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An Experimental Investigation for Wear Rate Optimization on Different Gear Materials Using Hardening

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ABSTRACT
An Experimental Investigation for Wear Rate Optimization on Different Gear Materials (EN8, 8620 & MILD STEEL) Using Hardening." mainly focuses on the mechanical design and analysis of gearbox as transmit the power and live long life. Gears play an essential role in the performance of many products that we rely on in our everyday lives. Gears are mainly used in lathes machines, automobiles and all torque transmitting units. The improved mechanical properties achieved by hardening process. This research focuses on optimizing wear rate of different gear materials using hardening process. The main Objective of this research is to find out the best material for manufacturing gear by hardening process.

Keywords: Experimental Investigation, Hardening, Gears manufacturing

I. INTRODUCTION TO GEARS MANUFACTURING

An enclosed system of assembled gears that transmits mechanical energy from a prime mover to an output device. A gear can also change the speed, direction, or torque of mechanical energy. A gearbox, also known as a gear case or gear head, is a gear or a hydraulic system responsible for transmitting mechanical power from a prime mover (an engine or electric motor) into some form of useful output. It is referred to the metal casing in which a number of gears are sealed gear heads are available in different sizes, capacities and speed ratios. Their main function is to convert the input provided by an electric motor into an output of lower rpm and higher torque. A gear is precisely bored to control gear and shaft alignment. It is used as a housing/container for gear oil. It is a metal casing for protecting gears and lubricant from water, dust and other contaminants.

II. METHODOLOGY

Selection of Gear Material

Materials and process selection are key issues in optimal design of industrial products. Recently many materials which have long been used in industry are being replaced by newer materials in order to meet demands of cost reduction and better performance. In the manufacture of mechanical parts, knowledge of material properties, cost, design concepts and their interactions is required. The large number of available materials, together with the complex relationships between the various selection parameters, oftenmakesthe selection processes a difficult task. When selecting materials, a large number of factors must be taken into account. These factors are mechanical properties, physical and electrical properties, corrosion resistance, environmental friendliness and economy. In mechanical design, however, mechanical properties are the most important. The most important mechanical material properties usually encountered in material selection process are fatigue strength, tensile strength, yield point, hardness, stiffness, toughness, creep resistance and density. The first step in the material selection is to specify the performance requirements of the component and to broadly outline the main materials characteristics and processing requirements. Accordingly, certain classes of materials may be eliminated and other chosen as probable candidates for making the component. Then, the relevant material properties are identified and ranked in order of importance. Then, optimization techniques are used to select the best material. There are a few strategies for material selection: on the base experience, on the base trial and error, Ashby method, which is advanced Grenoble team, graph theory and matrix approach. introduced materials selection charts which allow the identification, from among the full range of available materials, the subset most likely to perform best in a given application. He has used a multi-objective optimization method to compromise between several conflicting objectives in material selection. Using computer allows a large amount of information to be treated rapidly.

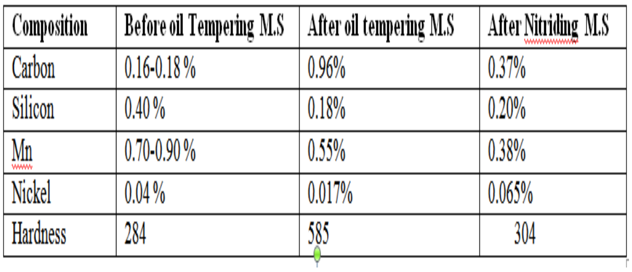
Selection Of Hardening Process

Heat Treatment Is A Critical And Complex Element In The Manufacturing Of Gears That Greatly Impacts How Each Will Perform In Transmitting Power Or Carrying Motion To Other Components In An Assembly. Heat Treatments Optimize The Performance And Extend The Life Of Gears In Service By Altering Their Chemical, Metallurgical, And Physical Properties. These Properties Are Determined by Considering the Gear's Geometry, Power Transmission Requirements, Stresses at Different Points within a Gear under Load, Load Cycling Rates, Material Type, Mating Part Designs, And Other Operating Conditions. Heat Treatments Improve Physical Properties Such As Surface Hardness, Which Imparts Wear Resistance To Prevent Tooth And Bearing Surfaces From Simply Wearing Out. Heat Treatments Also Improve A Gear's Fatigue Life By Generating Subsurface Compressive Stresses To Prevent Pitting And Deformation From High Contact Stresses On Gear Teeth. These Same Compressive Stresses Prevent Fatigue Failures In Gear Roots From Cyclic Tooth Bending. Physical Properties Such As Surface Hardness, Core Hardness, Case Depth, Ductility, Strength, Wear Resistance And Compressive Stress Profiles Can Vary Greatly Depending On The Type Of Heat Treatment Applied. For Any Given Type Of Heat Treatment The Results Can Be Tailored By Modifying Process Parameters Such As Heating Source, Temperatures, Cycle Times, Atmospheres, Quench Media, And Tempering Cycles To Meet SpecificApplicationRequirements. Besides Selecting Heat Treatments That Will Produce A Set Of Desired Physical Properties, Manufacturing Engineers Want To Minimize Distortion Of Dimensions From Treatment Such That Final Proper Fit Into A Gearbox Can Be Achieved. Many Gears Are Machined Into An Oversized Condition Prior To Heat Treatment So That A Planned Amount Of Grind Stock May Be Removed After The Process In Order To Meet Dimensional Requirements. By Selecting Heat Treatment Processes Where Distortion Is Reduced, The Amount Of Grind Stock Needed May Be Reduced To Minimize Machining On Hardened Surfaces After Heat Treatment And Thereby Reduce The Overall Costs Of Manufacturing. Removing Too Much Of The Outermost Portion Of A Case Hardened Gear That Distorted Excessively Will Also egatively Impact The Fatigue Properties And Wear Life Performance. Some Heat Treatment Processes Are Designed To Treat The Entire Surface Of A Gear, While Others Are Selective In Nature. Induction Hardening Or Selective Heating May Be Employed To Harden Just The Gear Teeth Only, Which Can Be An Effective Method Of Reducing The Distortion In A Gear. Masking Of Journals And Keyways May Be Employed In Case Hardening Processes To Keep Them Soft And Allow For Easier Grind Stock Removal After Heat Treatment. Reduction Of Distortion By Intelligent Heat Treatment Process Design Allows Manufacturing Engineers To Improve The Performance And/or Reduce The Overall Costs Of Manufacturing gears.

III. EXPERIMENTAL RUNS

Fig 3.1 Gear after nitriding process

Fig 3.2 Gear after oil tempering



Composition	Before oil Tempering M.S	After oil tempering M.S	After Nitriding M.S
Carbon	0.16-0.18 %	0.96%	0.37%
Silicon	0.40 %	0.18%	0.20%
Mn	0.70-0.90 %	0.55%	0.38%
Nickel	0.04 %	0.017%	0.065%
Hardness	284	585	304

Table 3.1 Chemical composition after oil tempering & nitriding

Table 3.1 Chemical composition after oil tempering & nitriding

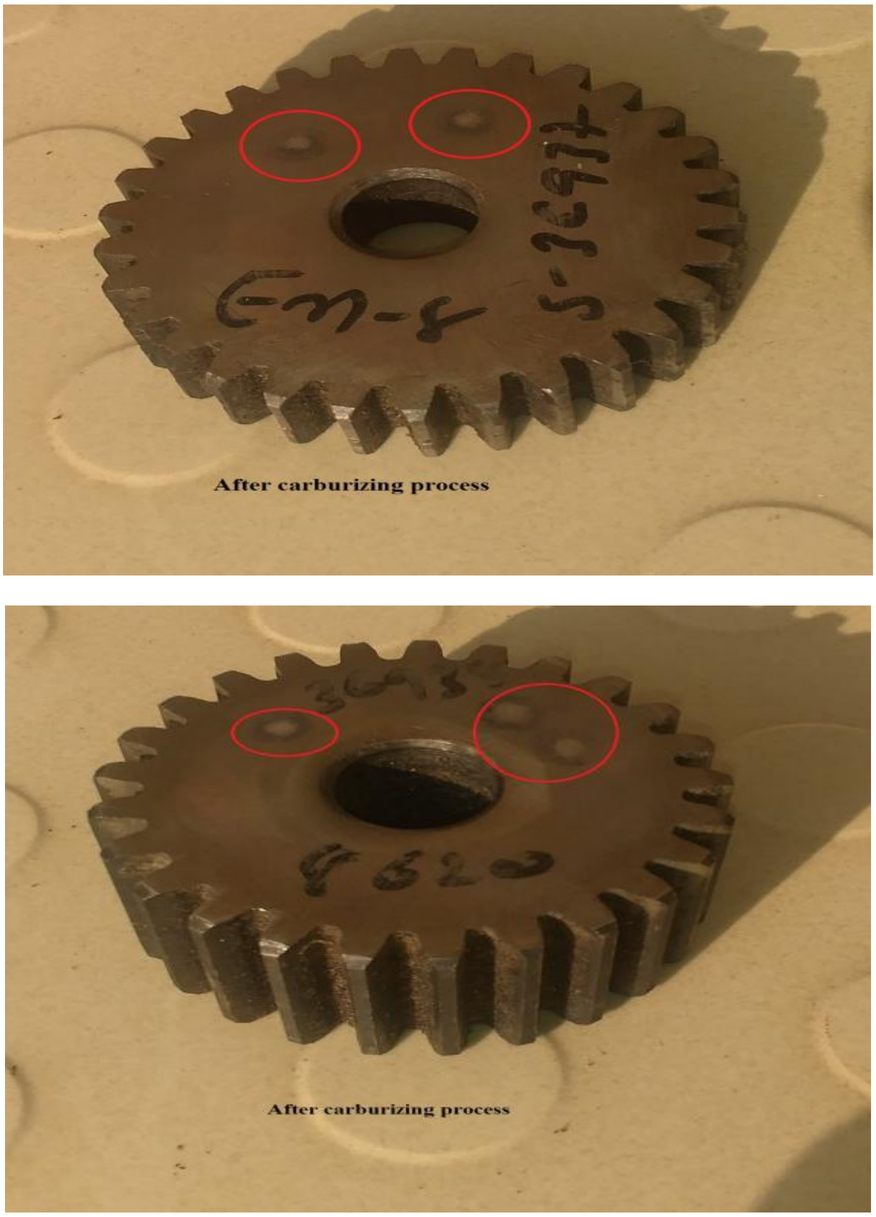


Fig 3.3 Gear after carburizing process

Composition	Before Carburizing of 8620	After Carburizing of 8620
Carbon	0.17%	0.45%
Silicon	0.10%	0.23%
Manganese	0.60%	0.80%
Nickel	0.35%	0.52%
Hardness	240	295

Table 3.2 Chemical composition after carburizing process

IV. WEAR RATE & ANALYSIS

The wear rate of spur gear tooth is given by,

$$F_W = d_p . b . Q . K$$

Where, $Q = \frac{2 . Z_g}{Z_g + Z_p}$

= Ratio factor for external gear pair

$$K = 0.16\left[\frac{BHN}{100}\right]^2$$

=Load – stress factor, N/mm^2

F_W = Wear strength of gear tooth, N

d_p = diameter of pinion, mm

b = face width, mm

Final optimization of wear rates

$$F_W = d_p.b.Q.K$$

In this equation, we find the wear rate,

d_p = 72 mm

b = 108 mm

Q = 1

❖ **In MILD-STEEL [M.S],**

$$F_W = 72 * 108 * 1 * \left[\frac{0.16 * 304}{100}\right]^2$$

$$= 11498.37 \quad N$$

❖ **In EN 8 ,**

$$F_W = 72 * 108 * 1 * \left[\frac{0.16 * 437}{100}\right]^2$$

= 23760.25 N

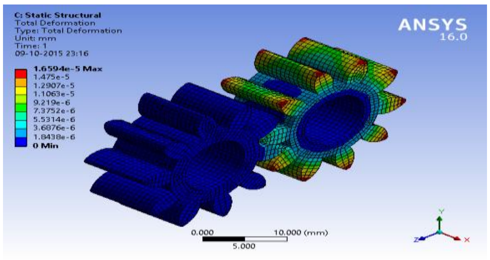
❖ **In 8620 ,**

$$F_W = 72 * 108 * 1 * \left[\frac{0.16 * 295}{100}\right]^2$$

$$= 10827.31 \quad N$$

V. OPTIMIZATION USING ANSYS

FOR MILD-STEEL
TOTAL DEFORMATION



EQUIVALENT ELASTIC STRAIN

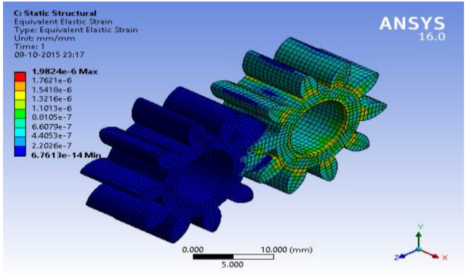
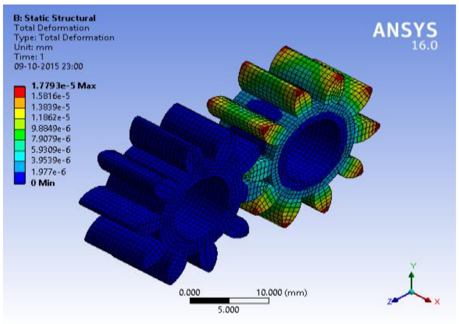
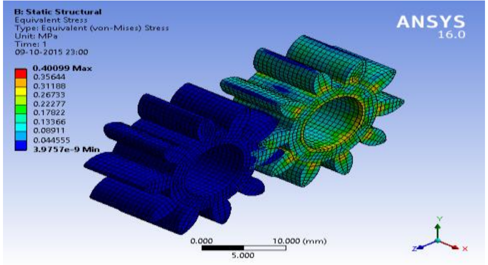


Fig 4.1 MILD STEEL ANALYSIS IN ANSYS

FOR EN 8 TOTAL DEFORMATION



EQUIVALENT ELASTIC STRAIN



SHEAR STRESS

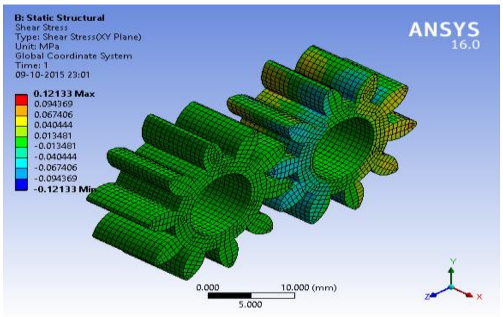
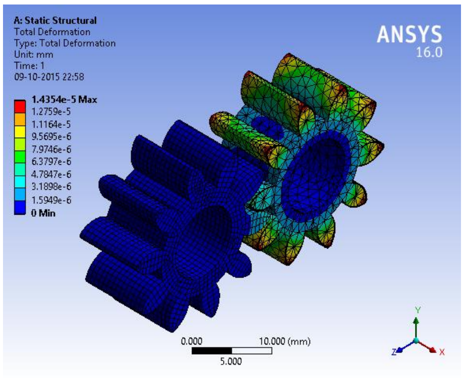


Fig 4.2 EN8 ANALYSIS IN ANSYS

FOR 8620
TOTAL DEFORMATION



EQUIVALENT STRESS

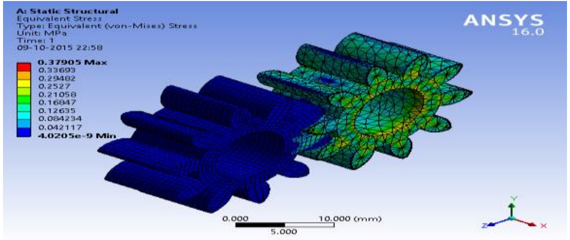


Fig 4.3 8620 ANALYSIS IN ANSYS

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