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Optimizing Influence of Process Parameters on Induction Hardening for IC Engine Valve

By

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Abstract:

Fatigue Behavior of induction hardened part is largely dependent on the correct combination of hardening depth and the magnitude. The objective of this work is to optimize the process parameters of the IHE of SH – 5395 Tuff Pattern in which experimentations have been conducted. Two types of coils quenched and tempered were investigated; the process parameters of IHE were varied to give a constant hardness penetration depth in both Spiral and Flat Coils,

Keywords: Hardness penetration depth, Spiral coil, Flat coil

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1. Introduction:

The experiment investigation showed that the process parameters of IHE in Spiral & Flat Coils for the Bajaj Pulsar Valves to a great extent. Induction surface hardened low alloyed medium carbon steel is widely used for critical automotive and machine application such as crack shaft and Knuckle joints which require high Fatigue resistance. Fatigue behavior of I.H parts depends to a great extent on the correct combinations of IH depth and magnitudes, in order to reduce the many cost in terms of material consumptions and elimination of number of processing steps. The effect of IH process parameters should already be considered in the design stage. In recent years number of investigations has been put forward dealing with modeling and simulation of Fatigue behavior of different components coupled to the used process parameters for Induction Hardened Valves(1). *Sehopfel et.al* found an almost linear correlation between Log of the heating and Log of the bending endurance limit irrespective of the hardness penetration depth of IH steel 37 Cr 4v An increase the endurance limit was observed when decreasing the heating power and consequently increasing the heat time in order to maintain hardness penetration depth constant. The objective of the presented work is to optimize the process parameters of IHE of SH 5395 Tuff, in which process parameters is varied to give a constant penetration depth. This depth were measures in micro hardness survey (HRC).

2. Experimental Procedure

2.1 Material

The Investigation was performed on the cylindrical samples made of SUH – 3 corresponding to SUH – 3.This chemical composition is indicated in table 1

Element	C	Si	Mn	S	P	Ni	Cr	Mo	Fe
Specification %	0.35 0.45	1.80 2.50	0.60 Max	0.030 Max	0.030 Max	0.60 Max	10.00 12.00	0.70 1.30	Bal ance
Observation % Valve No. 01	0.41	1.93	0.21	0.018	0.006	0.31	10.41	0.74	85.91
Observation % Valve No. 02	0.40	1.92	0.23	0.023	0.009	0.29	10.34	0.73	85.86

Two types of samples prepared, namely for Spiral Coil & Flat Coil, Valve Length 50 mm & dia of 4.6 mm Prior to IHE

Material Used for Bajaj Pulsar Inlet Valve is SUH – 3 in which Carbon % is 0.35 to 0.45 %

2.2 Induction Hardening

The aim of the satisfactory IHE was to vary the process parameters of available generator (25 KW & 150 KHz) to give an effective hardness zone of 1.0 to 2.5 mm from Tappet end with surface Hardness (min 56 HRC). Fig No.1 shows the Hardening occurred on Tappet End.

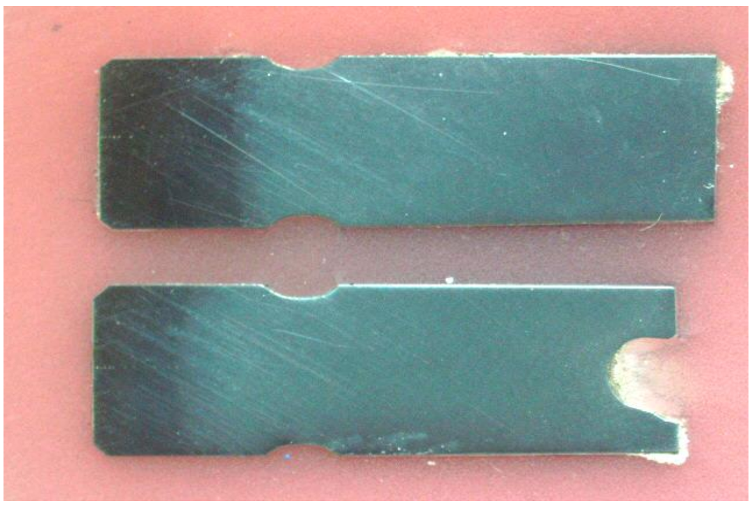

Fig No.1 Typical structure of Heat affected zone in IC Engine valve

First the inductor was 3.0 turn spiral coil distance of 4.0 mm and Meta Quench (Super C – 11) used as a quench media. The quench was applied immediately after the power had been turned off. The chuck rotated during induction hardening. No tempering was applied.

Table shows the selected IHE parameters that gives the desired surface hardness and effective hardness penetration depth.

Table:1 Spiral Coil Process Parameters

Material	Power (KW)	Heat Time (Sec)	Cooling Media	Hardness In HRC
SUH - 3	7.00	2.50	C - 11	54,53
SUH - 3	7.50	2.00	C - 11	52,54
SUH - 3	8.00	1.80	C - 11	53,54
SUH - 3	8.50	1.80	C - 11	55,56
SUH - 3	9.00	2.00	C - 11	54,55
SUH - 3	9.50	1.80	C - 11	51,54
End Hardness Test Record (Trial)				

Pattern No.:SH-5395 TUF		Date: 30/4/2009	
Material :SUH-3		Specification: Min 55 HRC (79 HRA)	
Sr.No.	Hardness In HRA	Sr.No.	Hardness In HRA
1	79	23	78
2	79	24	78
3	78	25	78
4	79	26	79
5	80	27	78
6	79	28	78
7	78	29	78
8	78	30	78
9	79	31	79
10	78	32	78
11	78	33	80
12	78	34	78
13	78	35	78
14	79	36	79
15	79	37	78
16	79	38	78
17	80	39	78
18	79	40	80
19	79	41	78
20	79	42	78
21	80	43	78
22	79	44	78

Similarly, when the inductor is changed to single turned flat coil, the following process parameters used

Table:2 Flat Coil Process Parameters

Material	Power (KW)	Heat Time (Sec)	Cooling Media	Hardness In HRC
SUH - 3	7.00	2.50	C - 11	57,58
SUH - 3	7.50	2.00	C - 11	56,57
SUH - 3	8.00	1.80	C - 11	56,57
SUH - 3	8.50	1.80	C - 11	57,57
SUH - 3	9.00	2.00	C - 11	58,57
SUH - 3	9.50	1.80	C - 11	58,58

Table No.3 Trail test for End hardness survey

End Hardness Test Record (Trial)							
Pattern No.:		SH-5395 TUF			Date:	20/4/2009	
Material :		SUH-3			Specification:	Min 55 HRC (78 HRA)	
Sr.No.	Observation In HRA	Sr.No.	Observation In HRA	Sr.No.	Observation In HRA	Sr.No.	Observation In HRA
1	82	14	83	27	78	40	79
2	80	15	80	28	81	41	81
3	81	16	79	29	84	42	84
4	79	17	82	30	84	43	81
5	80	18	80	31	81	44	81
6	79	19	78	32	79	45	81
7	85	20	82	33	81	46	81
8	82	21	83	34	82	47	79
9	79	22	82	35	79	48	83
10	79	23	85	36	79	49	79
11	79	24	81	37	78	50	82
12	78	25	80	38	79		
13	79	26	81	39	83		

6. Conclusions:

Valve stem hardening after nitriding in spiral coil is difficult to achieve hardness of 56 Hrc (at End 0.5 mm) , whereas in single turn flat coil, as the heat is applied from bottom of the valves, the 56 HRC min at Tappet end is easily achieved

Fig No.3 Hardened End Micro Structure

Valve No. 01 Valve No. 02

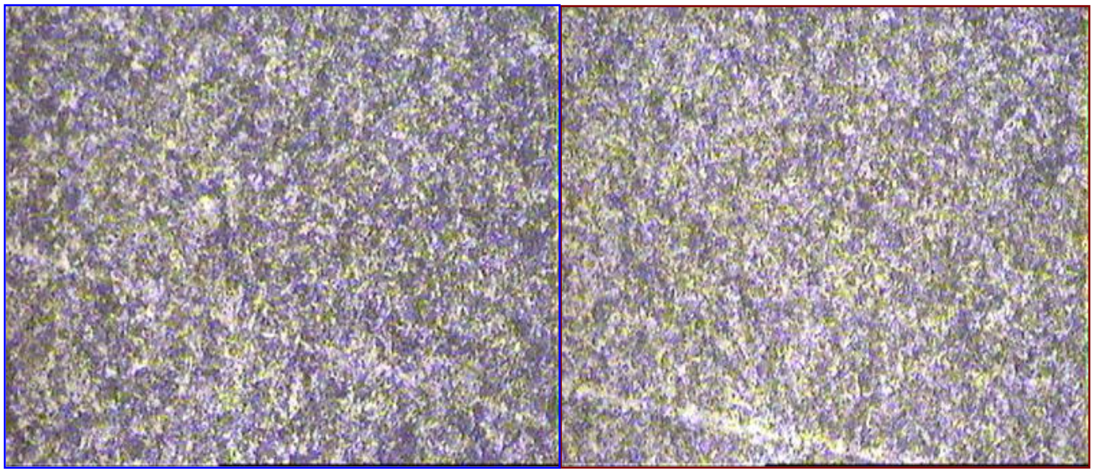

Table No.4 Micro Hardness survey

End Micro Hardness Survey:

Hardness Depth In (mm)	Hardness In HRc	
	Valve No. 01 (Flat coil)	Valve No. 02 (Spiral Coil)
End	57.00	54.00
0.10	57.40	55.30
0.20	57.70	55.10
0.30	57.90	55.00
0.40	56.10	54.70
0.50	55.90	54.60
0.60	55.10	54.30
0.70	55.00	54.20
0.80	53.90	52.90
0.90	53.70	52.40
1.00	53.70	51.30
1.10	53.10	51.20
1.20	52.60	51.00
1.30	52.30	50.20
1.50	52.10	49.90

From the above trial readings, single turn flat coil gives the consistent Hardness as per requirement. The investigated induction hardened samples a constant biaxial residual stress state at the surface .The induction hardening gave rise to compressive and tensile normal residual stresses in the hardened zone and outside the zone, respectively .The quenched and tempered starting microstructure revealed a smooth compression /tension at the case depth after induction hardening compared to the normalized microstructure.
This experimental investigation showed that for the same case depth, the process parameters of induction hardening influence of spiral and flat coil inductors

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