International Journal of Engineering Sciences Paradigms and Researches (IJESPR)
Volume 46, Issue: Special Issue of December 2017
An Indexed, Referred and Peer Reviewed Journal with ISSN (Online): 2319-6564
www.ijesonline.com

Review of Spur Gear Design Analysis and Modification

Dr. Sai Gani Prasad [1*], Dr. Nabnit Panigrahi [2]
[1*] Prof., Department of Mechanical Engineering, Nalanda Institute of Technology, Bhubaneswar, Odisha, India
[2]Asso.Prof., Department of Mechanical Engineering, Nalanda Institute of Technology, Bhubaneswar, Odisha, India
*Corresponding author e-mail: saiganiprasad@thenalanda.com

Abstract— **This essay reviews the analysis and modification of spur gear designs and describes the spur gear's design and sizing requirements. Studying weight reduction and stress distribution for cast steel and composite materials is necessary for the spur gear design. One of the most important parts of mechanical power transmission systems and the majority of industrial rotating machinery is gearing. Its intricate modern design, distinctive personality, unique materials, and attention of analysis of force and its mechanical qualities are all present. These methods for contemporary spur design involve changing the shape and dimensions of the tooth profiles. Spur gear is a cylindrical gear with teeth that are perpendicular to the axis. It is simple to produce and mostly used to transfer power from one shaft to another shaft over a short distance. It can also be used to change speed and torque. The primary goal of contemporary spur gear design is to maximise the capacity and efficiency of power transmission.**

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

I. INTRODUCTION

The most prevalent kind of gears are spur gears. They are typically cylindrical in shape and have teeth that are straight and parallel to the axis of rotation since they are used to transmit rotary motion between parallel shafts. To achieve very substantial reductions, spur gears may occasionally be utilised simultaneously. Several gadgets use spur gears, however since they make loud noises, autos do not. A gear is a cylindrical rotating wheel with teeth cut into it that meshes with another toothed component to impart power or torque. The simplest sort of gear is a spur gear, which has a tooth cut that is perpendicular to the shaft axis on which it is attached. Power is transferred between parallel shafts using spur gears

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

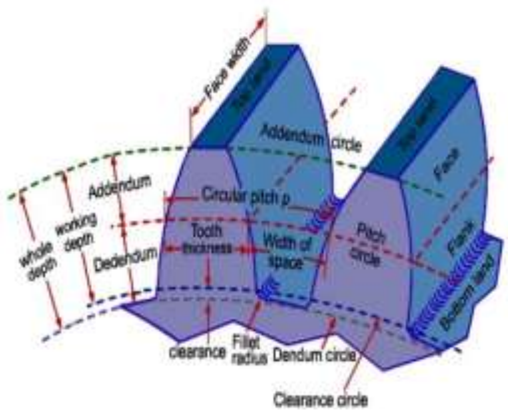


Fig.2. involute Spur gear (courtesy: NPTL/IIT-Madras) [15]

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)

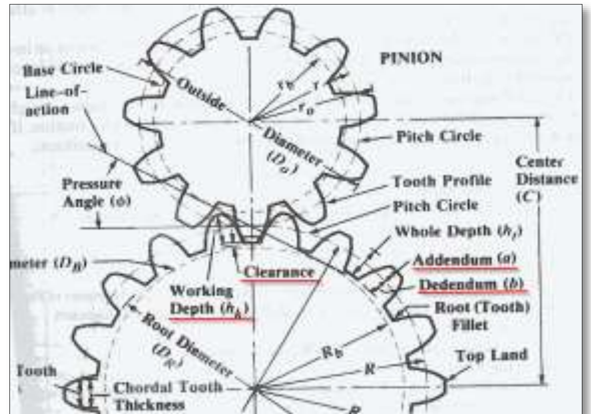
A. SOME IMPORTANT DEFINITION

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 pitchcircle to the top of the gear tooth

A=1/P

Dedendum (B): the radial distance from the pitchcircle 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 ofthe tooth

RD= (N-2)/P

Base circle (BC): the circle used to from the involutesection 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 measurealong 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 throughwhich forces are transmitted between meshing gears. Center distance: the distance from the center shaftof one spur gear to the center shaft of the other spurgear. 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 (σw × y) or (σo × y) is the *deciding factor. The Lewis equation is used to that wheel for which (σw × y) or (σo × y) is less.
- The product (σw × 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

$$W_D = W_T + W_I$$

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

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, WS should be greater than WD.
Finally, find the wear tooth load by using the relation

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

The wear load (WW) should not be less than the dynamic load (WD).

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. Usea 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 20^0 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 variouspoint 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

By the use of both practical experience and the conventional theory of gear modification, spur gears were compared in this study. The primary alteration was briefly described. Unloaded tooth contact analyses of the gears that had been altered in the lead (lengthwise) and profile directions were conducted and contrasted with those of the original forged gears. The suggested method was validated by the form and location of the actual and anticipated contact patterns, which were in good agreement.

According to the study, the Lewis formula uses two gears to calculate bending stress. Theoretically, the Lewis formula result was discovered by comparing it to a spur gear finite element analysis.

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.

REFERENCES

[1] Vivek Karaveer, Ashish Mogrekar and T. Preman Reynold Joseph (2013): Modeling and Finite Element Analysis of spur gear, International Journal of Current Engineering and Technology ISSN 2277-4106.

[2] Sandeep, R.K.Suresh, B. jayachandraiah, Department of Mechanical Engg. Kalahasteeswara institute of technology Srikala hasti chittor AP. Hyderabad, India. DeForabie body dynamic analysis of of planetary gear with thin rims journal of sound and vibration 262 (2003) 752-768.

[3] B Venkatesh, V. kamala, A.M.K. Prasad Assoc. Professor. MED Vardhaman college of Engg. Hyderabad India Professor. MED MJCET Hyderabad, DGM (Retd.), BHEL R&D, Hyderabad India.Professor & Head MED Osmania Csollage at Engg. University Hyderabad, India. Design Modeling and Manufacturing Helical Gears.

[4] F. R. M. Romlay (2008): Modeling of surface contact stress for spur gear mechanism using static and transient finite element method, Journal of Structural Durability & Health Monitoring (SDHM), Tech Science Press, Vol. 4, no.1.

[5] Kapelevich A.L.Geometry and design of involutes pure gear with asymmetric teeth Mechanism and machine theory 2000. Issue 35.pp.117-130.

[6] Litvion F.L. Q. lain and A.L. Kapelevich, asymmetric modified gear drive reduction of noise Localization of contact simulation of meshing and stress analysis, computer method in applied Mechanics and Engineering 2000 Issue 188.pp 363-390.

[7] CRCF Fundamental of machine elements 3rd Schmid Hamrock and Jacobson 2014 CRC pre-design procedure method to Increase the pitting Resistance.

[8] Costopoulos Th. Spitas V. (2009) "*Reduction of gear fillet stressed by using one-sided involute asymmetric teeth",* page no. 1524-1534.

[9] K. Mao, "A new approach for polymer composite gear design", Mechanical Engineering, School of Engineering and Design, Brunel University, Uxbridge, Middlesex UB8 3PH UK, accepted 14 June 2006.

[10] K. Mao, "A numerical method for polymer composite gear flash temperature prediction", Mechanical Engineering, School of Engineering and Design, Brunel University, Uxbridge, Middlesex UB8 3PH UK, accepted 14 June 2007.

[11] Andrews J.D. (1991) – " *A Finite Element Analysis of Bending Stress induced in external and internal involute spur gears",* The Journal of Strain Analysis for Engineering Design, page no.153-163.

[12] Atul Kumar, P. K. jain and P. M. Patha., Comparative Finite Element Analysis of Reconstructed New and Worn Tooth of Spur gear. Proceedings of the 1st International and 16th National Conference on Machines and Mechanisms (iNaCoMM2013), IIT Roorkee, India, Dec 18-20 2013.

[13] Mrs. C.M. Meenakshi, akash Kumar, Apoorva Priyadardsi, Digant Kumar Dash and Hare Krishna, "Analysis of Spur Gear Using Finite Element Analysis", Middle-East Journal of Scientific Research 12 (12): 1672-1674, 2012 ISSN 1990-9233.

[14] http://www.gearsandstuff.com/gear

[15] http://nptel.iitm.ac.in/courses/IIT-MADRAS/Machine_Design_II/pdf/2_3.pdf