

Design and Structural Analysis of Screw Gears

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ABSTRACT:

Two helical gears of opposite helix angle will mesh if their axes are crossed. As separate gear components, they are merely conventional helical gears. Installation on crossed axes converts them to screw gears. Two helical gears of opposite helix angle will mesh if their axes are crossed. As separate gear components, they are merely conventional helical gears. Installation on crossed axes converts them to screw gears. The project deals with analysis of screw gear with various momentums and swap sides of driving and driven sides. The model and momentums are given by different papers from different conditions, although various configurations are available, the basic configuration is selected for our analysis. In this study we apply momentum on driving side with respect to momentum and the driven side was rotated. So we calculate the stress deformation of screw gear when it drives with different momentums and result values are noted. The screw gear was designed in CATIA. The analysis takes place in ANSYS WORKBENCH, Static structural analysis.

1 INTRODUCTION:

Gears are the most important component in a power transmission system. Advances in engineering technology in recent years have brought demands for gear teeth, which can operate at ever increasing load capacities and speeds [6]. The gears generally fail when tooth stress exceeds the safe limit. Therefore it is essential to explore alternate gear material [15]. The important considerations while selecting a gear material is the ability of the gear material to withstand high frictional temperature and less abrasive wear [3]. Weight, manufacturability and cost are also important factors those are need to be considered during the design phase. [12] Moreover, the gear must have enough thermal storage capacity to prevent distortion or cracking from thermal stress until the heat can be dissipated [20].

It must have well anti fade characteristics i.e. their effectiveness should not decrease with constant prolonged application and should have well anti wear properties [4]. The upcoming requirement of power saving and efficiency of mechanical parts during the past few years increased the use of composite materials. Moreover the use of composite materials have also increased due to their properties such as weight reduction property with enough strength, high specific stiffness, corrosion free, ability to produce complex shapes, high specific strength, high impact energy absorption and many more[19]. Product development has changed from the traditional serial process of design, followed by prototype testing and manufacturing but to more on computer aids. CAE (Computer Aided Engineering) has greatly influenced the chain of processes between the initial design and the final realization of a product. CAE software helps in product designing, 3-D visualization, analysis, simulation and impacted a lot on time and cost saving to the industry[21], [22]. A Gear box is one of the important mechanical components of transmission system used in variety of machines. Differential Gear box increases effective weight of vehicle which in turn directly affects the performance and efficiency of the vehicle. So there is a requirement to make light and effective gears [15]. Therefore, in the present work composite materials are used to make light weight gears in order to perform such duty efficiently.

1.1.Importance of differential Gear Box:

A differential is a device, usually but not necessarily employing gears, capable of transmitting torque and rotation through three shafts, almost always used in one of two ways: in one way, it receives one input and provides two outputs this is found in most automobiles and in the other way, it combines two inputs to create an output that is the sum, difference, or average, of the inputs.

In automobiles and other wheeled vehicles, the differential allows each of the driving road wheels to rotate at different speeds, while for most vehicles supplying equal torque to each of them. A vehicle's wheels rotate at different speeds, mainly when turning corners. The differential is designed to drive a pair of wheels with equal torque while allowing them to rotate at different speeds. In vehicles without a differential, such as karts, both driving wheels are forced to rotate at the same speed, usually on a common axle driven by a simple chain-drive mechanism. When cornering, the inner wheel needs to travel a shorter distance than the outer wheel, so with no differential, the result is the inner wheel spinning and/or the outer wheel dragging, and this results in difficult and unpredictable handling, damage to tires and roads, and strain on (or possible failure of) the entire drive train.

1.2. Background :

The Differential Box transmits mechanical energy from a prime mover to an output device. It also changes the speed, direction or torque of mechanical energy. Differential gearbox is used when high speed, large power transmission where noise abatement is important. Some limitations in existing Differential gear box are as follows .It has poor weight to strength ratio, so high power loss. Existing differential has low tensile strength and elastic modulus. Its Poisson's ratio, mass density and shear modulus is also low. Thus Differential gear box needs to be redesigned providing energy saving by weight reduction, providing internal damping, reducing lubrication requirements and have high tensile strength, elastic modulus, poisson's ratio, mass density and shear modulus without increasing cost. Such a scope is provided by application of composite material providing substantial weight reduction in conformance with safety standards and also providing solution to other existing problems in current gears available.

1.3 Gears:

Gears are mechanical elements which are used for transmitting a synchronous motion directly between shafts, these may be parallel or at any skew axis. Gears are the most durable and rugged of all mechanical drives and can be used for transmitting high power with high efficiency (up to 99% in the case of parallel shafts).

The design of meshing gears is complex especially if an optimum solution is required in an application. British, American and ISO standards describe analytical techniques in much detail but they tend to be rather daunting to the inexperienced and infrequent gear designer. Manufacturers' catalogues, in contrast, often do not give adequate design information to enable a thorough verifying analysis to be performed on the gears they produce. Frequently a simplified analytical selection procedure is given but for a more comprehensive explanation it is necessary to make reference to the appropriate standard for details. This course provides a basic overview of the gear drives and transmission.

1.4 Gear Classification:

Gears may be classified according to the relative position of the axes of revolution. The axes may be 1) Parallel 2) Intersecting 3) Non-parallel and non-intersecting.

1) Parallel Gear Shafts - The gears that have parallel shafts are spur gears, helical gears, and herringbone gears. These are the gears that mesh in the same plane. They are used for transmission of rotary motion between parallel shafts. They offer maximum transmission of power and high efficiency. They are used in higher horsepower applications where long term operational efficiency is more important. They are more expensive to manufacture and create axial thrust. They have higher load capacity and make less noise. They are generally used in clocks, movie projector and car steering. They are widely used for manual transmission.

2) Intersecting Shaft Gears - The gears that have intersecting shaft are bevel gears, straight bevel gears, zerol bevel gears and spiral gears. These gears are designed for the efficient transmission of power and motion between intersecting shafts at an angle. These are ideal for applications requiring high load capacity and are cheaper than the parallel shaft gears. They are used where speed and strength are desirable along with the change in angle of power flow. These gears are widely used in hand drill, locomotives, automobiles, marine applications and all rotorcraft drive system 3) Neither Parallel nor Intersecting- The gears that have neither parallel nor intersecting shafts are hypoid gears, crossed helical gears and worm gears. These gears provide an effective answer for power transmission applications requiring high-ratio speed reduction in a limited space using non-intersecting shafts.

These are ideal for applications requiring only limited load capacity. Lowering ratios easily increases their efficiency. These gears are the cheapest of all gears and are widely used in automobile differentials, electric mixer, speedometer, sprinkler, machine tools, and packaging machinery. The chart below highlights the gear categories.



LITERATURE REVIEW :

In this paper, literature has been critically reviewed involving various studies carried out by various researchers related to the field of designing and analysis of Differential gearbox. Differential gearbox is an important part of the automobile i.e. used for transmitting different speeds, while for most vehicles supplying equal torque to each of them. Shoji Haizuka et al. [3], conducted experiments concerning the friction loss of helical gears with seven kinds of helix angle using one kind of lubricating oil under various loads and rotational speeds were carried out. The results were discussed as follows

1. The friction loss of the helical gears increases with the helix angle and height of the teeth. The helix angles lie in the range of $0, = 0 - 46.5$ deg.
2. The friction loss of the helical gears increases with the helix angle and applied load. This tendency was expressed with empirical formulas.

Dirk Wienecke et al. [4], showed the influences of gear oils, characterized by the base oil and the additive package, on the fuel economy of automobiles are discussed. By optimal oil formulations friction losses can be reduced resulting in higher efficiency data. In order to analyze these influences and to evaluate the effects the transmission gear is considered as; In complex tribo-technical system consisting of different single tribological systems, e. g. characterized by gear wheels, bearings, seals, etc. 'The tribo-system automobile transmission gear is defined and described in detail resulting in an analysis of the tribological stresses in the gear.

'The relationship between the structure of the single systems, their technical functions and the function of the lubricant are described. This systematic analysis was the approach for the simultaneous development of gear oils and a new automobile transmission gear. Jay Belsky [5], had showed the three potential explanations of the transmission gap pertaining to the limited power of heretically important determinants of attachment security to actually predict attachment security have been entertained. The first drew attention to the prospect that measurements of sensitivity may include a great deal of measurement error, but also that the same may be true with respect to Strange Situation assessments of attachment security. The second explanation raised the prospect that while mother's psychological availability to the infant, in the form of observed sensitivity, has appropriately figured centrally in theorizing about the determinants of attachment security, perhaps insufficient attention has been paid to the time that mother is simply physically available to the child.

The third explanation was that those students of attachment theory have not given sufficient consideration to the possibility that, in the case of some children, security hen security is born, whereas in others it is made; that is, that infants vary in the extent to which their felt security is determined by the sensitivity of the care they receive. F. K. Choy et al. [6], had provided a comparison and benchmarking of experimental results obtained from a damaged gear transmission system with those generated from a numerical model. Specific conclusions for this study can be summarized as follows: 1. A study of the dynamic changes in a gear transmission system due to (a) no gear tooth damage, (b) single gear tooth damage, (c) two consecutive gear teeth damage, and (d) three consecutive gear teeth damage is successfully conducted. 2. The vibration signature analysis using a joint time-frequency procedure, the Wigner-Ville distribution (WVD), seems to be quite effective in identifying single and multiple teeth damage in a gear transmission.

Riccardo Morselli et al. [7], had showed a detailed dynamic model of an electronically controlled steering differential has been proposed. To obtain faster and still reliable simulations reduced dynamic models have been obtained by a proper state-space transformation and simplification of the detailed model.

The steering differential models allow the simulation of the dynamical behavior of the most common car differentials. The proposed reduced model has been used to compare the effects of four kinds of differentials on the vehicle dynamics. F. Cheli, M. Pedrinelli et al. [8], showed the structure of a new control system and the analysis of the developed vehicle dynamics control algorithms for a semi-active differential has been presented. The experimental results have shown the capability of the system in following its time-varying references and in keeping a stable behavior of the vehicle at its limits while improving traction and absolute performance in terms of driving feeling. Erwin V. Zaretsky et al. [9], had developed two computational models to determine the fatigue life and reliability of a commercial turboprop gearbox are compared with each other and with field data. These models are (1) the Monte Carlo simulation of randomly selected lives of individual bearings and gears comprising the system and (2) the two-parameter Weibull distribution function for bearings and gears comprising the system using strict-series system reliability to combine the calculated individual component lives in the gearbox.

SOLID MODELLING:

Solid modeling consists of set of principles for mathematical and computer modeling of three-dimensional solid model. It refers to theories and computations that defines and manipulates representations of physical objects, their properties and the associated abstractions, and that support a variety of processes. Solid modeling of bevel and spur gears is done using parametric approach. Bevel gears for different dimensions can be generated by changing the variables (number of teeth, pressure angle, helix angle, tooth thickness, module). Required parameters that are used as variable for generating bevel gear and dependent parameters with relations are shown in table 1. In the reference model there are five bevel gears variable values for each gear as given in table2. Steps involved in the creation of parametric solid model of bevel gear are shown in Figure 2 while Figure 3 (a) - (e) shows the solid model models of gears.

3.1 STARTING TO CATIA:

To start CATIA there may be icon on the desktop or you may have to look in the Start menu at the bottom of left of the screen Windows taskbar.

The program takes a while to load, so be patient. The start-up is complete when your screen looks like the following figure, which is a default CATIA screen.

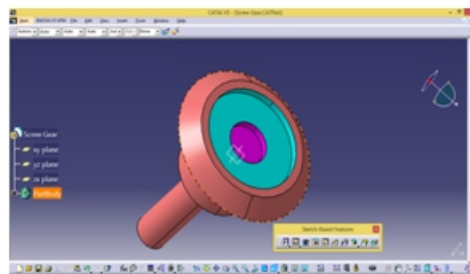


Fig 6 DESIGN OF SCREW GEAR

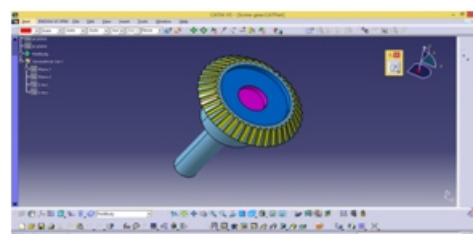


Fig 7

Select the entire sketcher and select shaft options from sketched base features and select the current sketch and reference axis as X-axis and press ok then screen looks like the below figure.7.

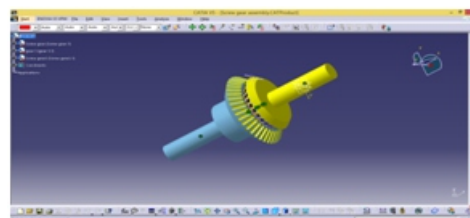


Fig 8 ASSEMBLY OF SCREW GEAR

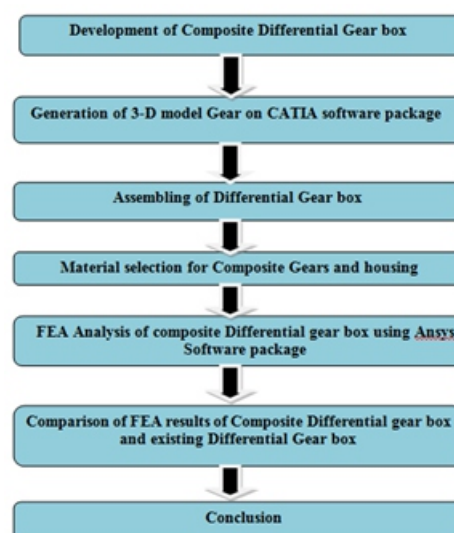


Figure 1 Steps involved in work flow

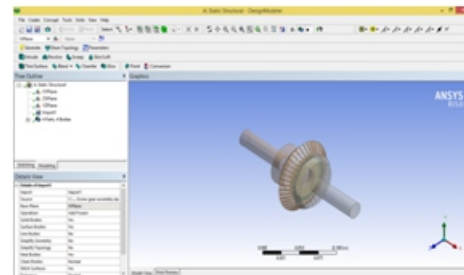
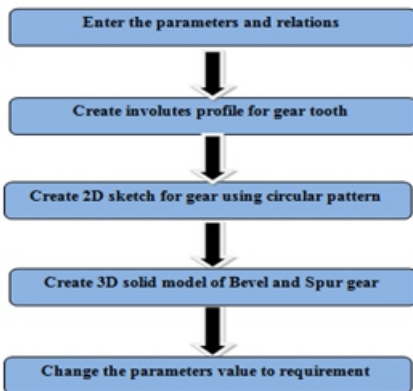


Figure 10 IMPORT OF DESIGN

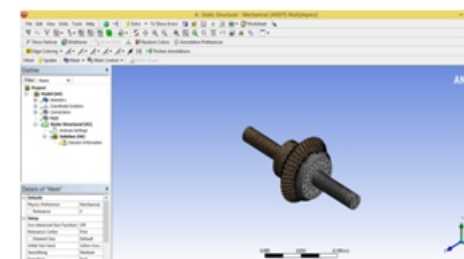


Fig 11 MESHING

INRODUCTION TO ANSYS:

1.9.1 HISTORY:

The company was founded in 1970 by Dr. John A Swanson Analysis systems, Inc. SASI. Its primary purpose was to develop and market finite element analysis software for structural physics that could simulate static (stationary), dynamic (moving) and heat transfer (thermal) problems. SASI developed its business in parallel with the growth in computer technology and engineering needs. The company grew by 10 to 20 percent year, and in 1994 it was sold to TA Associates. The new owners took SASI’s leading software called ANSYS as their flagship product and designated ANSYS, Inc as the new company name

1.9.2 INTRODUCTION:

The ANSYS program is a computer program for a finite element analysis and design. The operating conditions. The ANSYS program can also be used to calculate the optimal design for given operating conditions using the design optimization feature. The ANSYS program is a multi-purpose program, meaning that you can use it for almost any type of finite element analysis in virtually any industry - automobiles, aerospace, railways, machinery, electronics, sporting goods, power generation, power transmission, and biomechanics, to mention just a few. “Multipurpose” also refers to the fact that the program can be used in all disciplines of engineering – structural, mechanical, electrical, electromagnetic, electronic, thermal, fluid, and biomedical. The ANSYS program is also used as an educational tool in universities and other academic institutions.

**RESULTS AND DISCUSSIONS
 CASE-1**

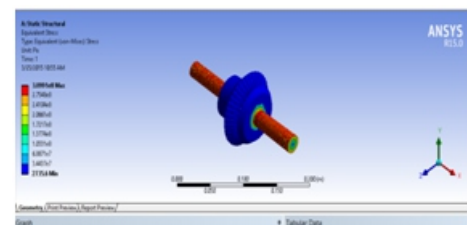


Figure 12.1 Von-Mises Stress

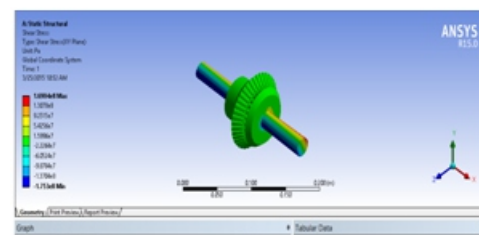


Figure 12.2 Maximum Shear Stress

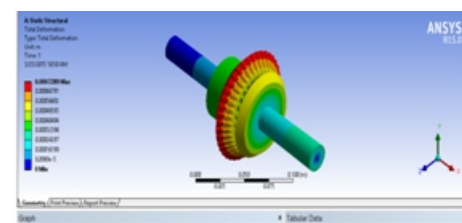


Figure 12.3 Displacements (Total Deformation) Moment for Structural Steel is 250 N-mm.

Equivalent Von-Misses Stress 3.0991e8 pa.
Maximum Shear Stress 1.6904e8 pa.
Displacement(Total Deformation) 0.0007289.
CASE-2

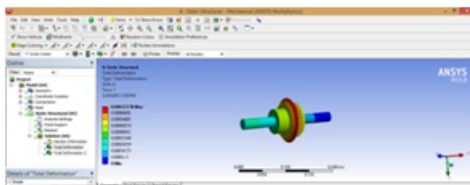


FIG12.4 TOTAL DEFORMATION

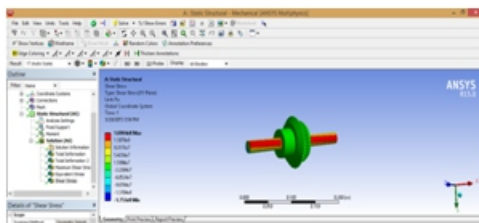


FIG12.5 SHEAR STRESS

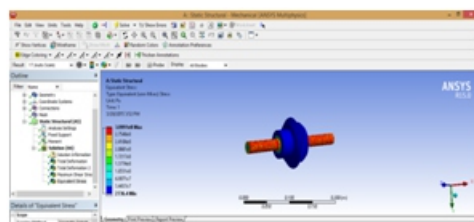


FIG 12.6 Equivalent (von-moses) stress Moment for Structural Steel is 250 N-mm.

Equivalent Von-Misses Stress 3.0991e8 pa.
Maximum Shear Stress 1.6904e8 pa.
Displacement(Total Deformation) 0.00072778.

CONCLUSION:

This project deals with analysis of screw gear with various momentums and swap sides of driving and driven sides. The model and momentums are taken for the basic configuration of screw gear for our analysis. In this study we apply momentum on driving side with respect to momentum and the driven side was rotated. So we calculate the stress deformation of screw gear when it drives with different momentums and result values are noted. In first case we fixed one side of the gear and apply momentum to the opposite side of the screw gear. After completion of static structural analysis results are observed as maximum deformation is 0.0007289m.

In next case the other side was fixed which is previously we applied momentum and the opposite side which we apply momentum. After completion of static structural analysis results are observed as maximum deformation is 0.00072778m. By considering above two cases in second case the total deformation was lesser than first case. So the screw gear was optimum in second case.

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