SPUR GEAR TOOTH STRESS ANALYSIS AND MODIFICATION USING STRESS REDUCING GEOMETRICAL FEATURES

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ABSTRACT:- Gears are used for a wide range of industrial applications. They have varied application starting from textile looms to aviation industries. They are the most common means of transmitting power. They change the rate of rotation of machinery shaft and also the axis of rotation. The continuous meshing of the gears is the most common cause of failure of the gears. In order to avoid this problem we have to design the geometrical features of the gears very properly. In the spur gears the tooth surface of the gears is exactly comes into contact with other gear. One of the important parameter of mating gears design is contact stress. In this project, we analyze the spur gear trains of various machines and find the contact stresses on individual teeth under the working conditions. After identifying the problem in the design, we hope to improve upon it by taking two geometrical parameters of a spur gear tooth and try to optimize the design to suit the industry needs.

Keywords- Spur gears, tooth failure, stress, stress relief, tooth matel

1. INTRODUCTION

Gears are commonly used to transmit rotational motion between machinery shafts. When gears of different types and sizes are combined, they can change the rate of rotation, the direction of the axis of rotation, and change rotary motion to linear motion. The escalating requirement for better power transmission in machines, generators, elevators and vehicles, has formed an increasing demand for an additional accurate examination of the characteristics of gear structures. In the automobile manufacturing, the biggest producer of gears, higher consistency and lighter weight gears are essential as lighter automobiles carry on to be in demand. Additionally, the achievement in engine stress reduction supports the production of better gear pairs for additional stress reduction. However, a lack of these experts exists in the newer, lightweight industries in Japan mainly because smaller amount young people are specializing in gear technology today and conventionally the specialists engaged in heavy industries tend to stay where they are.

There are two principal forms of failure for spur gears in contact with each other: failure by means of bending and failure through contact stress at the gear tooth surface, the contact stress, or pitting stress, between two contacting gears may be calculated by means of the Hertzian contact equation, and is relative to the square root of the applied tooth load. The bending stress is estimated by assuming the gear tooth as a cantilevered beam, by a cross section of face width by tooth thickness. The spur gear tooth load is directly proportional to bending stress. Usually, bending failure will happen when the stress on the tooth is superior than or equal to the yield strength of the gear tooth material.

2. PROBLEM DEFINITION

Rigid gears develop high stress concentration at the root and contact point when subjected to loads over a long duration of time. Due to these high stresses at the contact points, there is a higher chance of fatigue failure at these locations. As the contact point shifts along the profile of the tooth , a surface fatigue failure is more likely. The repeated stress that occurs on the contact points is practically found to be a major deciding factor in fatigue failure of the gear tooth. There is scope of improved design of gears by an introduction of stress relief features. It is proposed to investigate the effect of stress relief features of different size, shape, location and number. A study is done for spur gear with involute profile shapes for effects of stress relief feature on the spur gears.

3. Project objective

To analyze the spur gear trains in a Lathe machine, finding the contact stresses on individual teeth under the working condition and modifying the gear by varying their geometrical parameters in order to reduce the stress concentration.

Table 3.1- Lathe Machine Specification

Manufacturer Name	Mysore Kirloskar

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Electric Motor	2 HP, 3PH, 1440 rpm
Gear Type	Parallel Spur Gears

Figure 3.1- Lathe Machine Gear Mechanism

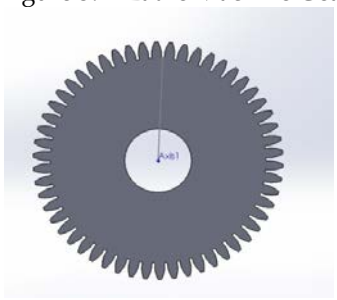


Figure 3.2- Solidworks Model of Gear A

Table 3.2- Specifications of Gear A

No. of teeth	71
Diametrical Pitch	0.5
Pressure Angle	20 deg
Addendum	2
Dedendum	2.5
Clearance	0.5
Pitch Circle Dia	142

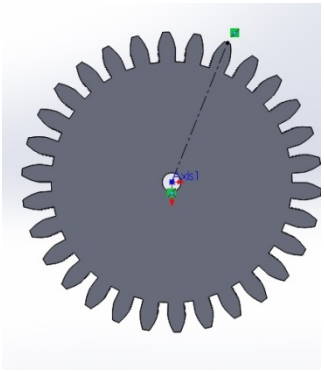


Figure 3.3- Solidworks Model of Gear B

Table 3.3- Specifications of Gear B

No. of teeth	24
Diametrical Pitch	0.5
Pressure Angle	20 deg
Addendum	2
Dedendum	2.5
Clearance	0.5
Pitch Circle Dia	48

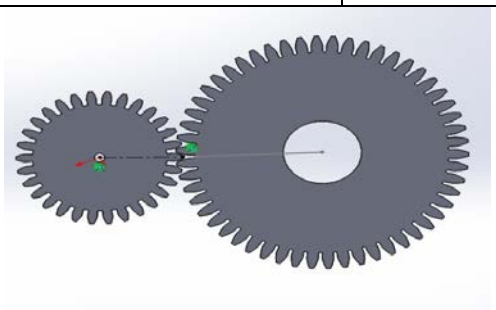


Figure 3.4- Meshing of Gear A and Gear B

MATERIAL OF THE GEAR PAIR

The material of the Spur gears used in Enterprise-3310 Lathe Machine is Cast Iron(Ductile)-SG700/2. The characteristics of this material are-

- Relatively inexpensive
- Durable
- Wear resistant
- Easy to cast into desired shape
- Good vibration damping

They are typically used in-

- Hardware: hinges, latches
- Stairs
- Tools and utensils
- Piping
- Ordnance
- Fences

Properties of SG700/2 are as follows

Density114	7300 kg/m3
Compressive Ultimate Strength114	840MPa
Tensile Ultimate Strength	700 MPa
Young's Modulus	35000 MPa
Poisson's Ratio	0.28

Methodology

➢ Analyze different Spur Gear Trains.

➢ Make their model in SOLIDWORKS.

➢ Identify the stress concentration areas after analyzing on ANSYS.

➢ On the basis of the following observations, optimize the design by varying parameters like module,fillet radius,material

Parameter 1

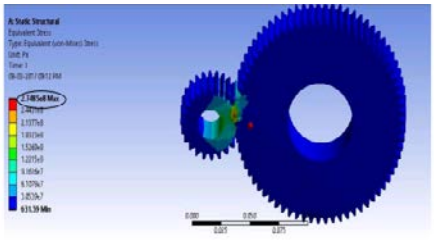
Modeling for the gear pair of module=3 in SOLIDWORKS and mating them Input the known data and check for equivalent stress.

Parameter 2

Fillet Radius of 1mm

We take the gear with module 2mm and keep the fillet radius as 1mm. We then apply all the given physical conditions and check for the contact pressure.

Module	stress(MPa)	deformation(mm)
2 mm	8.726e8	6.0154e-5
3 mm	2.748e8	2.079e-5
4 mm	1.236e8	9.159e-6



5.1.2 (c) Equivalent Stress in Gear of Module 3mm

Fig. 3.5 Stress distribution study

.➢Analyze the modified design on ANSYS to check for the reduced stress concentration.

SCOPE OF PROJECT

1. The analysis of different spur gear trains will enable the gear manufactures to manufacture gears with better design having longer lives.
2. In heavy use machines, optimization of gear will increase the life span of machine and hence their productivity.
3. Optimization of gears will reduce accidents caused due to gear failure and hence ensure safety of the workers operating the machines.
4. Gears are found in almost every machineries now a days, its optimization will improve the performance of the machines and contribute toward development of technology.

EXPECTED OUTCOMES

- Reduced Stress Concentration on gear tooth
- Prevention of gear tooth failure and increase in its life

Results

Parameter 1 (module)

Parameter 2 (fillet radius)

Fillet radius	stress(Pa)	deformation(m)
1 mm	95499	8.91e-9
0.4 mm	6534.3	7.823e-10

MODIFIED GEAR DESIGN

From the above observations, it can be derived as follow:

Module	4mm
Material	High carbon steel
Fillet radius	1mm

Fig. 3.6 Stress distribution study

4. CONCLUSION

In general, the entire development of the project work was educative and we gained a lot of experience by carrying out the project in a group. We could understand the practical constraints of developing such systems about which we have studied in the theory classes. It was satisfying to see so many theoretical aspects work before us in real practice which we had known only though theoretical knowledge. After analyzing the spur gear train of Lathe Machine and finding the contact stresses on its teeth under the working conditions we can conclude that the geometrical parameters of the gear play a vital role in deciding contact stresses on gear teeth.As the module increases the contact pressure on the gear tooth decreases. As the fillet radius increases, the contact pressure decreases due to more availability of area for distribution of stress. In case of materials, High Carbon Steel is more suitable for manufacturing of gear under the prescribed conditions. Such analysis of gear tooth under the working conditions play a vital role in gear manufacturing industry as it allows them to manufacture an efficient gear based on this study to be used in a particular industry under the given conditions.

REFFERENCES

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