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Efficient Heat Treatment Process on Flywheel Ring Gear

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Abstract: *Gear is very important component to transmit the power from one end to another end. Here we are going to study about the ring gear or Inner gear which used to mount on flywheel which directly meshes with the pinion gear to crank the engine. Here we will conduct study to reduce crack issue after Induction hardening process.Starter ring gear manufactured by coiling, blank ring machining, hobbing and Induction hardening process. Here during manufacturing of gears we go output that gear are getting fractured during its operating conditions so after brainstorming we got to know root cause for this ring gear breakage. There is major contribution of induction heat treatment process which causes building up the compressive stresses in the gear. Then after studying various research papers we found that dual frequency cycle for induction hardening process which reduces the formation of residual stresses. This dual frequency cycle is operating in two intervals first is low frequency cycle and second is high frequency cycle. If heat is transfer in two intervals which helps to austenitize the root of teeth first and flank of teeth in second stage. However, it is not advantageous always have two different frequencies working simultaneously all the time. Many times, depending on the gear geometry, it is preferable to apply lower frequency at the beginning of heating cycle, and after achieving a desirable root heating, the higher frequency can complement the initially applied lower frequency.*
Keywords: *Ring gear, Induction hardening,Dual frequency cycle, Residual stresses.*

I. Introduction

The flywheel ring gear is outer gear which mounts over the flywheel. Shrink fitting process is used to fix the ring gear over the flywheel. This combined assembly of ring gear and flywheel mounted over the crank shaft and engage with starter pinion gear. During performance these all parts are running at the high loading there may cause several chances of fracture or breakage of the gear. Excessive stress generation, improper manufacturing, flaws in heat treatment processes may cause failure of gear. As per requirement we can maintain various heat treatment patterns. In recent years, gear manufacturers gained additional knowledge about the technology can used to produce better quality induction hardened gears and gear with less distortion. Fig. No. 1 shows the assembly of pinion starter gear and flywheel ring gear.

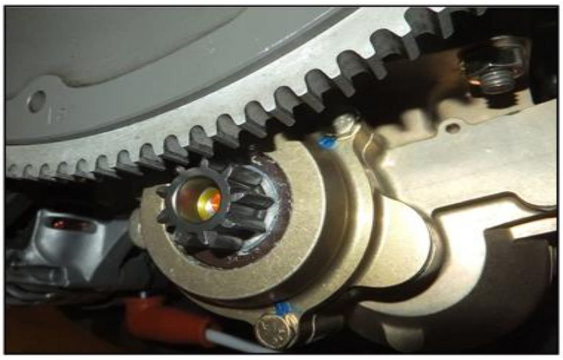

Fig 1: Assembly of Flywheel ring gear and Starter pinion gear

II. Objectives

To constitute an Efficient Heat Treatment Process to avoid the risk of Flywheel Ring Gear Breakage by reducing Internal Stresses:

- Optimization of Induction hardening cycle to achieve specified product parameter.
- Reduce amount of residual stresses in flywheel ring gear.
- Validation of process by measuring stress level on X – ray diffraction method, Gap analysis by cutting the gear
- Reducing the Time Lag between Quench and Temper Operations.

III. Dual Frequency Cycle

There are generally four types that can be used for the hardening process, they are as follows
1) Conventional single frequency concept (CSFC)
2) Pulsing single frequency concept (PSFC)
3) Pulsing dual frequency concept (PDFC)
4) Simultaneous dual frequency concept (SDFC)

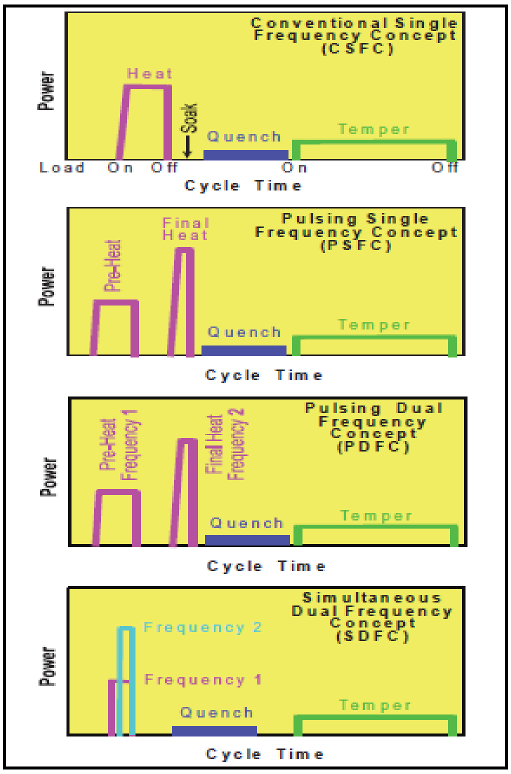

Fig 2: Induction hardening concepts.

If gear is treated under the dual frequency cycle if we see the Fig. No. 4 we can understand then first low frequency cycle will hardened the root of teeth and next to that second high frequency cycle will hardened flank of teeth. After conducting trials for setting up the power factor for the dual frequency cycle the P1 and P2 get finalized this gives us required results for the metallurgical parameters. After conducting trials Power factor % i.e.P1=88 and P2= 90 are finalized for efficient heat treatment process.

IV. Effective Case Depth

Effective case depth of a hardened case is the depth up to a further point, for which specified level of hardness is maintained. Micro Vickers hardness tester is being used to measure the ECD. After taking sectional cut piece of gear lapping and etching process is perform on gear. Then this cut piece hold under the Micro Vickers hardness tester. Then this cut piece move from tip towards the tooth root with giving 0.250 mm interval, 100 X resolution and took reading at every interval.[6]

Table : Hardness reading at every 0.250 mm interval from tip to root of tooth.

Distance from Tip to root of gear tooth in mm	Hardness	
	HV500	HRC
0.25 mm	552.2	52.5
0.50 mm	551.6	52.5
0.75 mm	551.4	52.5
1.00 mm	546.4	52.2
1.25 mm	546.4	52.2
1.50 mm	540.7	51.8
1.75 mm	534.8	51.4
2.00 mm	534.2	51.4
2.25 mm	530.2	51.1
2.50 mm	528.1	51
2.75 mm	523.1	50.7

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3.00 mm	505.4	49.5
3.25 mm	485.9	48.1
3.50 mm	450.6	45.4
3.75 mm	409.7	41.8
4.00 mm	357	36.3
4.25 mm	346.3	35.1
4.50 mm	333.8	33.8
4.75 mm	318.3	32
5.00 mm	301.2	29.9
5.25 mm	298.8	29.6
5.50 mm	297	29.4
5.75 mm	292.6	28.8
6.00 mm	291.4	28.7
6.25 mm	275.6	26.5
6.50 mm	269.1	25.5
6.75 mm	251.6	22.6
7.00 mm	228.2	17.6

V. X-Ray Diffraction Test

X-ray diffraction test is Non-destructive test which is used to measure residual stress which are present in the body. In this measurement system X-rays are emitted from source then these rays are impacted on surface of specimen then these reflected rays are collected at receiver. The measurement of residual stress by X-ray diffraction (XRD) relies on the fundamental interactions between the wave front of the X-ray beam, and the crystal lattice.

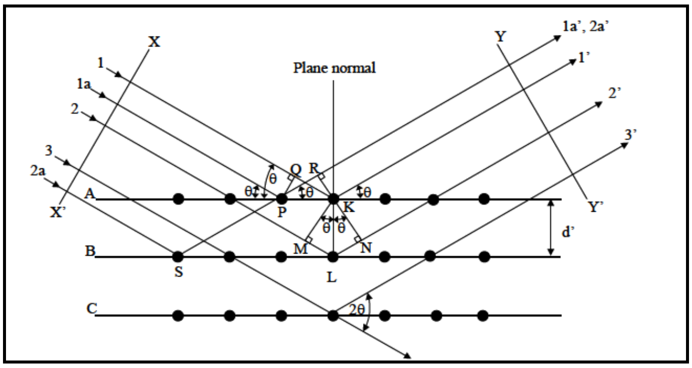

Fig8: Diffraction of X-Ray by crystal lattice.

IV. Gap Analysis

After carrying out X-ray diffraction test we perform the gap analysis test on hardened gear. The selected gears are of two types one was manufactured by our existing process and another was produced from dual frequency cycle. In these test we simply hold the gear under cut off saw then we cut this gear by this same machine and examine the spring force gap in between two cut ends. From this test we observed that the gear which was pass from existing hardening process was more expand than the gear pass from Dual frequency cycle.

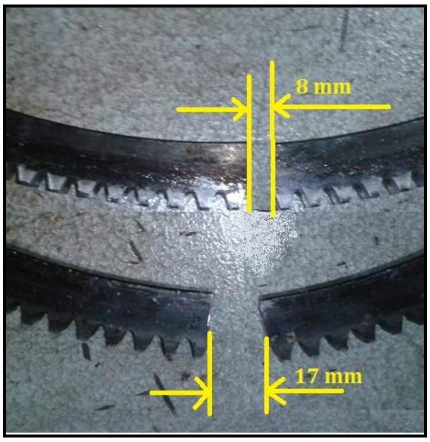

Fig 4: Gap test on ring gear

VI. Result

Adopting the dual frequency cycle for induction hardening, by taking optimized heating time and quenching time and also by taking suitable polymer quenchant adequate results are obtained for the hardness measured value which is within the specification. From XRD test, Gap test is clearly observed that the gears which are produced from dual frequency cycle hardening process has less residual stresses as compared with existing hardening process.The microstructure of the surface of the ring gear after induction hardening also observed by preparing the specimen under the optical metallurgical microscope. From figure it is observed that upto 3.50 mm depth tempered martensite is observed which indicates the hardened surface and then below this combination of tempered martensite, ferrite, pearlite is observed which shows hardness in addition with strength. Core structure of the ring gear shows the ferrite and pearlite which gives the surety about tough core structure which is main intension of the surface hardening treatment,

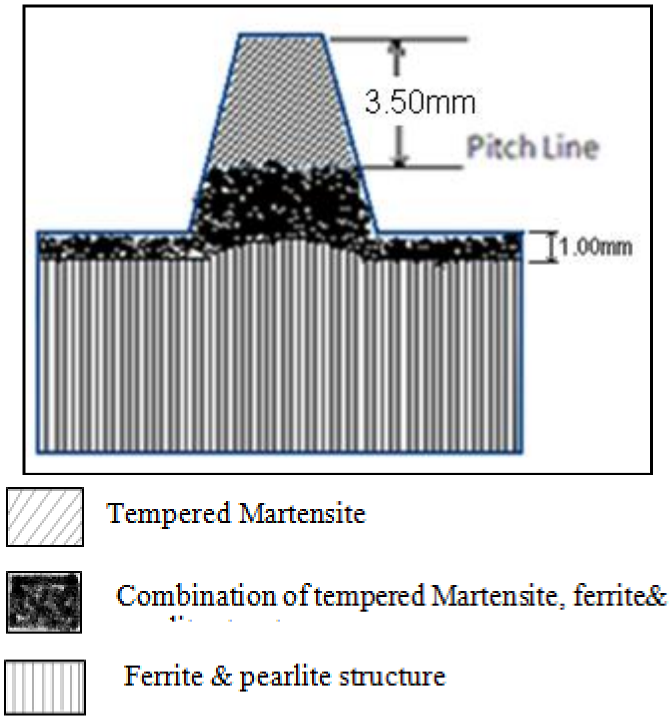

Fig 10: Microstructure of Ring Gear.

VII. Conclusion

- Efficient heat treatment process set for Induction hardening process of gears.
- After implementing Dual frequency hardening process Residual stress i.e. compressive stress reduces from -237.25 MPa to -148.3 MPa.
- After reducing residual stresses from gears, there is no complaint for online ring gear breakage.
- As per specification required ECD maintained

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