SampleNo.40



Mag:400X Etchant2%NITAL

Microstructureanalysis:
Microstructureanalysisofspecimenshasrevealedmartensiteatcaseandcore.Specimensfreefromdecarburization&ferritepatches.

Remarks:
Trialresultsconformshardnessandmicrostructurespecification.

CheckedBy ApprovedBy

(C.Logeshkumar) (S.Saravanaperumal)

Fig 6.7 material test report for Micro Structure Analysis

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VI. RESULT

7.1 Quality Cost Development Method Results:

Water cooling jacket width increased and cooling rate increased *Benefits:* Cooling time reduced and productivity increased. *Results & Benefits:*

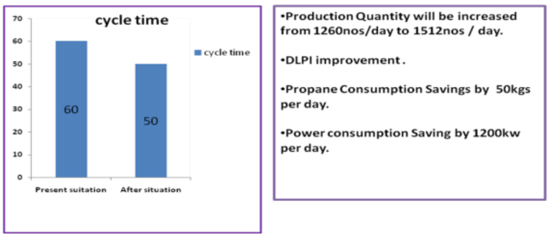

Fig 7.1 Cycle Time

VII. CONCLUSION

Productivity improvement in Model k diesel diaphragm hot forming by reducing cycle time from 60 sec to 50 sec has been improved by the cooling jacket improvement.

Estimated cost saving:

MKD DSP Cycle Time Reduction		
	Before	After
Cycle time	60	50
Qty/Day	1260	1512
Increased Capacity / day	252 nos	
Increased Capacity /annum	75600 nos	
Reduced shift/Annum	180 shifts	
DL+Process cost/hour	1600 INR	
Cost saving/Annum in INR	3136.00 KINR	

Table 8.1 Estimated cost saving

ACKNOWLEDGEMENT

We take this opportunity to express our gratitude to Amalgamations Valeo Clutch Pvt Ltd, For this kind support and for providing necessary facilities to carry out the work and guide us during critical situations and for giving constant encouragement towards the successful completion of our work.

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