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Enhancement in Performance of Connecting Rod Using Surface Treatment Process

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Abstract: *Connecting rods are used in every vehicle. A fracture of the connecting rod in the running engine leads to a failure of the engine So great attention is paid to the connecting rods, eliminating stress risers by such techniques as grinding the edges of the rod to a smooth radius, shot peening to induce compressive surface stresses (to prevent crack initiation), balancing all connecting rod/piston assemblies to the same weight and Magnafluxing to reveal otherwise invisible small cracks which would cause the rod to fail under stress. But still there is need of enhancement of connecting rod. Therefore, in this paper surface treatment processes like Hardening and Tempering, Nitriding, Carburizing process were done on specimen to increase its performance. The processes and various testing are done on the sample specimens in furnace and lab respectively. By various testing and processes, various parameter of connecting rod are measured like Tensile Strength, Hardness, Microstructure, and Corrosive Resistance, Toughness. Then parameters of before heat treatment and after heat treatment are shown.*
Keywords*-20MnCr5, Connecting Rod, Heat treatment process*

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I. INTRODUCTION

A connecting rod is a component which is connected to piston by Gudgeon Pin and crank by Crank Pin in a reciprocating engine. Together with the crank, it forms a simple mechanism that converts reciprocating motion into rotating motion. A connecting rod also converts rotating motion into reciprocating motion. The body of the connecting rod is dominantly loaded against the pressure of the gas force and the tensile force due to inertial forces. Both the maximum gas force and maximum value of the inertialforce occur in the expansion stroke. These forces generate the minimum and maximum normal stress within the cross-section of the body of the connecting rod.[1]

The connecting rod is an element of the internal combustion engine that transmits motion and forces amongst the piston and crankshaft. Due to the cyclical nature of internal combustion (IC) engine work process, all moving elements are subjected to variable loads and change in the direction of motion. The body of the connecting rod is dominantly loaded against the pressure of the gas force and the tensile force due to the inertia of the components in motion, either alternative or rotational. Both the maximum gas force and maximum value of the inertial force occur in the expansion stroke. These forces generate the minimum and maximum normal stress within the cross-section of the body of the connecting rod.

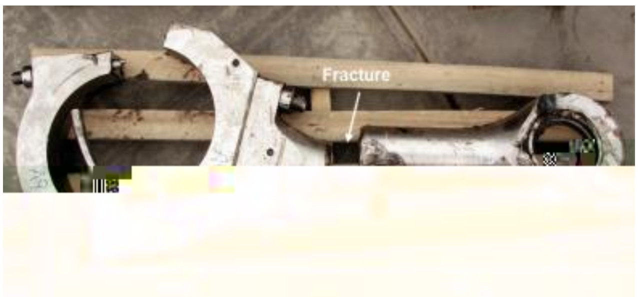

Figure no. 1– Failed Connecting rod

Connecting rods as well as other mechanical parts, which are exposed to variable load, are dimensioned to meet the durable dynamic strength. The dynamic strength is subject to the influence of several parameters. In this case, the condition of the connecting rod surface and material properties are crucial. A fracture of the connecting rod in the running engine leads to a complete stop of the engine. The same occurrence can lead to catastrophic consequences in other engine designs.

II. METHODOLOGY

Method I
- Keep one heat treatment process constant.
- Then study change in strength of the component according to change in hardness.

Method II
- Change heat treatment processes.
- Then compare the strength of the component by keeping hardness nearly constant for various heat treatment processes.

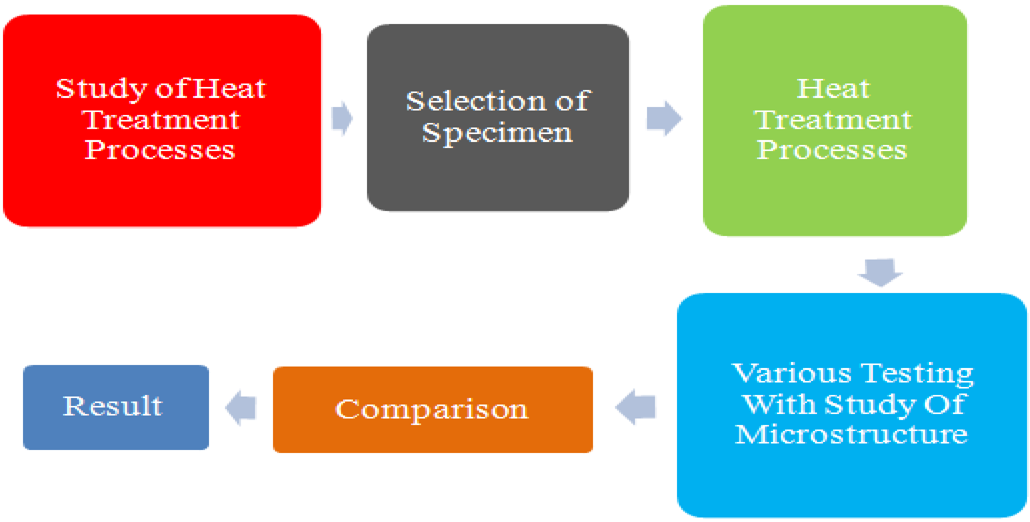

Figure no.2 –Methodology

III. EXPERIMENTAL WORK

Material Selection

Table 1 -Different Materials of connecting rod with Mechanical Properties

Material	Hardness BHN	Young's Modulus of elasticity	Yield strength MPa	Tensile strength MPa	Poisson's ratio %	Density kg/m3
C-70	183	211.5	573.11	965.8	0.3	7850
AISI-4340	217	210	445	745	0.28	7800
35Mn5	167	200	450	765	0.33	7700
Al-360	217	71	363	422	0.33	2680
T-2024	125	80	370	495	0.33	2760
Al-7068	190	73.1	655	683	0.33	2850
20Mncr5	179	210	750	1100.83	0.28	7800

The Aluminum alloys are less expensive as well as less durable. The C-70 material cannot be heat treated. The AISI 4340 and 20MnCr5 are both alloy steels hence their properties are almost same. Therefore selected material is 20MnCr5 because of its availability and durability.

The 20MnCr5 material is selected for the Hardness Test, Tensile Test, Impact Test, Salt Spray Test and Microstructure. For the ease of operations while testing, sample bars are taken of the 20MnCr5 material.

Figure no.3 -Unprocessed Component

Composition of 20MnCr5 material is as follows

Table 2– Composition

Material	C	Si	Mn	P	S	Cr
20CrMn5	0.2	0.2	1.09	0.021	0.019	1.19

Hardening and Tempering Set Up-

First Hardening process is carried out in the temperature range of 920 ^{0}C for the duration of 2.5 hours then oil cooling is done. Then in the first stage of tempering the components are held in the temperature range of 250 ^{0}C for 2 hours and in second stage of tempering temperature range of 560 ^{0}C for 3.25 hours. After this water cooling is done on the components.

Figure no.4 -Hardening and Tempering Furnace

Nitriding Set Up

The Liquid Nitriding process is carried out in the temperature range of 550 ^{0}C for 4 to 6 hours. After this water quenching is done in the components.

Figure no.5 - Nitriding Furnace

Carburizing Set Up

In the Carburizing process, the components are held for 8 hours in the temperature range of 930 ^{0}C then for 1 hour in the temperature range of 830 ^{0}C. To achieve less hardness value, Tempering is carried out in the temperature range of 200 C for 2.5 Hours. After that oil quenching is done on the components.

Figure no. 6 - Carburizing Furnace

Various Testing Set Up

Hardness Testing

Hardness is a measure of a material's resistance to localized plastic deformation Quantitative hardness techniques have been developed over the years in which a small indenter is forced into the surface of a material to be tested, under controlled conditions of load and rate of application. The depth or size of the resulting indentation is measured, which in turn is related to a hardness number;the softer the material, the larger and deeper is the indentation, and the lower the hardness index number.[9]

Figure no. 7- Brinell hardness testing machine

Tensile Test Set Up

In the Universal Testing Machine, various parameters can be found such as Yield Strength, Ultimate Tensile Strength, % Reduction Area, % Elongation. The specimen is held by suitable means between the two heads of testing machines and subject to a progressively increasing tensile loaded until it fractures a record of load acting on the specimen with the progressive extension of the specimen in the obtained. [8]

Figure no. 8 - Universal Testing Machine

Impact Test Set Up

Materials which show identical properties when tested in tension can show pronounced difference in their properties when tested in a notched Impact Test. In each case a certain mass is released from some distance above the impact point which strikes the specimen. The kinetic energy of the tup or head at the moment of the impact is $(mv^2)/2$ which is the equal to the potential energy of the tup before its released (mgh).

From this it will be seen that the drop height determines the velocity and the drop height and mass jointly determine the energy. For different test and material different levels of kinetic energy and tangential velocity at the point of impact are required and hence this can be achieved by changing the mass of the head and the position of the pendulum are before release. [6]

Figure no. 9 - Charpy Impact Testing Machine

Salt Spray Set Up

The salt spray test is carried out for the determination of Rust. In this test, different components are placed in the chamber which is subjected to environment of 5% NaCl solution. After some time, Red Rust or White Rust or Black Spots are observed on the components depending on the material.

Figure no. 10 - Salt Spray Testing Machine

Microstructure

The microstructure of specimen before heat treatment and after heat treatment is studied with the help of Optical Microscope. In this paper we determined microstructure of unprocessed and hardening-tempering component because remarkable change is observed. But, since Nitriding and Carburizing processes are case hardening processes so no significant change will be observed.

Figure no.11 - Optical Microscope

IV. RESULT AND DISSUSION

Hardness Test Result

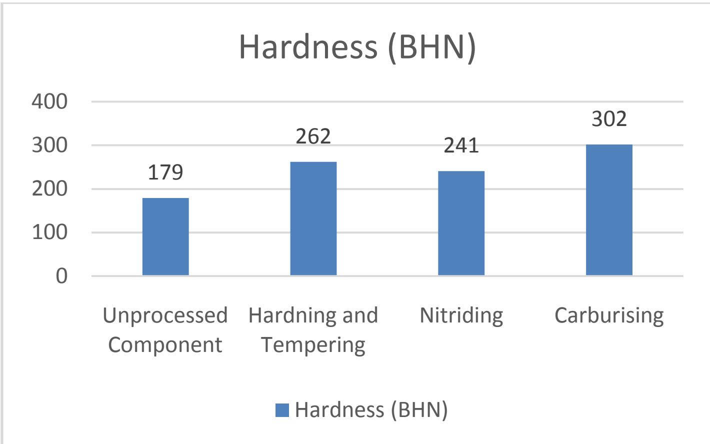

Figure no. 12 - Hardness of Heat Treatment Processes

Tensile Test Result

Table 3 – Tensile Test Result

Tensile Test					
Process	**Test Specimen**	**Y. S. (KN/mm^2)**	**U.T.S. (KN/mm^2)**	**% Elongation**	**Max. Displacement (mm)**
Original Component	1	358	588	25.88	15.29
	2	359	586	25.46	14.84
Hardening and Tempering	1	820	896	18.1	11.19
	2	803	858	17.46	11.41
Nitriding	1	759	818	17	12.89
	2	755	815	17.7	12.37
Carburizing	1	1096	1103	1.34	5.85
	2	1086	1091	1.78	6.21

Following graphs shows load (KN) variation with respect to displacement (mm). From this graph we can get yield load, ultimate load, maximum displacement, fracture point, etc. By dividing area to yield load and ultimate load, we can get yield stress and ultimate stress in KN/mm^2.

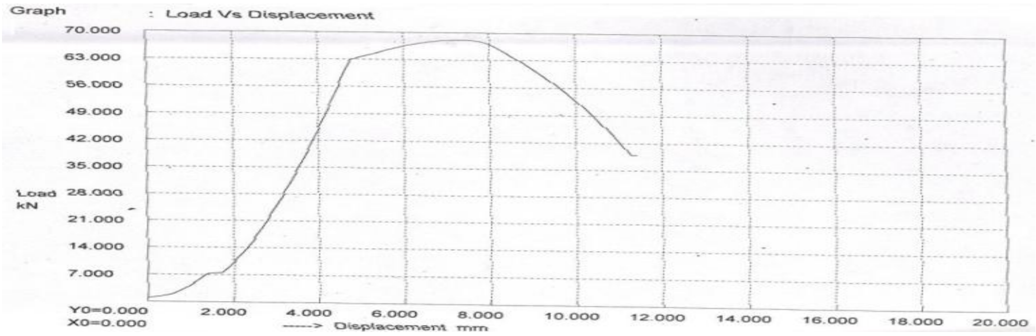

Figure no. 13 – Load vs Displacement Graph of Original Component

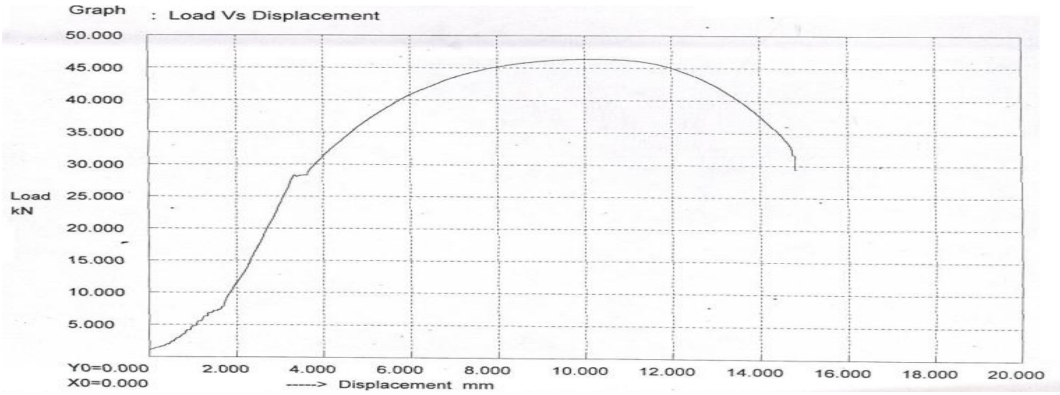

Figure no. 14 – Load vs Displacement Graph of Hardening and Tempering

Figure no. 15 – Load Vs Displacement Graph of Nitriding

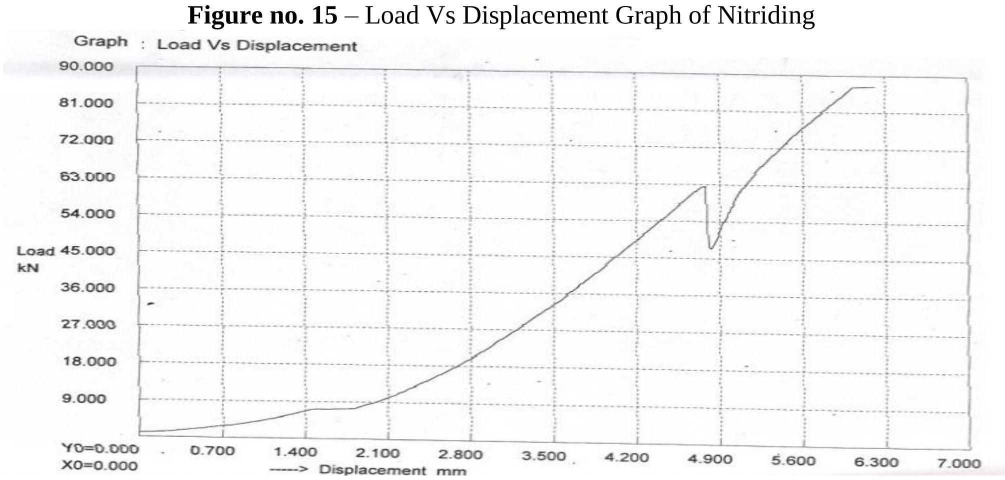

Figure no. 16– Load vs Displacement Graph of Carburizing

Impact Test Result

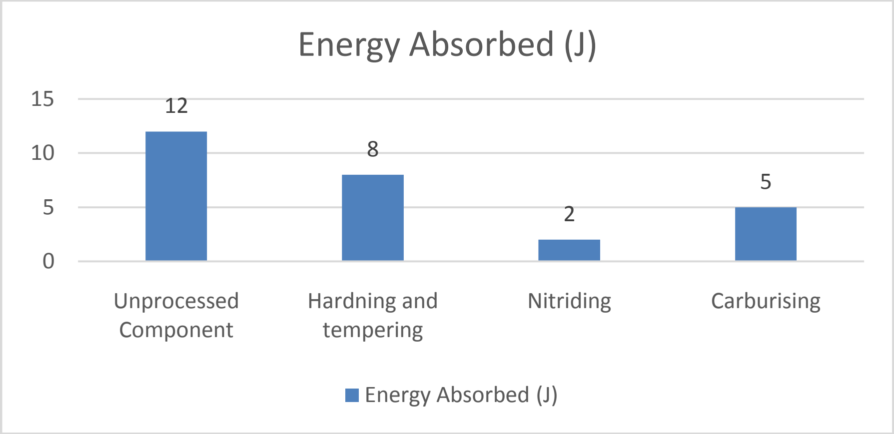

Figure no. 17 – Energy Absorbed during Impact Test

Salt Spray Test Result

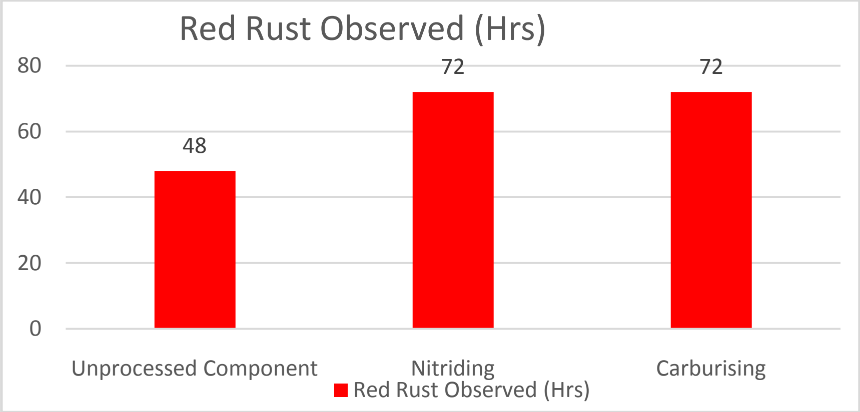

Figure no. 18 – Result of Salt Spray Test

Microstructure Result

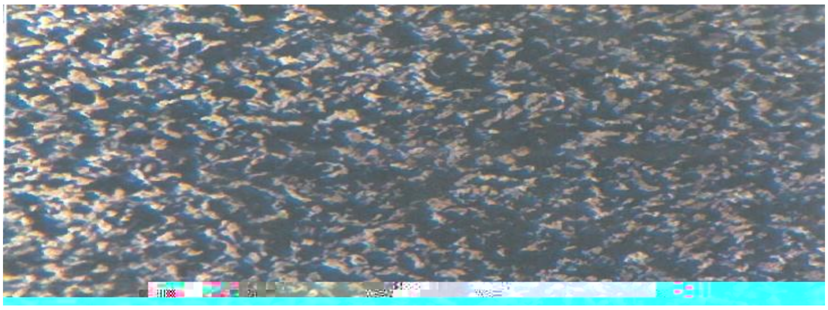

Figure no. 19- Microstructure of Original Specimen

The microstructure reports states that before heat treatment the Uniform distribution of Pearlite and Ferrite structure was observed.

Figure no. 20 - Microstructure of Hardening-Tempering

After Hardening and Tempering the Tempered Martensite Structure was observed because when Martensite is reheated to subcritical temperature after quenching the tempering precipitates and the coagulates carbides. Hence the microstructure consists of carbide particles .often spheroidal in shape, dispersed in ferrite matrix. The result is loss in Hardness but considerable improvement in Ductility and Toughness. [7]

V. CONCLUSION

- Though carburized specimen has more strength, still we can't use it. Because the specimen has become brittle because it has high hardness value, so connecting rod will fail instantly without giving any idea before failure.
- It is important to increase hardness up to certain level; beyond that level toughness of that component will decrease.
- By above result, due to Nitriding and Carburizing process, corrosion resistance had increased compare to original component i.e. in idle condition of vehicle these connecting rod are more durable than that of original one.
- Because of Nitriding and Carburizing process Wear Resistance of the component increases, which is useful in case of 2-wheeler connecting rod where, there is continuous wear and tear of connecting rod with crank shaft and no provision of cap.
- Hardening and tempering process has optimum results. It shows nearly same tensile strength and hardness as carburizing process and also it shows nearly same impact strength as original component.

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