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TESTING OF MECHANICAL PROPERTIES OF STEEL EN39 AND EN41B: COMPARISION STUDY WITH EN19

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Abstract: The Camshaft is the most crucial part of an internal combustion engine. The camshaft's role in the engine is to control the valve timing, ensuring that the intake valves open at the proper time to feed air and fuel into the engine. The second part of this operation is to give the exhaust sufficient time to escape out of the combustion space before the whole process starts over again. The diesel engine 523 camshaft is made by EN19 Steel material. However, EN19 steel material has low wear resistance and it cannot have longer service life. In camshaft, particularly lobes suffer wear over time to a point where valve lift is reduced and engine performance is degraded.

To overcome above said problem in camshaft an alternate material namely, Nitrite steel EN41B has been identified and analyzed for its performance. The mechanical properties of EN19 Steel and Nitride steel EN41B Material ware analyzed and compared using three types of mechanical tests namely hardness test, impact test and wear test.

1. INTRODUCTION

The camshaft is an apparatus often used in piston engines to operate poppet valves. It consists of a cylindrical rod running the length of the cylinder bank with a number of oblong lobes or cams protruding from it, one for each valve. The cams force the valves -open by pressing on the valve, or on some intermediate mechanism, as they rotate.

Depending on the location of the camshaft, the cams operate the valves either directly or through a linkage of pushrods and rockers. Direct operation involves a simpler mechanism and leads to fewer failures, but requires the camshaft to be positioned at the top of the cylinders. In the past when engines were not as reliable as today this was seen as too much bother, but in modern gasoline engines the overhead cam system, where the camshaft is on top of the cylinder head, is quite common. Some engines use two camshafts each for the intake and exhaust valves; such an arrangement is known as a double or dual overhead cam (DOHC), thus, a V engine may have four camshafts.

PROBLEM IDENTIFICATION

The diesel engine 523 camshaft are generally made by EN19 Steel material. However, EN19 steel material has low wear resistance and its service life is shorter. In camshaft, particularly lobes suffer wear over time to a point where valve lift is reduced and engine performance is degraded. Also it necessitates frequent replacement leading to loss of time and money of the camshaft.

There are three types of cam followers, and since the type of follower influences the profile of the cam it is worthwhile considering the advantages and disadvantages of each type. The three types are the knife-edge, the roller follower and the flatfoot or mushroom follower.

Chemical Composition EN 19 Steel

Fe	96.86%
C	0.382%
Si	0.213%
Mn	0.912%
P	0.0093%
S	0.012%
Cr	1.04%
Mo	0.233%
Ni	0.228%
Al	0.0421%
Cu	0.0634%

Nitride Steel 41B

To overcome above said, problem in camshaft an alternate material namely, Nitrite steel EN41B has been identified, chosen and analyzed for its performance.

Chemical Composition of Nitride Steel EN 41B

Al	1.20 %
C	0.40 %
Cr	1.60 %
Fe	95.55 %
Mn	0.60 %
Mo	0.35 %
Si	0.30 %

Application of Nitride Steel EN 41B

- Die casting dies
- Gears
- Plungers and cylinders
- Abrasive wheels
- Plastic mould parts
- Spindles

CASE HARDENING

The case hardening (or) surface hardening is the process of hardening the surface of metal, often low carbon steel, by infusing element into the material surface, forming a thin layer of a harder alloy.

Types of case hardening

a) Flame and induction hardening
b) Carburizing
c) Nitriding
d) Cyaniding
e) Carbonitriding

INDUCTION HARDENING

Induction heating is a non contact heating process which utilizes the principle of electromagnetic induction to produce heat the surface layer of a work-piece. By placing a conductive material into a strong alternating magnetic field electrical current can be made to flow in the steel thereby creating heat due to the I2R losses in the material. In magnetic materials, further heat is generated below the curie point due to hysteresis losses. The current generated flows predominantly in the surface layer, the depth of this layer being dictated by the frequency of the alternating field, the surface power density, the permeability of the material, the

heat time and the diameter of the bar or material thickness. By quenching this heated layer in water, oil or a polymer based quench the surface layer is altered to form a martensitic structure which is harder than the base metal.

Impact Test for Nitrite Steel EN41B

Identification : Nitride steel EN41B

Type of test : Charpy V-notch 2mm depth

Specimen size : 10mm x 10mm x 55mm

IDENTIFICATION	IMPACT ENERGY IN JOULES
NITRIDE STEEL EN41B	40
	39
	40

Impact Test for Nitrite Steel EN19

Identification : Nitride steel EN19

Type of test : Charpy V-notch 2mm depth

Specimen size : 10mm x 10mm x 55mm

IDENTIFICATION	IMPACT ENERGY IN JOULES
EN 19 STEEL	28
	30
	29

ROCKWELL HARDNESS TEST

During the test, the specimen is placed on the anvil and is raised till it comes in contact with the indenter. A minor load of 10kg is applied on the specimen and the small pointer indicates 'set'. Now the main pointer is also brought to the 'set' position. Then the major load is applied and it allowed continuing for one second. For B scale a total load of 100kg is employed with a 1.58 mm diameter ball indenter. For C scale a total load of 150kg with a diamond cone diameter ball indenter. An oil dashpot device helps in controlling the rate of application of load. Reading of the hardness given by the main pointer is taken on the scale corresponding to the indenter. The reading taken is prefixed by RHB for B scale and by RHC for C scale.

Before Induction Hardening

Hardness Test for Nitride Steel EN41B

SERIAL NUMBER	HARDNESS
1	17HRC
2	16HRC
3	17HRC

After Induction Hardening

Hardness Test for Nitride Steel EN41B

SERIAL NUMBER	HARDNESS
1	58HRC
2	58HRC
3	58HRC

Before Induction Hardening

Hardness Test for EN19 Steel

SERIAL NUMBER	HARDNESS
1	13HRC
2	13HRC
3	13HRC

After Induction Hardening

Hardness Test for En19 Steel

SERIAL NUMBER	HARDNESS
1	40HRC
2	40HRC
3	40HRC

PIN ON DISC

A pin on disc tribometer is the standard equipment used to determine the sliding friction coefficient and wear resistance of surfaces. The tester consists of a stationary "pin" under an applied load in contact with a rotating disc. Either the pin or the disc can be wear- and friction-tested using the pin on disc tester. The pin is usually a sphere however it may be any geometry that simulates the actual application counter surface. A load cell attached to the pin on disc tester is used to measure the evolution of the friction coefficient with sliding distance. Sliding wear of the disc can be measured after the pin on disc test using a simple piece of equipment called a Calo tester. The pin on disc test has proved particularly useful in providing a simple wear and friction test for low friction coatings on machine components, such as the valve train, particularly in motor sports. These components are now coated with low frictioncoatings such as diamond-like carbon to reduce energy losses and the requirement for lubricant.

WEAR TEST RESULT

MATERIAL	WEAR
EN 19 STEEL	7 MICRONS
NITRIDE STEEL 41B	5 MICRONS

The percentage of wear resistance

$$= \frac{7-5}{5} \times 100 = 40\%$$

Therefore, the Nitride steel has 40% higher wear resistance than EN19 steel.

RESULT

Hardness Test Result

MATERIAL	HARDNESS	
	BEFORE INDUCTION HARDENING	AFTER INDUCTION HARDENING
EN 19 STEEL	13HRC	40HRC
NITRIDE STEEL 41B	17HRC	58HRC

Before Induction Hardening The percentage of hardness $= \frac{17-13}{13} \times 100 = 31\%$

Therefore, the Nitride steel EN41B has 31% higher hardness than EN19 Steel.

After induction hardening The percentage of hardness $= \frac{58-40}{40} \times 100 = 45\%$

Therefore, the Nitride steel EN41B has 45% higher hardness than EN19 Steel

Toughness

Toughness Test Result

MATERIAL	IMPACT ENERGY IN JOULES
EN 19 STEEL	29
NITRIDE STEEL 41B	40

The percentage of toughness

$$= \frac{40-29}{29} \times 100 = 38\%$$

Therefore, the Nitride steel has 38% higher toughness than EN19 steel.

CONCLUSION

In this project the suitable alternate material Nitride steel EN41B has been identified and analyzed for the diesel engine 523 camshaft instead of EN19 Steel material. Since the existing material necessitates frequent replacement leading to loss of time and money. Mechanical properties such as hardness, toughness and wear resistance of Nitride steel EN 41B were studied. The results obtained from hardness test indicated that the hardness of the Nitride steel EN 41B is 31% higher than EN19 Steel before induction hardening and the hardness of the Nitride steel EN41B is 45% higher than EN19 steel after induction hardening with 1.5mm case depth. Impact test indicated that the toughness of Nitride steel EN41B is 38% higher than EN19 steel. Pin on disc test indicated that the Nitride steel has 40% higher wear resistance than EN19 steel. In addition, ANSYS results showed that Nitride steel EN41B camshaft suffered lower displacement than EN19 steel camshaft for all load conditions. From these results it can be observed that camshaft made using Nitride steel EN41B has higher service life.

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