Design of Spur Gear

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Abstract— A gear or "gear wheel" is a rotating machine part having cut teeth, or cogs, which mesh with another toothed part in order to transmit power. Spur gear is a gear which is used to transmit power from one shaft to another shaft. At the time of Power Transmission several types of stresses presented on gear while designing. The bending stress is considered as the main cause of failure during the transmission of power. The major purpose of this study is to know the design procedure of Spur Gear. The Gear drive consists of two wheels. The small Wheel is called as Pinion and larger wheel is called as Gear.

Key words: Spur Gear, Design Procedure

I. INTRODUCTION

Spur gears are the most common type of gears. They are used to transmit rotary motion between parallel shafts. The knowledge of gear behavior in mesh such As stress distribution, work condition and distortion is critical to monitoring and controlling the gear transmission system. Gears generally fail when the working stress exceeds the maximum permissible stress. The spur gears are mainly used because they have high power transmission efficiency. They are compact and easy to install. Depending on their construction and arrangement, geared devices can transmit forces at different speeds, torques, or in a different direction, from the power source. Gears are a very useful simple machine. The most common situation is for a gear to mesh with another gear, but a gear can mesh with any device having compatible teeth, such as linear moving racks. They offer constant velocity ratio. Unlike belt drives, spur gear drives have no slip. Spur gears are highly reliable. They can be used to transmit large amount of power (of the order of 50,000 kW). They are simplest of all the gears and easiest in production. The teeth of spur gear are cut along the periphery and parallel to the axis of gear. Spur gears can be made of steels, brass, other metals and plastics. Spur gears are having wide range of applications. They are using in metal cutting machines, power plants, Mechanical clocks and watches, Fuel pumps, Washing machines, Gear motors and gear pumps, Automobile gearboxes , etc

II. LITERATURE REVIEW

J.L. Moya, et al. (2007) they have performed a theoretical analysis of a procedure to determine the Lewis Factor and also performed the contact analysis of spur gears to find the stress distribution between gear teeth.

PINAKNATH PEWANJI., This paper analyses the bending stresses characteristics of an involute spur gear tooth under static load condition s. The tooth profile is generated using catia and analysis is carried out by ansys software. The stress at the tooth root are evaluated analytically using existing theoretical models.

III. OBJECTIVE

- To learn the Design procedure of a Spur Gear.
- To learn and Design a Spur Gear according to the application and prevent the Failure of the Gear under loading conditions.
- To apply theoretical and practical knowledge based on the application of Gear.
- To determine the safe Design of the Gear.

IV. MATERIALS AND METHODOLOGY

As we know that for proper designing the Selection of material is an important factor. One of the first steps in addressing a customer's needs is to determine what size spur gears are needed for a particular application. But before we do, it is helpful to know the meanings of several terms that are commonly used are:

- Diametric Pitch: the ratio of the number of teeth to the pitch diameter.
- Pitch Circle: the imaginary circle that comes in contact with the imaginary circle of another gear when the two are in mesh.
- Pitch Diameter: the diameter of the pitch circle.
- The following terms are used when describing the Dimensions of a gear tooth:
- Addendum: the distance from the top of a tooth to the pitch circle.
- Dedendum: the distance from the pitch circle to the root circle. It equals the addendum + the working clearance.
- Whole Depth: the distance from the top to the bottom of the gear tooth.
- Working Depth: the total depth of a tooth space. It is equal to the addendum + the dedendum (or the working depth + the variance).
- Working Clearance: the distance from the working Depth to the root circle.

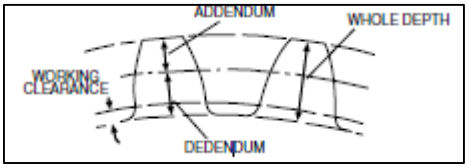

Fig. 1: Diagram showing Addendum and Dedendum location.

Example: A gear with a 1-1/2" pitch diameter and 72 teeth is a 48-pitch gear (72 ÷ 1.5). (See Figure 1.2)

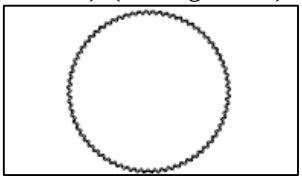

Fig. 1.1: a gear with 72 teeth and a 1-1/2" Pitch Diameter is 48 Pitch.

A. PRESSURE ANGLE

Pressure angle (also referred to as "tooth shape") is the angle at which the pressure from the tooth of one gear is passed on to the tooth of another gear. Spur gears come in two pressure angles: 14 1/2º and 20º
The 14 1/2º pressure angle is the original standard
Tooth shape. It is still widely used today.

B. CIRCULAR PITCH

Sometimes spur gears are measured according to their circular pitch. Simply put, circular pitch is the distance – measuring along the pitch circle or pitch line – from any point on a gear tooth to the corresponding point on the next tooth. It is also equal to the circumference of the pitch circle divided by the total number of teeth on the gear.
Example: 5" circumference ÷ 20 teeth = .25 circular pitch.

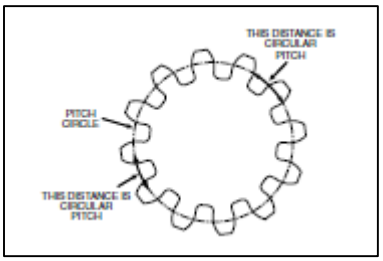

Fig. 2 Diagrams Represents Circular Pitch Phenomenon.

C. BACKLASH

Backlash is the distance (spacing) between two "mating" gears measured at the back of the driver on the pitch circle. Backlash, which is purposely built in, is very important because it helps prevent noise, abnormal wear and excessive heat while providing space for lubrication of the gears.

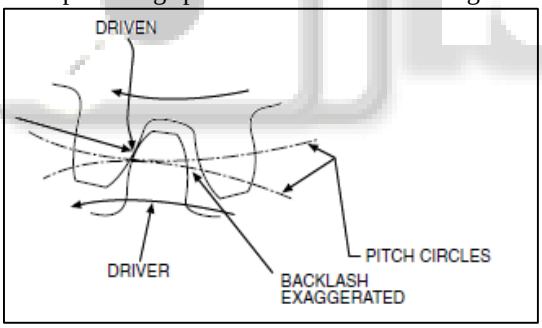

Fig. 2.2: Diagram Represents Backlash Phenomenon.

D. CENTRE DISTANCE

Centre Distance is the distance between the centers of the shaft of one spur gear to the center of the shaft of the other spur gear. In a spur gear drive having two gears, center distance is equal to one-half the pitch diameter of the pinion plus one-half the pitch diameter of the gear. Or, better still, simply add the sum of the two pitch diameters and divide by two.

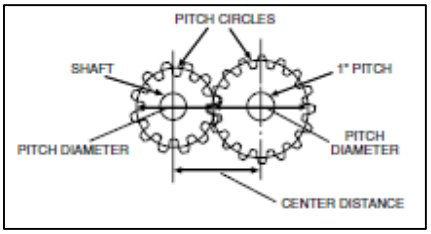

Fig. 2.3 Diagram indicates Centre Distance of shafts.

Example: The center distance of a 4-inch pitch diameter gear running with a 2-inch pitch diameter pinion is 3 inches. 4" + 2" ÷ 2 = 3" CD.

E. ROTATION

The direction in which a gear revolves while in operation – is one of the most important concepts in the power transmission.

- In a spur drive having two gears, the pinion and gear will rotate in opposite directions.
- In a spur gear train having three gears, the pinion and gear will rotate in the same direction.

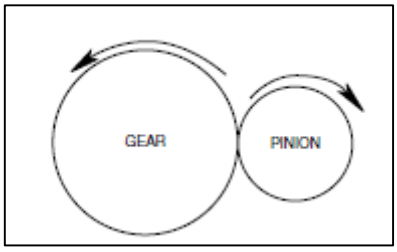

Fig. 2.4 Diagram indicates Rotation of Gear and Pinion.

F. GEAR RATIO

Gear Ratio is the mathematical ratio of a pair of spur gears – is determined by dividing the number of teeth on the larger gear with the number of teeth on the pinion.
Example: The ratio of a 72-tooth gear running with a 16-tooth pinion is 4.5:1.
Ratio: 72÷16 = 4.5

G. Selecting the Right Gear Drive for the Application

When selecting gears, the service class is dependent on operating conditions – also referred to as the duty cycle. You can determine your gear needs using the following procedure

1) Determine the service factor.
2) Multiply the horsepower required for the application by the service factor.
3) Select the spur gear pinion with a Boston Gear catalog rating equal to or greater than the horsepower determined in step 2.
4) Select spur gear with a Boston Gear catalog rating equal to or greater than the horsepower determined in step 2.

Example: An application having a service factor of 1.5 and a required horsepower of 6.0 would require a pinion with a rating equal to or greater than 9.0 (1.5 x 6.0) and a gear with a rating equal to or greater than 9. (1.5 x 6.0).

When you know the five variables listed above – horsepower, torque, duty cycle, center distance and ratio – you can select the right spur gears for any application using a three-step process. Let's walk through that process using the following variables:

- Center distance = 3"
- Ratio required = 3:1
- Horsepower required = 5.5
- Velocity of pinion = 1,800 rpm
- Velocity of gear = 600 rpm
- Service factor = 1.25

1) Step 1 – Find the pitch diameter (PD) of the pinion and gear (assuming the center distance and ratio are fixed) using the following formulas:
PD of pinion = 2 x center distance ÷ ratio + 1
PD of gear = PD of pinion x ratio

Now let's insert the figures from our sample set of variables and do the math:
PD of pinion = (2 x 3") ÷ (3 + 1) = 6 ÷ 4 or 1.5
PD of pinion = 1.5"
Now that we know the PD of the pinion (1.5) and the
Required ratio (3:1), we can figure the PD of the gear.
PD of gear = 1.5" x 3 or 4.5"

2) Step 2 – Multiply the required horsepower by the service factor to determine the horsepower rating for the pinion and gear (making sure to check the horsepower rating sheets in the appropriate Boston Gear catalog). Select the pinion and gear according to these known specifications.

Required horsepower = 5.5
Service factor = 1.25
5.5 x 1.25 = 6.88, therefore:
Horsepower rating for pinion = 6.88 at 1800 rpm
Horsepower rating for gear = 6.88 at 600 rpm

3) Step 3 – Check the horsepower ratings of both the pinion and gear selected against the ratings in the appropriate catalogs.

Using the horsepower calculations for the pinion and gear (as determined in Step 2). (which have two keyways 180-degrees apart), standard spur gears are normally stocked without set-screws or keyways.

H. GEAR GLOSSARY

- ADDENDUM (a) is the height by which a tooth projects beyond the pitch circle or pitch line.
- BASE DIAMETER (Db) is the diameter of the base cylinder from which the involute portion of a tooth profile is generated.
- BACKLASH (B) is the amount by which the width of a tooth space exceeds the thickness of the engaging tooth on the pitch circles. As actually indicated by measuring devices, backlash may be determined variously in the transverse, normal, or axial-planes, and either in the direction of the pitch circles or on the line of action. Such measurements should be corrected to corresponding values on transverse pitch circles for general comparisons.
- BORE LENGTH is the total length through a gear, sprocket, or coupling bore.
- CIRCULAR PITCH (p) is the distance along the pitch circle or pitch line between corresponding profiles of adjacent teeth.
- CIRCULAR THICKNESS (t) is the length of arc between the two sides of a gear tooth on the pitch circle, unless otherwise specified.
- CLEARANCE-OPERATING (c) is the amount by which the dedendum in a given gear exceeds the addendum of its mating gear.
- CONTACT RATIO (mc) in general, the number of angular pitches through which a tooth surface rotates from the beginning to the end of contact.
- DEDENDUM (b) is the depth of a tooth space below the pitch line. It is normally greater than the addendum of the mating gear to provide clearance.
- DIAMETRAL PITCH (P) is the ratio of the number of teeth to the pitch diameter.
- FACE WIDTH (F) is the length of the teeth in an axial plane.
- FILLET RADIUS (rf) is the radius of the fillet curve at the base of the gear tooth.
- FULL DEPTH TEETH are those in which the working depth equals 2.000 divided by the normal diametric pitch.
- GEAR is a machine part with gear teeth. When two gears run together, the one with the larger number of teeth is called the gear.
- HUB DIAMETER is outside diameter of a gear, sprocket or coupling hub.
- HUB PROJECTION is the distance the hub extends beyond the gear face.
- INVOLUTE TEETH of spur gears, helical gears and worms are those in which the active portion of the profile in the transverse plane is the involutes of a circle.
- LONG- AND SHORT-ADDENDUM TEETH are those of engaging gears (on a standard designed center distance) one of which has a long addendum and the other has a short addendum.
- KEYWAY is the machined groove running the length of the
- bore. A similar groove is machined in the shaft and a key fits into this opening.
- NORMAL DIAMETRAL PITCH (Pn) is the value of the diametric pitch as calculated in the normal plane of a helical gear or worm.
- NORMAL PLANE is the plane normal to the tooth surface at a pitch point and perpendicular to the pitch plane. For a helical gear this plane can be normal to one tooth at a point laying in the plane surface. At such point, the normal plane contains the line normal to the tooth surface and this is normal to the pitch circle.
- NORMAL PRESSURE ANGLE (øn) in a normal plane of helical tooth.
- OUTSIDE DIAMETER (Do) is the diameter of the addendum (outside) circle.
- PITCH CIRCLE is the circle derived from a number of teeth and a specified diametric or circular pitch. Circle on which spacing or tooth profiles is established and from which the tooth proportions are constructed.
- PITCH CYLINDER is the cylinder of diameter equal to the pitch circle.
- PINION is a machine part with gear teeth. When two gears run together, the one with the smaller number of teeth is called the pinion.
- PITCH DIAMETER (D) is the diameter of the pitch circle. In parallel shaft gears, the pitch diameters can be determined directly from the center distance and the number of teeth.
- PRESSURE ANGLE (ø) is the angle at a pitch point between the line of pressure which is normal to the tooth surface, and the plane tangent to the pitch surface. In involutes teeth, pressure angle is often described also as the angle between the line of action and the line tangent to the pitch circle. Standard pressure angles are established in connection with standard gear-tooth proportions.

- ROOT DIAMETER (Dr) is the diameter at the base of the tooth space.
- PRESSURE ANGLE—OPERATING (ør) is determined by the center distance at which the gears operate. It is the pressure angle at the operating pitch diameter.
- TIP RELIEF is an arbitrary modification of a tooth profile whereby a small amount of material is removed near the tip of the gear tooth.
- UNDERCUT is a condition in generated gear teeth when any part of the fillet curve lies inside a line drawn tangent to the working profile at its point of juncture with the fillet.
- WHOLE DEPTH (ht) is the total depth of a tooth space, equal to addendum plus dedendum, equal to the working depth plus variance.
- WORKING DEPTH (hk) is the depth of engagement of two gears; that is, the sum of their addendums.

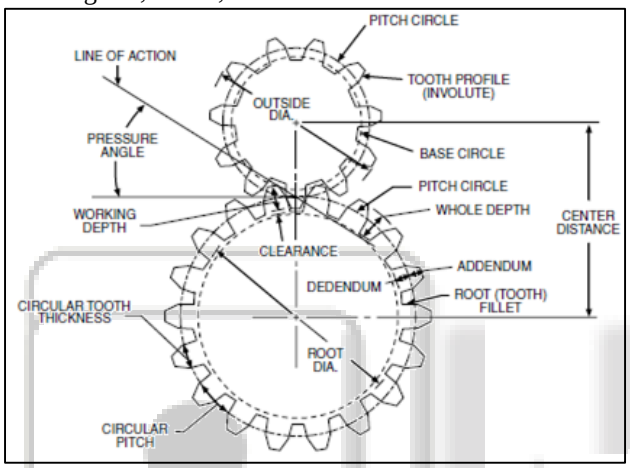

Fig. 3: Diagram of Gear and Pinion arrangement.

V. RESULTS

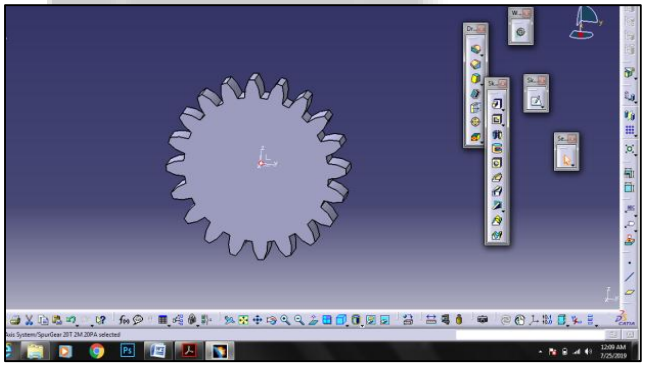

Fig. 4: Catia Model of Spur Gear

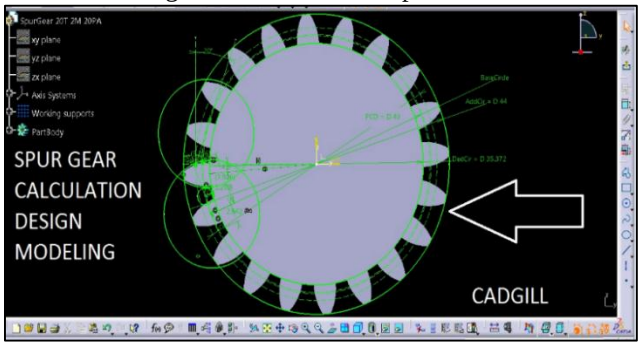

Fig. 4.1: Spur Gear calculation Design modeling on Catia

VI. CONCLUSION

- The literature survey of spur gear was performed.
- Theoretical method for designing a spur gear was learnt during this process.
- Method of Designing a spur gear according to the application was carried out.
- Determining the Dimensions of the tooth profile for designing a spur gear.
- Use of CAD software for designing a Spur gear having involutes profile.

ACKNOWLEDGMENT

I gained knowledge of designing spur gear through the reference books. Major role for the knowledge enhancing was various research papers and internet, which helped me to work on the spur gear design procedure.

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