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STRUCTURAL ANALYSIS OF SPUR GEAR USING FEM

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ABSTRACT-

To achieve improved static gear drives and enhanced load carrying capacity and reliability, a complete study about gear drive design and analysis is carried out. The structural analysis is examined for spur gear drive. Gear drives transmit motion and power by tooth mesh mostly in the form of involute profiles, gear tooth mesh is a complex process involving multi tooth engagement, multipoint contact and varying load conditions. The contact stresses were examined using 3-D FEM model. The gears are modeled by using AUTO- CAD and analyzed by ANSYS 16.0. In the present work an attempt is proposed to find the structural analysis at the point of gear tooth engagement under static loading conditions through finite element software.

Key words: *Spur gear, CAD, ANSYS, Static analysis, Total deformation, FEM.*

1. INTRODUCTION

Gears are toothed members which transmit power / motion between two shafts by meshing without any slip and the power is usually transferred in such a way velocity ratio remains constant. In any pair of gears, the smaller one is called pinion and larger one is called gear immaterial of which is driving the other. When pinion is the driver, it results in step down drive in which the output speed decreases and the torque increases. On the other hand, when the gear is the driver, it results in step up drive in which the output speed increases and the torque decreases. Gears are classified as spur, helical, double helical, bevel, worm and spiral gears. The contact stress and fatigue analysis of both spur and helical gear drive are examined in this research and it will be useful for further investigators to improve gear behaviors on various aspects.

Spur Gears: -The spur gear is simplest type of gear manufactured and is generally used for transmission of rotary motion between parallel shafts. The spur gear is the first choice option for gears except when high speeds, loads, and ratios direct towards other options. Other gear types may also be preferred to provide more silent low- vibration operation. A single spur gear is generally selected to have a ratio range of between 1:1 and 1:6 with a pitch line velocity up to 25 m/s. The spur gear has an operating efficiency of 98-99%. The pinion is made from a harder material than the wheel. A gear pair should be selected to have the highest number of teeth consistent with a suitable safety margin in strength and wear. The minimum numbers of teeth on a gear with a normal pressure angle of 20 degrees are 18 and 15.This is a cylindrical shaped gear in which the teeth are parallel to the axis. It has the largest applications and also it is the easiest to manufacture.

They are simple in construction, easy to manufacture and cost less. They have highest efficiency and excellent precision rating. They are used in high speed and high load application in all types of trains and a wide range of velocity ratios. Hence, they find wide applications right from clocks, household gadgets, motor cycles, automobiles, and railways to aircrafts.

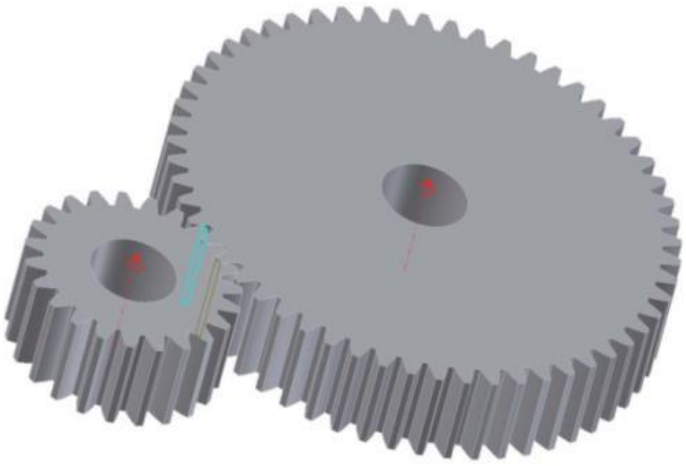

Figure 1: Spur gear

Mahendran, K.M.Eazhil, L.Senthil Kumar [1] carried out DESIGN AND ANALYSIS OF COMPOSITE SPUR GEAR. This project includes design of the spur gear to study the weight reduction and stress distribution for cast steel and composite materials. They designed the spur gear model using design software and studied the impact analysis and torque loading fore cast steel and composite materials. Finally, by comparing and analyzing the composite gear with existing cast steel gear they concluded that the stress induced, deformation and weight of the composite spur gear is less as compared to the cast steel spur gear.

Utkarsh.M.Desail, Prof.Dhaval.A.Patel [2] carried out MODELING AND STRESS ANALYSIS OF COMPOSITE MATERIAL FOR SPUR GEAR UNDER STATIC LOADING CONDITION. The objective of this project is to improve the performance of gear by using alternate materials.

Composite materials provide adequate strength with weight reduction and they are emerging as a better alternative for replacing metallic gears. In this work, a metallic gear of Alloy Steel is replaced by the composite gear of 30% Glass filled Poly-Ether-Ether-Ketone(PEEK) to increase the working life of the gears to improve overall performance of machine. Such composite materials provide much improved mechanical properties such as better strength to weight ratio, more hardness, and hence less chances of failure. In this project, the modeling of spur gear is carried out using SOLIDWORKS and bending stress analysis of spur gear is arrived out using ANSYS V14.

R. Yakut et al [3]. The purpose of the paper is to examine the load capacity of PC/ABS spur gears and investigation of gear damage. Further in this study usability of PC/ABS composite plastic material as spur gear was investigated and was defined that PC/ABS gears were tested by applying three different loading at two different numbers of revolutions on the FZG experiment set. The experiment result summarized that the usage of PC/ABS materials brings an advantage in many industrial area because such materials are durable against flame, air, ultraviolet lights and holding lower moister than PA66 GFR 30 materials.The another result of this study was that good operating conditions are comprised at low numbers of revolution and the tooth loads. Further the suitable environmental condition must be revolutions and the tooth load for gears. PC/ABS gear should be preferred at low tooth and unwanted high power transmission.

V. Siva Prasad et al [4]. This paper describes design and analysis of spur gear and it is proposed to substitute the metallic gears of sugarcane juice machine with polymer gears to reduce the weight and noise. A virtual model of spur gear was created in PRO-E, Model is imported in ANSYS 10.0 for analysis by applying normal load condition. The main purpose of this paper to analysis the different polymer gears namely nylon, polycarbonate and their viability checked with counterpart metallic gear like as cast iron. Concluding the study using the FEA methodology, it can be proved that the composite gears, if well designed and analyzed, will give the useful properties like as a low cost, noise, weight, vibration and perform its operation similar to the metallic gears. Based on the static analysis Nylon gears are suitable for the application of sugarcane juice machine under limited load condition in comparison with cast iron spur gears.

Vivek Karaveer et al [5]. This paper presents the stress analysis of mating teeth of the spur gear to find maximum contact stress in the gear tooth The results obtained from finite element analysis are compared with theoretical Hertz equation values. The spur gears are modeled and assembled in ANSYS DESIGN MODELER and stress analysis

of Spur gear tooth is done by the ANSYS 14.5 software. It was found that the results from both Hertz equation and Finite Element Analysis are comparable. From the deformation pattern of steel and grey cast iron, it could be concluded that difference between the maximum values of steel and grey CI gear deformation is very less.

Table 1: Properties of Gray Cast Iron

Material	**Gray Cast Iron**
Young modulus	= 110 GPa
Poisson's ratio	= 0.28
Ultimate Tensile Strength	= 430 MPa
Ultimate Compressive Strength	= 820MPa
Yield Tensile Strength	= 276 MPa
Bulk modulus	= 83.3 GPa

Table 2: Symbol and descriptions

Symbol	**Descriptions**
α O.D P.C.D m Z C.D.	Pressure angle Outside Diameter Pitch circle diameter Module Number of teeth Center Distance

Table 3: Specifications of spur gear

Specifications	**Pinion**	**Gear**
α	20^0	20^0
O.D	100mm	85mm
P.C.D	90mm	75mm
m	5mm	5mm
Z	18	15
C.D.	82.5mm	82.5mm

2. STATIC ANALYSIS

Static analysis is concerned with determination of response of a gear to steady loads whose response remains unchanged with time. The response of the gear is expressed in terms of stress, strain, displacement. The tool used in the static analysis is Static structural.

The finite element analysis procedure of the spur gear was given below:
A three-dimensional model of the spur gear was created using the pro/engineer CAD software.
The material properties were defined for gears.
The model was meshed using finite element software.

Boundary conditions for ANSYS Workbench as mentioned below.
Fixed displacement constraint was applied on gear
A Revaluated joints is provided to each gears with Body-Ground connection.
The revolution of gears is ready as 60 revolutions per minute
In order to arrest the displacement on x, y, z directions and rotations on x, y directions remote displacement constraint is applied on pinion surface.

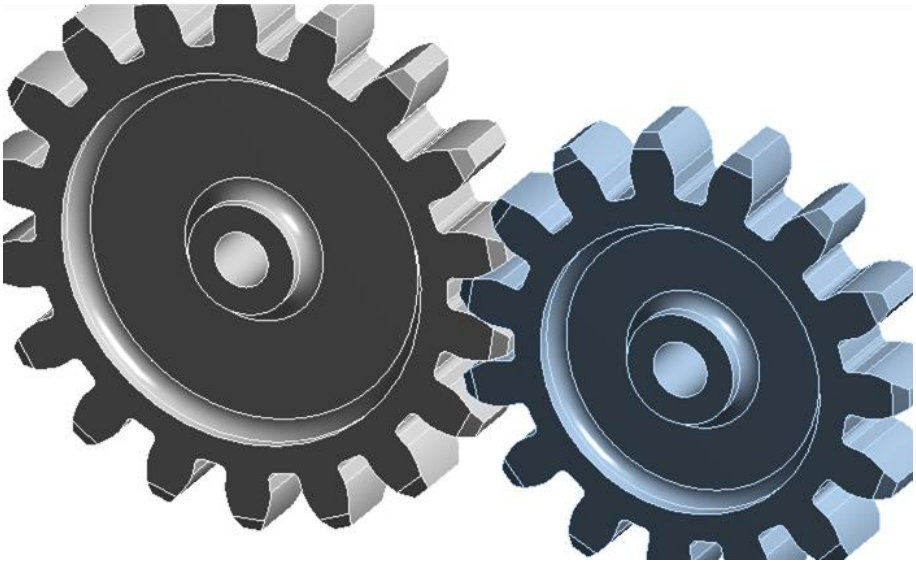

Figure 2: A three-dimensional model of the spur gear

Figure 3 shows the meshed finite element model of the spur gear which had been utilized for the analysis.

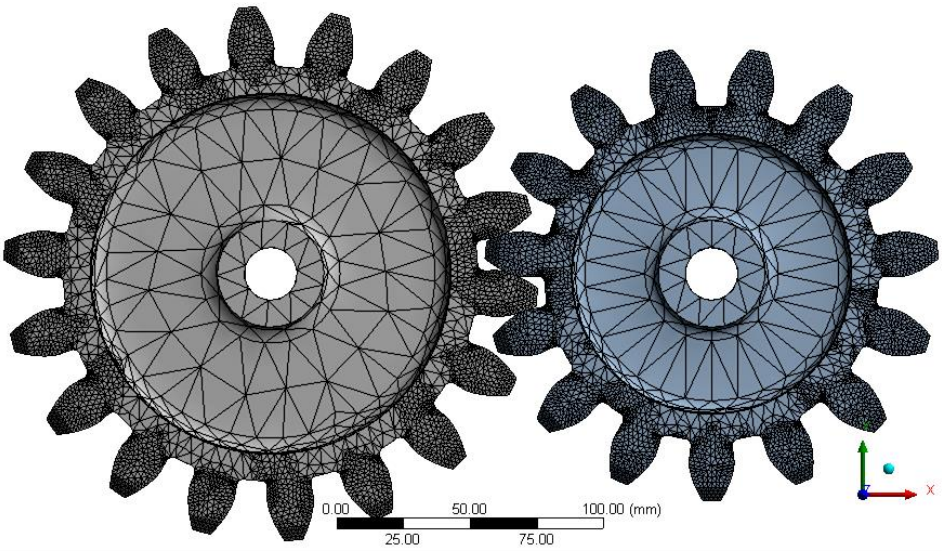

Figure 3: Meshed model of spur gear

3. RESULTS AND DISCUSSIONS

Static Analysis

The below figure shows contact stress on tooth meshing area made up of Gray Cast Iron with hardening and tempering. The maximum and minimum von-mises stress values found are 976.19 N/mm^2 and 0.0034781 N/mm^2.

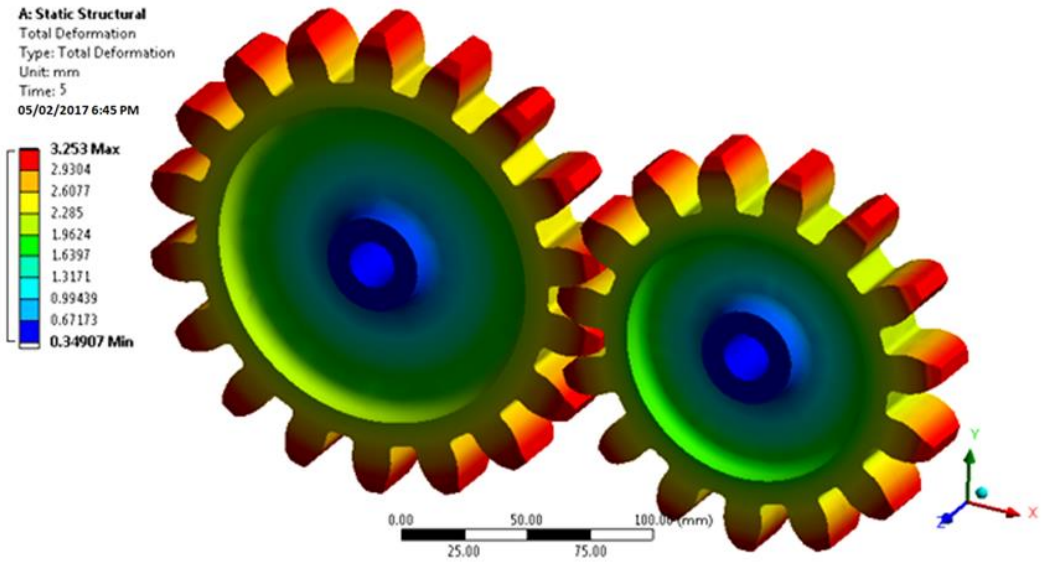

Figure 4.5: Total Deformation of Spur gears

The maximum and minimum total deformation values found are 3.253mm and 0.34907 mm.

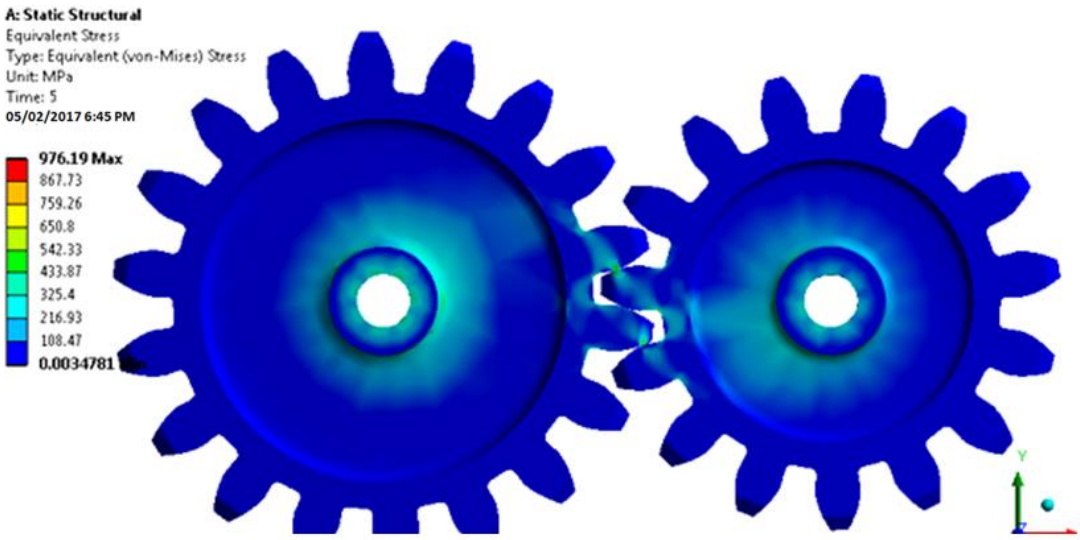

Figure 4.5: Von-Mises Stress of Spur gears

The maximum and minimum von-mises stress values found is 976.19 N/mm^2 and 0.0034781 N/mm^2.

4. CONCLUSION

This project work focuses three dimensional spur gear analyses under static conditions. The purpose of three-dimensional analysis is to predict the gear behavior on real operating conditions. In the static analysis, gear is fixed and rotational load is applied on pinion. In dynamic analysis of gear both gear and pinion are allowed to rotate in opposite direction on time basis. From analysis it is proved as per theory that once the gear meshes and stars to rotate they are subjected to maximum deformation.

- The total deformation of Spur Gear has been observed 3.253 mm.
- The Directional deformation of Spur Gear has been observed, its value is 3.27mm
- The Equivalent stress (von-mises stress) of Spur Gear has been observed, its maximum value is 976.16 Mpa.

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