

PROFILE MODIFICATION AND VALIDATION AND ADDITIVE MANUFACTURING OF A SPUR GEAR TO INCREASE THE GEAR TOOTH STRENGTH

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Abstract

In recent years, asymmetric tooth shapes have been more prominent in gearing design practice. Stage two involves producing a basic rack for a pair of matching gears, whereas stage one involves calculating tooth action parameters, much like symmetric basic rack gears. For certain gears in a gearbox, the specifications of particular fundamental rack tooth profiles are determined. Advantages of asymmetrical profile gearings include a higher pressure angle relative to operational profiles (due to a lower pressure angle relative to non-operating profiles) and the potential for a much higher face contact ratio. Ansys finite element analysis will be used in this thesis to compare and contrast symmetrical and asymmetrical tooth profiles. In CATIA, a 3D modelling programme, we will create models of the symmetric and asymmetric tooth profiles, which have distinct pressure angles. The designs made of mild steel and EN 32 steel will undergo structural studies.

INTRODUCTION

Transmitting torque is the job of gears, which are spinning machine components with cut teeth, or cogs, that mesh with another toothed component. A basic mechanism that uses two or more gears to provide mechanical advantage via a gear ratio is termed a gearbox. A power source's speed, magnitude, and direction may be altered using geared devices. Though gear meshing with other gears is the most frequent kind, gears may also mesh with racks, which are toothed parts that do not rotate but can produce translation instead.

Similar to how wheels on a pulley system work, gears in

a gearbox do the same thing. The fact that gear teeth don't allow for sliding is one of its advantages.

With a straightforward connection between the two gears' rotational speeds and torques, combining two gears with an uneven number of teeth produces a mechanical advantage.

The word "gear" is more often used to describe a gear ratio than a physical gear when discussing vehicles and bicycles with multiple gear ratio gearboxes. Even in cases where the gear ratio is continuous instead of discrete, or in the absence of gears altogether (as in a continuously changing gearbox), the word is used to characterise systems that are otherwise functionally equivalent.

ASYMMETRICAL GEARS

In the past, the working involute flanks were the primary focus of attempts to enhance gear geometry. Depending on the gear's use and the tolerance limitations defined for criteria like run out, profile, lead, pitch variation, and others, they are theoretically well-described and categorised by several standard accuracy grades. Additionally, the working involute flanks are adjusted to pinpoint a bearing contact and provide the necessary performance across various combinations of tolerances and potential misalignment caused by operational factors like as temperature and loads. Gear inspection equipment rigorously regulate their precision. An location of maximal bending stress is the gear tooth fillet. But its contour and accuracy are established on the gear design by the difficult-to-inspect minimum fillet radius and, in certain instances, by the usually extremely large root diameter tolerance. In reality, gear technology (case hardening and shot peening to provide compressive strengths) is often what improves tooth bending strength.

in place of the gear shape, for instance, but instead of the

residual stress layer. The tooth tip trajectory, also known as the trochoid, of the producing cutting tool (gear hob or shaper cutter) usually dictates the gear tooth fillet profile.



Fig: asymmetrical gear

Applications:

For gear systems that need extraordinary performance, such as in aircraft applications, asymmetric tooth gears should be considered. They are also useful for gearboxes used in mass manufacturing, such as those used in automobile gears, where the tooling cost per gear is negligible. Asymmetric profiles show the greatest promise when used with powder metal gears and moulded gears. Asymmetric tooth profiles do not raise tooling or manufacturing costs, since moulded gears already need specialised tooling. Asymmetric gear teeth are simpler to construct using the direct method than standard gears. Standardised tooling and the tool-based design technique are not limitations of asymmetric gear design.

LITERATURE REVIEW

Effect of Pressure Angle on Bending Stress And Deformation of Asymmetric Spur Gear Using FEA

A gear is a rotating machine part having cut teeth, which mesh with another toothed part in order to transmit torque. Gears may be spur, helical, bevel or worm in which spur gear is most common type of gear used in engineering applications. In the automobile and aerospace industries, higher strength, higher reliability and lighter weight gears are necessary as lighter automobiles continue to be in demand. This has led to development of new designs, such as gears with asymmetric teeth. The geometry of these teeth is such that the drive side profile is not symmetric to the coast side profile and it is beneficial for special applications where the

loading of the gear is unidirectional. In such an instance, the loading on the gear tooth is not symmetric, thus calling for asymmetric teeth. The coefficient of asymmetry is dependent on pressure angle; therefore study of effect on pressure angle on asymmetric tooth is of great importance. This paper presents a study on effect of pressure angle on asymmetric involutes spur gear.

Theoretical and Finite Element Analysis of Load Carrying Capacity of Asymmetric Involute Spur Gears. The paper presents a method for investigating the bending stress at the critical section of "Asymmetric Involute spur Gear". The method, ISO/TC60 has been used to theoretically calculate bending stress at the critical section of this Gear. The determination of the tooth form factor, stress concentration factor, critical section parameters and contact ratio has been accomplished for each set of gear. The gears with different pressure angle have been modeled by using "CATIA V5R15" software. The results obtained by the theoretical method have been verified by using "ANSYS 12.0 software". The comparative analysis of bending stress at critical section has been carried out.

Computer Aided Design of Asymmetric Gear Gear design becomes inevitable for the development of any mechanical system and it necessitates considerable expertise. Due to the evolution of new materials and

Manufacturing processes, the utilization of asymmetric gears increases in recent years. Designers will be able to develop gear drives to handle larger torque with lesser noise and vibrations with the asymmetric profile. However the existing design procedure of symmetric gears does not hold good for these asymmetric gears. Hence by modifying tooth form factor, stress concentration factor, and load sharing factor, a MATLAB code has been developed for designing asymmetric spur gears. Pressure angle limits were initially arrived by considering the gear tooth peaking and law of gearing. Within the range of pressure angle values, the asymmetric gear teeth which experiences minimum bending and contact stresses

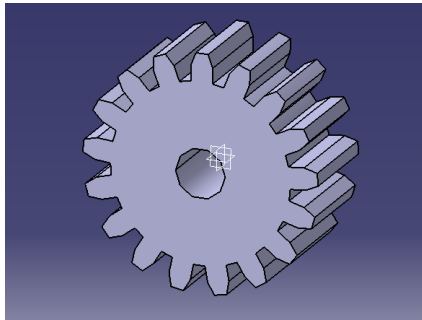
CATIA

Computer Aided Three-dimensional Interactive Application goes by the abbreviation CATIA. Organisations in a wide variety of sectors, from consumer goods to aerospace, utilise it as one of the top 3D programmes.

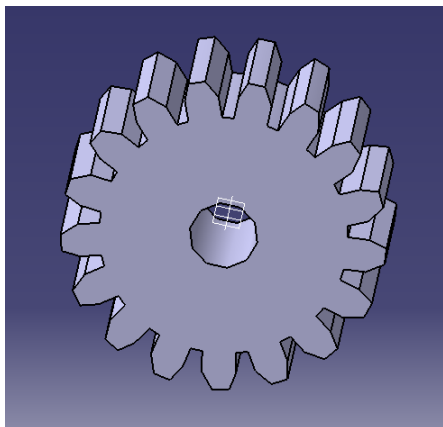
CAD, CAM, and CAE are all part of Dassault Systèmes'

CATIA, a cross-platform 3D software package. A French engineering behemoth, Dassault specialises in aircraft, 3D design, digital mockups in 3D, and software for managing products from start to finish. CATIA is a solid modelling programme that handles every step of the design-to-manufacturing process and brings together 2D tools with 3D parametric features. Orthographic, sectional, auxiliary, isometric, and detailed two-dimensional drawing views are all within CATIA's purview, in addition to the creation of solid models and assemblies. In addition, the drawing views allow you to produce model dimensions and reference dimensions. Changes made to the model will be reflected in the drawing views and vice versa thanks to CATIA's bi-directional associative feature.

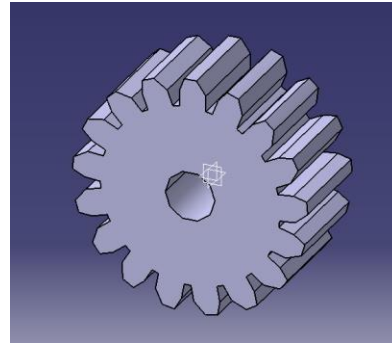
Case: 1 SYMMETRIC GEAR (pressure angle 20°)



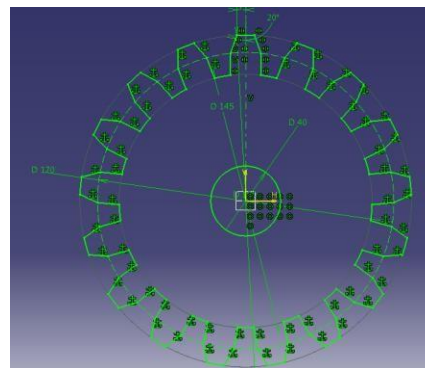
Case: 2 ASYMMETRIC GEAR (pressure angle 30° - 20°)



Case: 3 ASYMMETRIC GEAR (pressure angle 35° - 20°)



2D drawing



Static Analysis

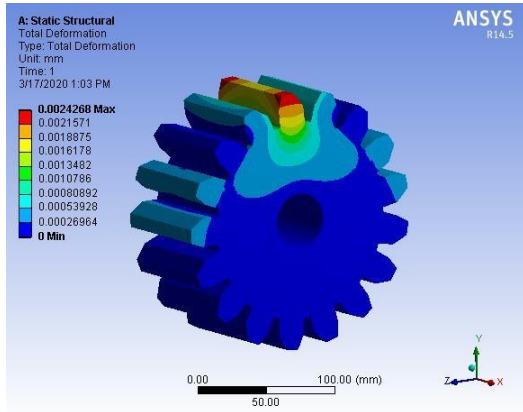
A static analysis calculates the effects of steady loading conditions on a structure, while ignoring inertia and damping effects, such as those caused by time-varying loads. A static analysis can, however, include steady inertia loads (such as gravity and rotational velocity), and time-varying loads that can be approximated as static equivalent loads (such as the static equivalent wind and seismic loads commonly defined in many building codes).

Loads in a Static Analysis

Static analysis is used to determine the displacements, stresses, strains, and forces in structures or components caused by loads that do not induce significant inertia and damping effects. Steady loading and response conditions are assumed; that is, the loads and the structure's response are assumed to vary slowly with respect to time.

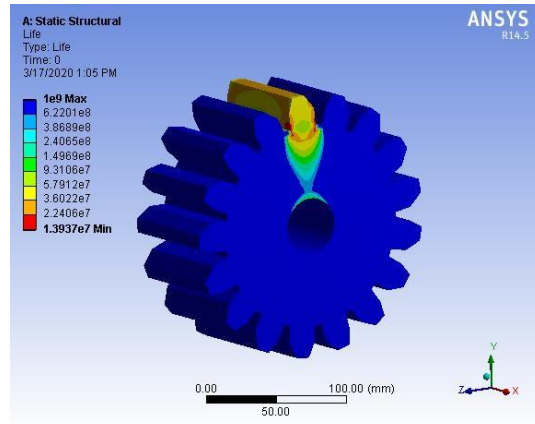
FINITE ELEMENT ANALYSIS OF SPUR GEAR USING ANSYS WORKBENCH

Deformation

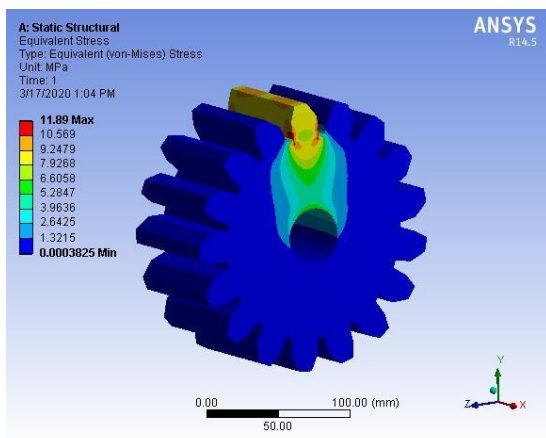


Fatigue analysis

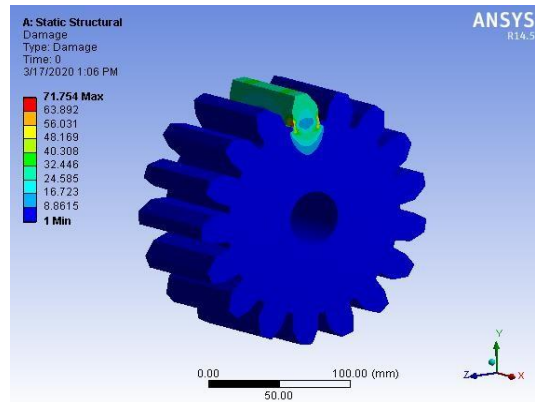
Life



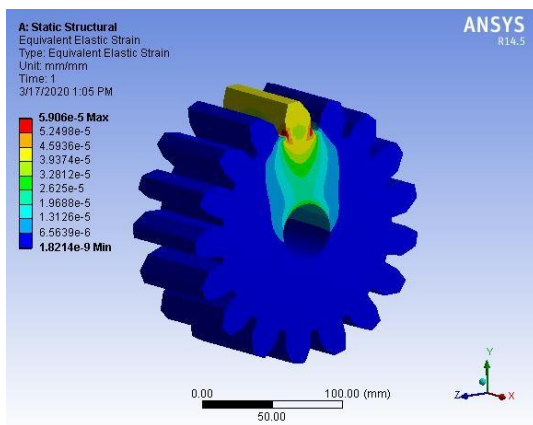
Stress



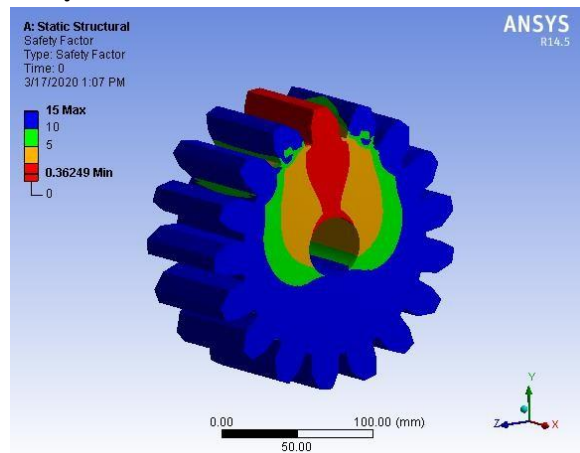
Damage



Strain



Safetyfactor



Static analysis results

Pressure angle($^{\circ}$)	Material	Deformation(mm)	Stress(N/mm 2)	Strain
Symmetric gear-20 $^{\circ}$	Steel	0.0029163	13.464	6.917e-5
	EN31 steel	0.0025556	12.389	6.0615e-5
Asymmetric gear-30 $^{\circ}$	Steel	0.0027233	12.929	6.2398e-5
	EN31 steel	0.0025911	12.302	5.9369e-5
Asymmetric gear-35 $^{\circ}$	Steel	0.0025885	12.683	6.2998e-5
	EN31 steel	0.0024268	11.89	5.906e-5

Fatigue analysis results

Pressure angle($^{\circ}$)	Material	Life	Damage	Safety factor	
				Min	Max
Symmetric gear-20 $^{\circ}$	Steel	1e9	108.84	0.32011	15
	EN31 steel	1e9	85.598	0.34789	15
Asymmetric gear-30 $^{\circ}$	Steel	1e9	95.605	0.3335	15
	EN31 steel	1e9	80.623	0.35036	15
Asymmetric gear-35 $^{\circ}$	Steel	1e9	89.505	0.33983	15
	EN31 steel	1e9	71.754	0.36249	15

CONCLUSION

This project utilises CATIA, a 3D modelling programme, to design and create both symmetric and asymmetric gears. Three distinct angles were used in gears. We model 20, 30, and 35 degrees. In order to conduct structural and fatigue analyses, the Gears were made from two different types of steel: AISI 1050 and EN31.

Stress levels are more asymmetric at 300 degrees compared to 350 degrees and 20 degrees, according to the structural analysis findings. Structural study suggests that symmetric at 350 degrees is the best option. Since the strains caused by utilising EN 31 steel are lower than

those caused by employing the

The symmetric gears have a lower allowed stress and weight compared to EN 31 steel. Because of its lower density.

Consequently, we are making asymmetric gears with a pressure angle of 35 degrees and using EN 31 steel, which is an improved material.

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