

# Review on Analysis and Modification of Spur Gear Design

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**Abstract**— This paper present the Review on Analysis and modification of spur gear design and explain the design the spur gear and dimension specification. To design the spur gear to study the weight reduction and stress distribution for cast steel and composite materials. Gearing is one of the most critical components in mechanical power transmission system, and in most industrial rotating machinery. Its have a involving modern design, specific character, specific materials, with consideration of analysis of force and its mechanical properties. These approach for modern spur design developing the tooth profiles with modified the shape and improving dimension. Spur gear is cylindrical shaped gear in which the teeth are parallel to the axis. It is easy to manufacture and it is mostly used in transmitting power from one shaft to another shaft up to certain distance & also used to vary the speed & Torque. the main purpose of modern spur gear design it increases the power transmitting capacity and also improves the efficiency of power transmission.

**Index Terms**- Spur gear design, Gear, Composite, analysis, dimension

## I. INTRODUCTION

Spur gears are the most common type of gears. They are used to transmit rotary motion between parallel shaft i.e. they are usually cylindrical in shape, and the teeth are straight and parallel to the axis of rotation. Sometimes spur gears are used at once to create very large reductions. Spur gears are used in many devices but not in cars as they produce large noises. Gears is rotation cylindrical wheel having tooth cut on it and which meshes with another toothed part to transmit the power or torque. Spur gear is the simplest type of gear having at tooth cut parallel the axis of shaft on which the gear is mounted. Spur gears are used to transmit the power between parallel shafts. Spur gear gives 98-99% operating efficiency [1].



Fig.1. Spur Gear (courtesy: spur gear [14])

This gear can be meshed together correctly only if they are fitted to parallel shaft. The main reason for the popularity of spur gear is their simplicity in design and manufacturing. The two parameters i.e. tip radius and in tooth widths which play a key role gear design are studied [2]. A gear is a rotating machine part having cut teeth which is meshing the gear teeth to transmit the torque. a geared device can be changed the speed, direction of power sources and magnitude [3]. Spur gear 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. Spur gears are the most common type used. Tooth contact is primarily rolling, with sliding occurring during engagement and disengagement. Some noise is normal but it may become objectionable at high speeds. Now days there are so many mechanisms those involve with load and requirement to understand the stress in component is increased. The mechanism and the always come together and they have a strong relation between each other [4].

II. BASIC TERMS OF SPUR GEAR

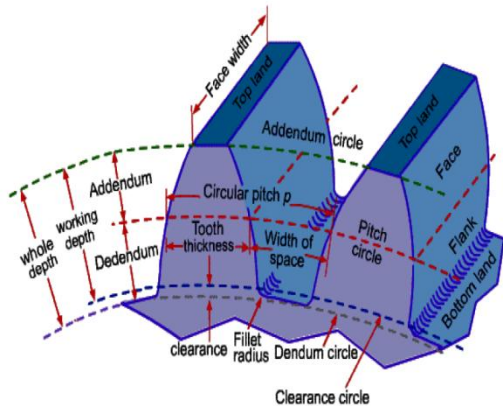


Fig.2. involute Spur gear (courtesy: NPTL/IIT-Madras) [15]

**MODULE:** module of gear is defined as ratio of diameter to number of teeth.  $m = d/N$

**FACE WIDTH:** the width along the contact surface between the the gear is called the face width.

**TOOTH THICKNESS:** the thickness of the tooth along the pitch circle is called the tooth thickness.

**DIAMETRAL PITCH (DP):** The gear tooth size is described by diametral Pitch larger gear have fewer teeth per inch of daimetral pitch, daimetral pitch is iversely gear teeth size.

**PITCH DIAMETER:** The pitch diameter is indicated the diameter of the pitch circle.if the diameter of the gear pitch is known pitch diameter. We can mathematically expression.

$$PD = N/P$$

PD=pitch diameter

N= number of teeth on the gears

P=diametral pitch (gear size)

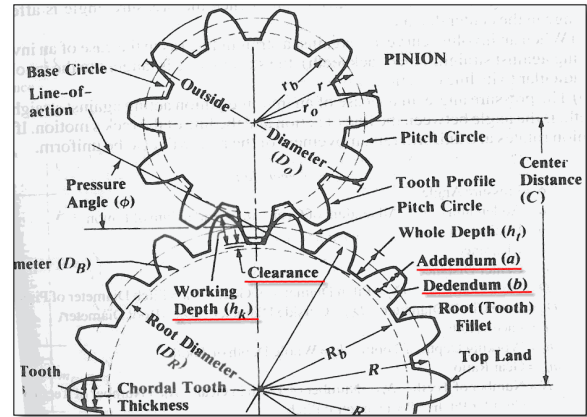
A. SOME IMPORTANT DEFINITION

Fig.3. Gear rotion = driven gear teeth/drive gear teeth

**Pitch diameter (D):** the diameter of the pitch circle from which the gear is design. An imaginary circle, which will contact the pitch circle of another gear when in mesh.

$$D = N/P$$

**Diametral pitch (P):** a ratio of the number of teeth per inch of pitch diameter



$$P = N/D$$

**Addendum (A):** the radial distance from the pitch circle to the top of the gear tooth

$$A = 1/P$$

**Dedendum (B):** the radial distance from the pitch circle to the bottom of the tooth

$$B = 1.157/p$$

**Outer diameter (OD):** the overall diameter of the gear

$$OD = (N+2)/P$$

**Root diameter (RD):** the diameter at the bottom of the tooth

$$RD = (N-2)/P$$

**Base circle (BC):** the circle used to from the involute section of the gear tooth

$$BC = D * \cos PA$$

**Circle pitch (CP):** the measured distance along the circumference of the pitch diameter from the point of one tooth to the corresponding point on an adjacent tooth.

$$CP = 3.1416/P$$

**Circular thickness (T):** thickness of a tooth measure along the circumference of the pitch circle

$$T = 1.57/P$$

**Clearance (C):** refer to the radial distance between the top and bottom of gears in mesh some mechanism,. In other word the gap between two distances is known as clearance

**Whole depth (WD):** the distance from the top of the tooth to the bottom of the tooth .the whole depth is calculated by

$$WD = 2.157/P$$

**Pressure angle (PA):** it refers to the angle through which forces are transmitted between meshing gears.

**Center distance:** the distance from the center shaft of one spur gear to the center shaft of the other spur gear. it is called center distance.

Gear ratio: the ratio of a given pair of spur gears is calculated by dividing the number of teeth on the driven gear, by the number of teeth on the drive gear [5].

### III. DESIGN PROCEDURE OF SPUR GEAR

First of all, the design tangential tooth load is obtained from the power transmitted and the pitch line velocity by using the following relation:

$$W_T = (P/v) \times C_S$$

Where,

$W_T$  = Permissible tangential tooth load in newtons,

$P$  = Power transmitted in watts,

$v$  = Pitch line velocity in m / s ,

$D$  = Pitch circle diameter in metres

$N$  = Speed in r.p.m.,

$C_S$  = Service factor.

A. Apply the Lewis equation as follows

$$W_T = \sigma_w b p_c y = \sigma_w b \pi m y$$

- The Lewis equation is applied only to the weaker of the two wheels (i.e. pinion or gear).
- When both the pinion and the gear are made of the same material, then pinion is the weaker.
- When the pinion and the gear are made of different materials, then the product of ( $\sigma_w \times y$ ) or ( $\sigma_o \times y$ ) is the \*deciding factor. The Lewis equation is used to that wheel for which ( $\sigma_w \times y$ ) or ( $\sigma_o \times y$ ) is less.
- The product ( $\sigma_w \times y$ ) is called strength factor of the gear.
- The face width ( $b$ ) may be taken as 3 pc to 4 pc (or 9.5 m to 12.5 m) for cut teeth and 2 pc to 3 pc (or 6.5 m to 9.5 m) for cast teeth.

B. Calculate the dynamic load (WD) on the tooth by using Buckingham equation

$$W_D = W_T + W_I$$

$$W_T + \frac{21v(b.C + W_T)}{21v + \sqrt{b.C + W_T}}$$

C. Find the static tooth load

(i.e. beam strength or the endurance strength of the tooth) by using the relation,

$$W_S = \sigma_e b p_c y = \sigma_e b \pi m y$$

For safety against breakage,  $W_S$  should be greater than  $W_D$ .

Finally, find the wear tooth load by using the relation

$$W_W = D_p . b . Q . K$$

The wear load ( $W_W$ ) should not be less than the dynamic load ( $W_D$ ).

### D. GEAR STRENGTH

It has good strength, durability, wear resistance, and chemical resistance, so can be used to each gear. gear wreck will happen because of its tooth fatigue and tooth surface wear, so strength design from both side is necessary.

### E. TOOTH SURFACE STRENGTH

The design intent of asymmetric teeth is to improve performance of main contacting profiles by degrading opposite profiles. These opposite profiles are unloaded or lightly loaded, and usually work for a relatively short period. The improved performance could mean increasing load capacity or reducing weight, noise, vibration, etc.

Direct gear design for asymmetric tooth profiles opens additional reserves for improvement of gear drives with unidirectional load cycles that are typical for many mechanical transmissions[5].[6]

Direct gear design is an alternative approach to traditional gear design .it allows analysis of a wide range of parameter for all possible gear combinations in order to find the most suitable solution for a particular application. This optimum gear solution cans exceed the limits of traditional rack generating methods of gear design. [6]

If a gear does not produce a satisfactory design based on bending requirements, a design alteration may be needed. This is not always straightforward, since such alterations may help in one area and hurt in another, and may affect associated machine elements such as bearings. However, some factors that improve bending performance are the following:

1. Reduction in the load, such as by increasing contact ratio, or altering other aspects of the system.

2. Increase the center distance.
3. Apply gears with a finer pitch.
4. Use a higher pressure angle.
5. Use a helical gear instead of a spur gear.
6. Use a carburized material.
7. Increase the surface hardness by material selection, or by performing a surface hardening operation.
8. Improve the gear accuracy through manufacturing process selection.
9. Use a wider effective face width.
10. Increase the lubricant film thickness.[7]

#### IV. LITRATURE REVIEW

Studied the reduction of gear fillet stressed by using one-sided involutes teeth, For increasing the load carrying capacity of geared power transmissions several tooth designs alternative to the standard involute have been proposed. The use of non-involutes teeth has a number of disadvantages and for this reason a symmetric involute-type teeth have been studied as a promising alternative. In this paper the idea of one side involute asymmetric spur gear teeth is introduced to increase load carrying capacity and combine the good meshing properties of the driving involute and increased strength of non involutes curves. These novel teeth are intended for constant direction way for reverse rotation. Both flanks are fully generated by hob, the design of which is also investigated. The increase in load carrying capacity can reach up to 28% compared to the standard 20<sup>0</sup> involutes teeth [8].

The polymer gear wear rate will be increased, when the load reaches a critical value for a specific geometry. The gear surface will wear slowly with a low specific wear rate if the gear is sudden increase in wear rate is due to the gear operating temperature reaching the material melting point under the critical load condition. Actual gear performance was found to be entirely dependent on load. A sudden transition to high wear rates was noted as the transmitted torque was increased to a critical value. This is to be associated with the gear surface temperature of the material reaching its melting point. That is for a given geometry of actual gear, a critical torque can be decided from its surface temperature calculation [9].

The detail analysis of the flash temperature for polymer composite gears and the heat partition

between gear teeth problem is treated as an unsteady one where the intensity distribution and velocity of heat source changes as meshing proceeds. A numerical approximation is adopted using semi-analytical method assuming no internal hysteresis and the material properties are constant. Blok's solution can be used to provide a quasi-steady approximation that is for mean flash temperature estimation. A numerical method has been developed in the current paper for polymer composite gear flash temperature prediction.[10].

Investigated the finite element analysis of bending stress in involute gears. This paper describes the use of the finite element method for predicting the fillet stress distribution experienced by loaded spur gears. The location of the finite element model boundary and the element mesh density are investigated. Fillet stress predicted by the finite element model are compare with the result of photo elastic experiments. Both external and internal spur gear tooth forms are considered.[11].

Spur gear wears either due to rubbing action between the meshed gears or by the occurrence of unwanted elements like dust particles, metal fragments, etc. which reduces its efficiency and service life. It is always a challenging task to determine the remaining life of a component or the strength of a component once wear has occurred on teeth surface. This paper presents an application of reverse engineering approach for reconstruct the spur gear 3D CAD model using scanned data. A gear has been scanned using PICZA 3D laser scanner (RolandLPX60) [12].

The objective of paper is to study the various stress state of spur gear. They calculated the tangential and radial forces which acts on various point upon that basis we can analyze by applying the forces. By using ansys software bending stress and contact stress on the tooth of spur gear drive is found gears are machine element used to transmit power between rotating shafts by means of engagement of projection called teeth. Gears are most common means of transmitting power in the wooden mechanical world. They vary from a tiny size used in watches to larger gears used in massive speed reducers, bridge lifting mechanism and rail road turn table drive. The gears are vital elements of main and auxiliary mechanism in many machines such as automobiles, tractors, metal cutting machine tool

rolling mills hosting and transmitting and transporting machinery, massive engines etc. [13]

#### V. CONCLUSION

This paper performed a comparative analysis of spur gears, through the combination of both experience and the traditional theory of gear modification. A short overview of the major modification was given. Unloaded tooth contact analysis of the gears modified in profile and lead (lengthwise) directions was performed, and compared to the actual forged gears. The shape and position of the actual and predicted contact patterns were in good agreement, verifying the proposed procedure.

The study is show that Lewis formula is use for calculating bending stress is a pair of gear. Theoretically result obtained Lewis formula result found by comparable with finite element analysis of spur gear.

As a result, based on this finding if the contact stress minimization in the primary concern and if the larger 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.

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