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A Review on Reduction Box

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Abstract - A gear is a rotating machine part having a cut tooth, which meshes with another toothed part in order to transmit torque. Gears are mainly typed like spur gears, helical gears, double helical gears, bevel gears, crown gears, hypoid gears, worm gears, rack and pinion, epi cyclic gears etc.
There is a great need for efficient and compact gear boxes in automotive and industrial applications to improve upon their power density while reducing their dynamic vibration and noise deliveries.The less efficiency of gear box of a machine tool is a serious problem as it increases maintenance cost and affects the reputation of a firm. Whenever a frequent change in speed/torque at the output is required, we use multispeed multistage gearbox.

Keywords: - Reduction Box, Bending stress, Contact stress, Gearbox design, Assembly Analysis, Spur gear, Gear Design.

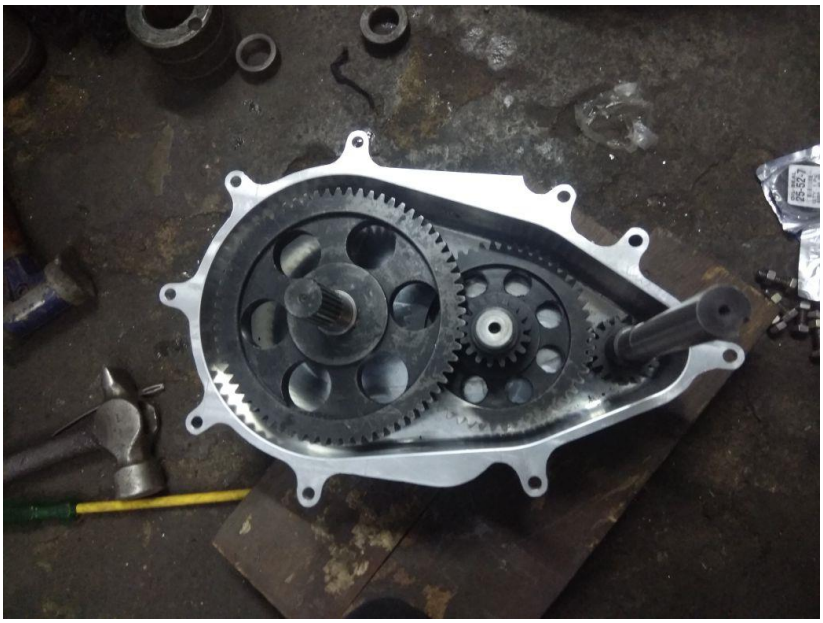


Figure 1: Open gearbox casing

I. INTRODUCTION

A gearbox can be simple or complex and is a machine that is used to transfer rotational energy from a motor to another device. They are generally used to increase the torque while decreasing rotational speed, they do not have any effect on the power developed by the motor because as torque increases, rotational speed decreases and vice versa.
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. A gearbox is a set of gears for transmitting power from one rotating shaft to another. They are used in a wide range of industrial, automotive and home machinery application.
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.Many machines that are used today are made up of a power source and a gearbox. Gearboxes are essential in vehicles because without gearbox cars would have very limited top speed. A gearbox can be used in many different applications such as, generation power and construction.

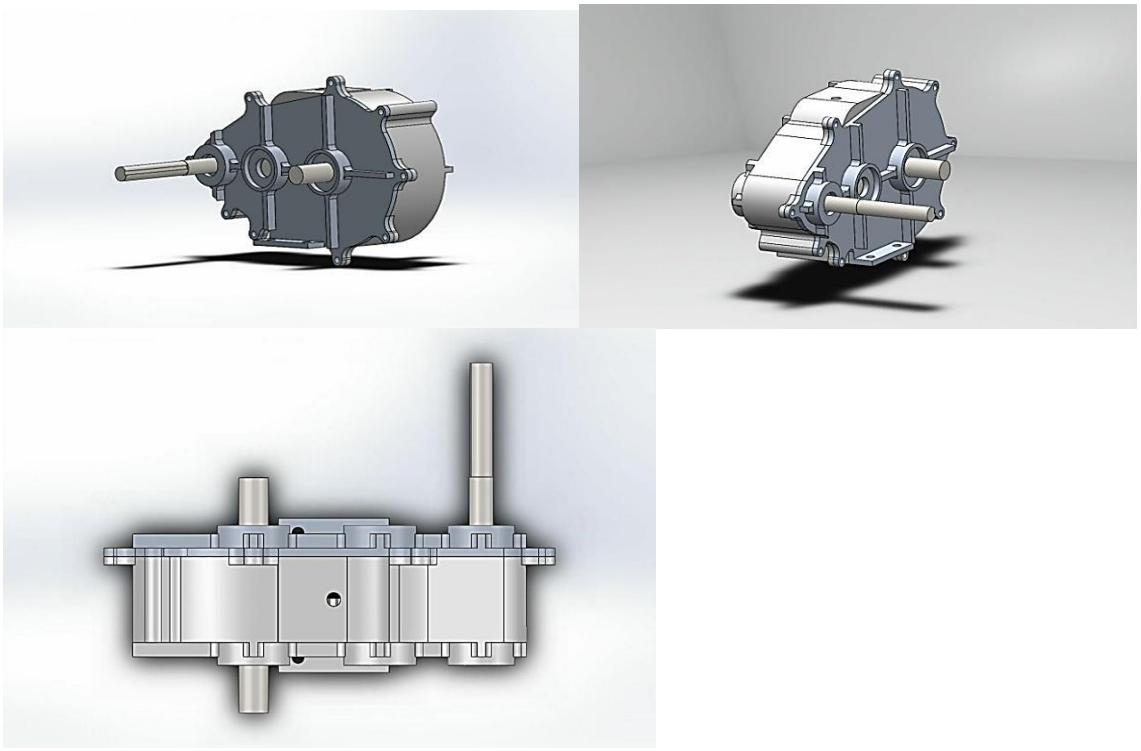


Figure 2: CAD model of assembly

Necessity and functions

The gear box is necessary in the transmission system to maintain engine speed at the most economical value under all conditions of vehicle movement. An ideal gear box would provide an infinite range of gear ratios, so that the engine speed should be kept at or near that the maximum power is developed whatever the speed of the vehicle.

To provide the high torque at the time of starting, hill climbing, accelerating and pulling a load since high tractive effort is needed. It permits engine crankshaft to revolve at high speed, while the wheels turn at slower speeds. Vehicle speed can be changed keeping engine speed same with certain limit.

II. LITERATURE REVIEW

Spur Gear Tooth Stress Analysis and Stress Reduction

Gears are commonly used for transmitting power. The repeated stressing on the fillets causes the fatigue failure of gear tooth. The main objective of this study is to add different shaped holes to reduce stress concentration.

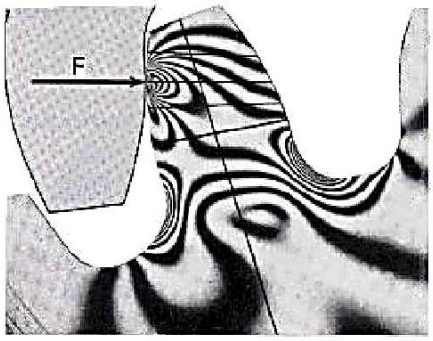


Figure 3: Stresses occurring on meshing of gears [1]

Observation: Stress relieving feature having a shape of aero-fin is used in the path of stress flow which helped to regulate stress flow by redistributing the lines of force. This also yielded better results when compared to elliptical and circular holes. In this study, the best result is obtained by introducing aero-fin hole at (38.7653, 65.4083, 0) and having scaling factor of 0.6. The result displayed a stress reduction by 50.23% and displacement reduction by 45.34%.

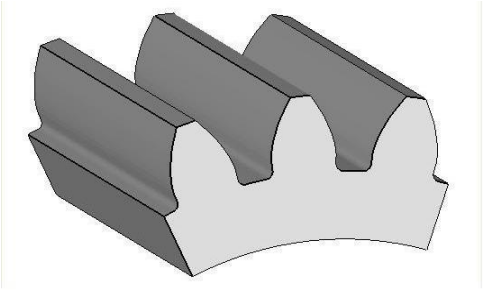


Figure 4: Extruded Spur gear [1]

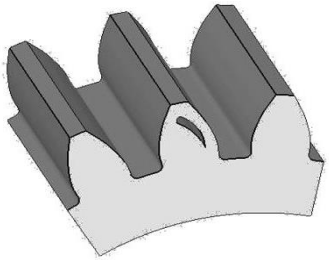


Figure 5: Spur gear with aero-fin hole [1]

Stress Analysis Spur Gear Design by Using Ansys Workbench

Spur gear have straight tooth and are parallel to the axis of the wheel. s. A pair of spur gear tooth in action is generally subjected to two types of cyclic stress: contact stress and bending stress including bending fatigue. Both stresses may not attain their maximum values at the same point of contact fatigue. These types of failure can be minimized by analysis of the problem during the design stage and creating proper tooth surface profile with proper manufacturing methods. In this paper using ansys work bench software, bending stress, contact stress and static load on the tooth of spur gear drive is found.

Observation: The finite element method is most widely for find a real model of the geared set using the stress analysis in the pair of gears. contact stress calculation and bending stress calculation is play more significant role in the design of gears. Hertz theory is the basis of contact stress calculation and Lewis formula is use for calculating bending stress is a pair of gear. As a result, based on this finding if the contact stress minimization in the primary concern and if the large power is to be transmitted then spur gears with higher model is preferred. Hence we conclude that analysis software can be used for other analyzing purpose.

Design and Structural Analysis of Differential Gearbox at Different Loads

The main aim of this paper is to focus on the mechanical design and analysis on assembly of gears in gear box when they transmit power at different speeds i.e-2500 rpm, 5000 rpm and 7500 rpm. Analysis is also conducted by varying the materials for gears, Cast Iron, Cast Steels and Aluminum Alloy. Presently used materials for gears and gear shafts are Cast Iron, Cast steel. It is made clear in this paper that Aluminum is used for reducing the weight of the product. The analysis is done in Cosmos software. Modeling and assembly is done in Solid Works.

Table1: Stress Strain Values at 2400RPM[3]

Material	Ni Cr Alloy steel	Aluminum Alloy	Cast iron
Tangential Load(N)	2093.8	2922.51	3243.08
Displacement(mm)	0.00615413	0.0241696	0.0100566
Stress(N/mm^2)	2.29414	3.19018	3.57544
Strain	$1.0400e^{-5}$	$4.1593e^{-5}$	$1.69558e^{-5}$
Static load	56141.9	18143.3	37933.7
Displacement(mm)	0.164988	0.150063	0.11763
Stress(N/mm^2)	63.5052	19.8068	41.8212
Strain	0.000280882	0.000258239	0.000198329

Table2: Stress Strain Values at 5000RPM[3]

Material	Ni Cr Alloy steel	Aluminum Alloy	Cast iron
Tangential Load(N)	1818054	1595.22	1770.24
Displacement(mm)	0.0054118	0.0131944	0.00548866
Stress(N/mm^2)	2.584	1.70369	2.01579
Strain	$1.04958e^{-5}$	$2.2558e^{-5}$	$9.32532e^{-6}$
Static load	56141.9	18143.3	37933.7

Displacement(mm)	0.164853	0.150036	0.117614
Stress(N/mm^2)	74.4963	22.6949	43.1949
Strain	0.000309415	0.000274774	0.000199826

Table3: Stress Strain Values at 6400RPM [3]

Material	Ni Cr Alloy steel	Aluminum Alloy	Cast iron
Tangential Load(N)	915.177	1276.18	1416.19
Displacement(mm)	0.00268949	0.0105555	0.00439091
Stress(N/mm^2)	1.03521	1.36296	1.61261
Strain	$4.57869e^{-6}$	$1.80467e^{-5}$	$7.46017e^{-6}$
Static load	56141.9	18143.3	37933.7
Displacement(mm)	0.164873	0.11763	0.117614
Stress(N/mm^2)	61.8853	19.3772	41.8212
Strain	0.000290205	0.000256567	0.000198329

Observation: using Aluminum Alloy is safe for differential gear. When comparing the stress values of the three materials for all speeds 2400rpm, 5000rpm and 6400 rpm, the values are less for Aluminum alloy than Alloy Steel and Cast Iron. By observing the frequency analysis, the vibrations are less for Aluminum Alloy than other two materials since its natural frequency is less. And also weight of the Aluminum alloy reduces almost 3 times when compared with Alloy Steel and Cast Iron since its density is very less. Thereby mechanical efficiency will be increased. By observing analysis results, Aluminum Alloy is best material for Differential.

Finite Element Analysis and Fatigue Analysis of Spur Gear under Random Loading

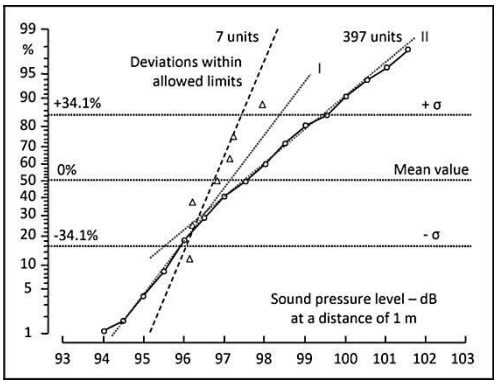
The gear fitted in the gearbox Armored tracked vehicle is vulnerable to considerable fatigue damage over its life period due to the dynamic excitations caused by the terrain undulations. Initially static analysis of the model was carried out to validate the model and the boundary conditions correctness. Further Modal analysis is carried out to determine the dynamic characteristics of the gear model.

Observation:purpose of power transmission and positioned of heavy mass to the desired angle with high accuracy are subjected to fluctuating loads that are random in nature. Therefore, it is analyzed for random loading and also under constant amplitude loading conditions for fatigue analysis and life of gear has been obtained by finite element package ANSYS.

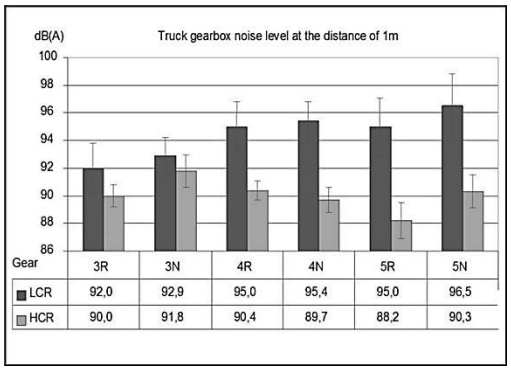
Gearbox Noise and Vibration Prediction and Control

Solving the gear noise problem at the very source to introduce an enclosure as a means to reduce radiated noise, which seems to be easy but its effect on the sound pressure level is small. The gearbox noise problem solution is focused on the improvement of gear design; on the verification of its effect on the radiated noise and the determination of the gears' contribution to the truck's or car's overall noise levels and on the analytical and/or numerical computer-based tools needed to perform the signal processing and diagnostics of geared axis systems. All of the analytical methods are based on the time and frequency domain approach. Special care is addressed to the smoothness of the drive resulting from the transmission error variation during a mesh cycle. This paper will review the progress in technique of the gear angular vibration analysis and its effect on gear noise due to the self-excited vibration. This presentation will include some examples of the use of such approaches in practical engineering problems.

Graph 1: Experimental distribution function of gearbox [5]



Graph 2: The gearbox overall noise level of the HCR gears in comparison with the LCR gears [5]



Gear	3R	3N	4R	4N	5R	5N
LCR	92,0	92,9	95,0	95,4	95,0	96,5
HCR	90,0	91,8	90,4	89,7	88,2	90,3

Observation: This paper reviews the researchwork on reducing truck gearbox noise. Gear design improvement is preferred to protection against noise by using a gearbox enclosure. This approach is more effective than the additional cover. The measurement methods and the effect of improving the gear design focused on the problem of reducing gear noise are described. Gearbox noise and vibration analysis is based on the time and frequency methods. Gearbox noise is tonal with a set of dominating frequency components. The sum of the power contributions of the tooth meshing harmonic components results in the noise level of an individual gear pair. Averaging the acceleration signal in the time domain, synchronized by revolutions and tooth-pitch rotations, results in an averaged tooth mesh response serving to compare the effects of improving gear design. Gear design and accuracy may be tested by the transmission error measurement.

Design of Extruder Helical Gearbox

This paper provides a review of the literature on designing and analysis of a gearbox casing. Gearbox is an important machinery component in any industry. Helical gears are widely used in numerous engineering applications. Industry is facing the problem of higher disassembly time and difficulty in maintenance. As a solution, split casing needs to be developed. Stress analysis is engineering discipline that determines the stress in materials and structures subjected to static and dynamic forces or loads. Vibrational analysis of casing also plays a vital role in proper working of the gearbox. Gearbox with moving parts gives rise to noise and vibration, which reveals the gearbox condition. FEA method is used for static and vibration analysis. In this paper, we have reviewed the current research state of modal analysis and harmonic frequency response on gearbox casing and also an insight into future research and challenges in this field of study.

Figure 6:- XC-16 Helical gearbox [6]

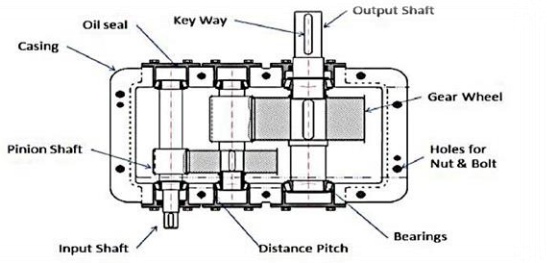


Figure 7:- Helical gearbox assembly [6]

Figure 8: Dimensional assembly modelling of gear case in Pro-E [6]

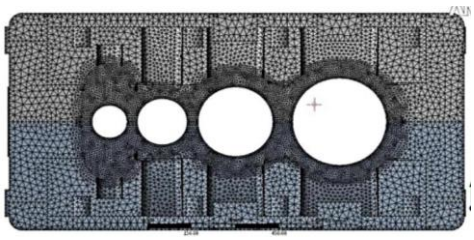


Figure 9: FEA model of gearbox casing [6]

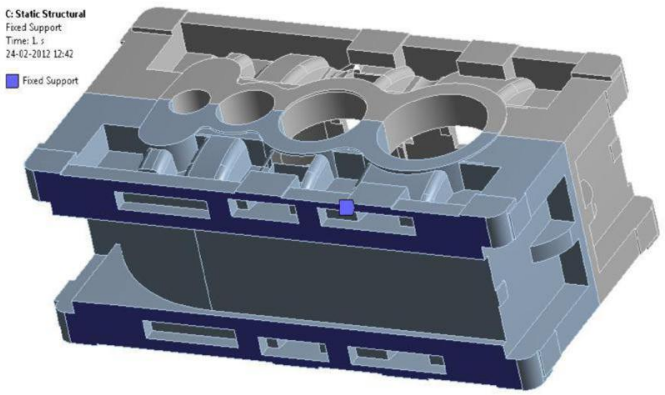


Figure10: Fixed support of bottom in gearbox casing [6]

Observation: Gearbox is an important machinery component in any industry. Helical gears are widely used in numerous engineering applications. The literatures on the gearbox casing recent papers provide design parameters and stress analysis in ansys software. From literatures we can get meshing strategy, boundary condition for gearbox casing. Some researchers studied about vibration analysis on casing. From this modal analysis have been done on gearbox casing and find natural frequency & mode shape. Harmonic frequency response has been applied on casing and find amplitude vs. frequency graph to prevent resonance of gearbox casing.

Optimization of Gearbox Efficiency

Although mechanical gearboxes used as torque and speed converters have already very high efficiency it is not only a task in automotive applications to further decrease gearbox power losses but also in many industrial applications. Different methods are discussed for power loss reduction in a gearbox. No load losses can be reduced, especially at low temperatures and part load conditions when using low viscosity oils with a high viscosity index and low oil immersion depth of the components. This in turn influences the cooling properties in the gear and bearing meshes. Bearing systems can be optimized when using more efficient systems than cross loading arrangements with high preload. Low loss gears can contribute substantially to load dependent power loss reduction in the gear mesh. Low friction oils are available for further reduction of gear and bearing mesh losses. All in all a reduction of the gearbox losses in average of 50 % is technically feasible. The challenge is substantial power loss reduction with only minor impact on load carrying capacity, component size and weight and noise generation. Adequate compromises have to be proposed.

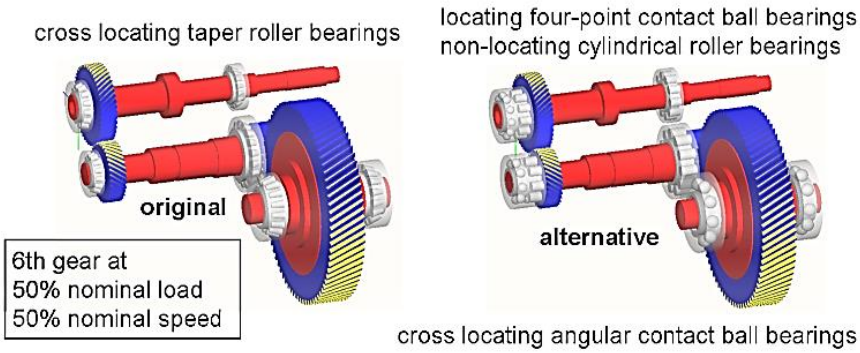
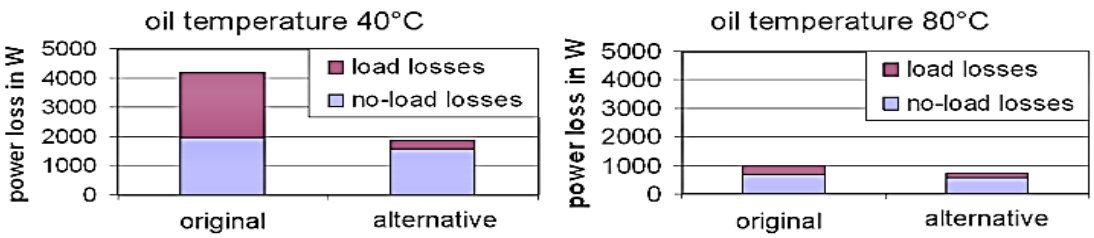
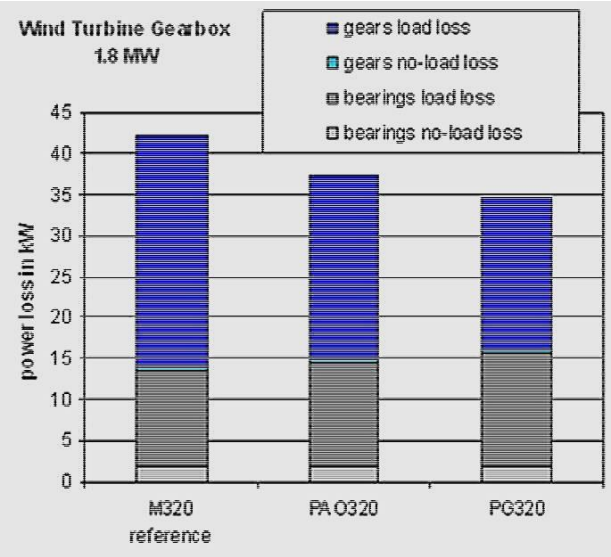


Figure11: Alternative bearing design in a manual transmission with final drive [7]

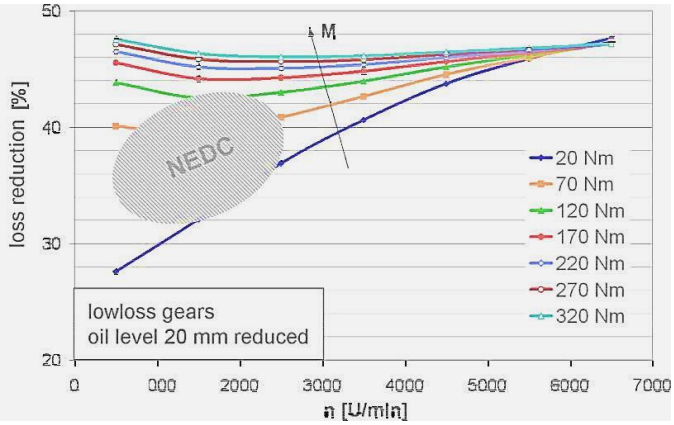
Graph 3: Influence of design and operating temperature on bearing losses[7]



Graph 4: Calculated power loss with different lubricant types for a wind turbine gearbox [7]



Graph 5: Loss reduction with low loss gears and reduced oil level, 2nd gear (acc. Kurth, 2009)[7]



Observation: Dependent on the application and the operating regimes a power loss reduction potential in a gearbox of some 50% was proven to be possible. In some applications only the simple change to a highly efficient lubricant can save some 20% power loss. For maximum efficiency optimization alternative solutions have to be found for gear and bearing design as well as lubricant type, viscosity and supply to the components. The challenges of these new approaches are adequate compromises between power loss reduction on the one hand and load carrying capacity and noise properties on the other hand.

Design and Analysis of Gearbox for Tractor Transmission System

The tractor gear box plays an important role for various torque transmission to assure wider range of speed. Gearbox transmits power from engine to differential of tractor through propeller shaft. Generally tractor consists of gearbox with various configurations. The main objective of Paper is to design tractor gear box of 16 forward speed and 16 reverse speed. Paper work contains analytical method and Duty cycle analysis technique of the tractor gear box. In this Paper work, the significant parameters of gear box like speed, torque etc., are considered while modeling the gearbox. The modeling and the analysis of the gearbox was done using ROMAX software. Validation of the same has been done with the help experimental published data.

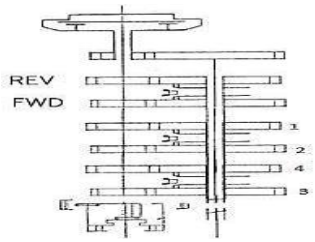


Figure 12: Schematic layout of 8 by 8 tractor gearbox [8]

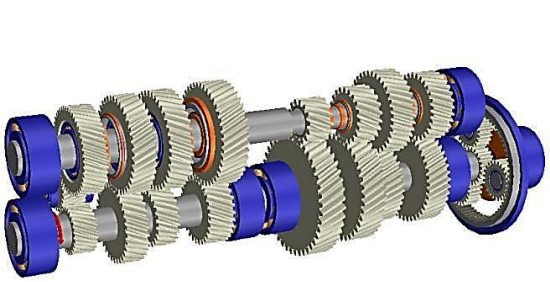


Figure 13: ROMAX model – Isometric view [8]

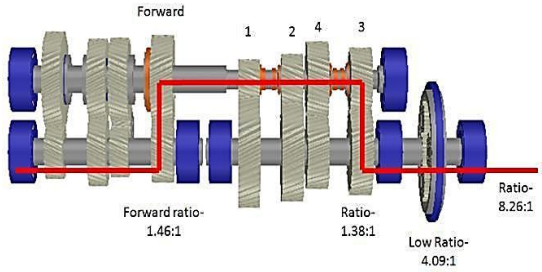


Figure 14: Power flow Diagram for forward 3rd speed [8]

Observation: This paper discusses in detail the design and duty cycle analysis of gears and shafts also selection of bearing for 16 forward speeds and 16 reverse speeds gearbox of tractor application. Given gear ratios are tailored specifically for tractor application.

1. Gears are analysed for safety parameters like root safety, flank safety and scuffing safety by using Romax software.
2. Also gear pair meshing contact pressure and stress distribution was analysed.
3. Factor of safety for all gear pairs are in acceptable range.
4. Shaft are analysed for its deflection, bending and stress distribution.

Design of a Multispeed Multistage Gearbox

Whenever a frequent change in speed/torque at the output is required, we use multispeed multistage gearbox. Aim of the paper is to design a 4 speed 2 stage gearbox using spur gears so as to make the transmission highly efficient as well as to keep the gearbox economically feasible. Cad plot for the same was plotted and stress strain analysis for each was done. The paper includes all the calculations and verification of those at places to justify the success of design.

Observation: The gearbox can be used efficiently for very low to medium power applications. The gearbox seems to be suitable for light load carrying machineries or low rpm machineries. A successful attempt to design this gearbox was made. Thus we designed a gearbox which is satisfactory and meets the various requirements which were specified.

III. SUMMARY OF OBSERVATION

- When gears mesh with each other they develop certain stressesat some points
- Noise level of gearbox during operation is very loud
- Using helical gear, gearbox becomes complex in size
- Analysis of gear train
- Overall efficiency of gearbox
- Reviewing the observation, it can be said that to reduces the stresses at the point of meshing, grain structure of gear material can be changed.
- Using Spur gear in gearbox can reduce the size of the gearbox, although we cannot achieve the gear strength like helical gear but hardening of spur gear increases its hardenability.
- Noise level can be considerably reduced by modifying the designof the gearbox casing.
- Gear train analysis can be done to check the deformation of gears along with input and output shafts.

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