To Investigate and Eliminate the Causes of Chordal Thickness Error in Non Metallic Spur gear Manufactured on Universal Milling Machine.

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Abstract

Gear is used to transmit power and motion from one shaft to another shaft. Spur gear is one of the type of gear in which teeth are parallel to the centre line of the gear. Teeth of gear are straight and used to transmit power between parallel shafts. Spur gear is used in many fields like construction machineries, machine tools and automobile. The Spur gear should be manufactured accurately and precisely. After manufacturing the gear it should be inspect precisely. If gear is not manufactured accurately then gear would not work properly in concern mechanism. Manufacturing quality of spur gear should be check by proper measurement method. For standard performance of gear it should be inspected and measured at each stage of manufacturing process. While measuring the gear many parameters are checked. Chordal thickness is one of the important geometrical parameter in spur gear.Chordal thickness is measured by Gear tooth vernier caliper with chordal thickness method. Here attempt is made to find the reasons behind Choral thickness error and suggest the techniques to eliminate the chordal thickness error in spur gear manufactured on milling machine.

Keywords: Spur Gear, Chordal thickness, Measurement, Manufacturing, Inspection

1. Introduction

Gear is the key element in power transmission system. Gear drive is positive drive and provides constant velocity ratio. Types of gear are spur gear, helical gear, Worm and worm gear and Bevel Gear. Spur gear is used to transmit power in parallel direction. Spur gears are involute gears. Transmission efficiency of spur gear is 97 to 99 %. The teeth of spur gear are straight and straight and parallel with corresponding gear. The teeth of gear should match with each other properly.

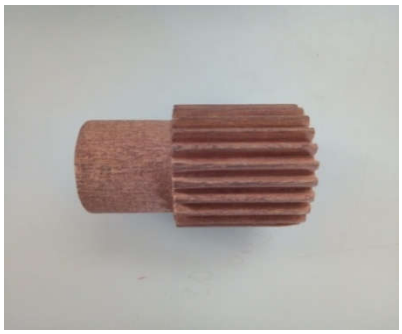

Fig. 1 wooden Spur Gear

The pressure angle and angle of contact should be proper for the smooth operation of mechanical system. Spur gears are normally made by generating or reproducing method. Spur gear is manufactured in milling machine. The gear is required to produce as per specification. After manufacturing the gear should be inspected according to standard. If gear having geometrical error the gear will not work smoothly. Geometrically defected gear will generate noise and there is chance of failure during operation. It is quite important to measure all geometrical parameters of gears.

Chordal thickness is one of the important parameter. Chordal thickness is thickness is the thickness of gear measured at pitch points of teeth where pitch circle diameter is obtained. Choral thickness is measured by constant chord and chordal thickness method. Gear tooth caliper is the measuring instrument used to measure chordal thickness.

Spur gear can be manufactured in universal milling machine. Proper indexing is necessary for accurate and precise manufacturing of gear. There are many reasons behind defected manufactured gear. Here suggestions are given to eliminate the chordal thickness error in spur gear and mentioned the procedure of chordal thickness measurement.

1.1 Material of Gear

I. Steel –Ferrous metals

II. Non Ferrous metals

III. Non Metallic Metals

For smooth and proper operation of gear, it should be inspected and measured at each stage of manufacturing process.

1.2 Method of Spur Gear Manufacturing

The various manufacturing methods for gear are Casting, Machining and Metal forming. Generally metal removing i.e machining is categorized in two types

i. Metal Forming
ii. Generating

To cut a spur gear on a milling machine, first the gear blank is mounted on an arbor. The milling cutter also mounted on arbor.

The indexing of gear blank should be proper as per requirement. The table of machine is adjusted at which the cutter the cutter aligned with periphery of work piece. Rotating cutter contacts with gear blank the gear cutting process starts.

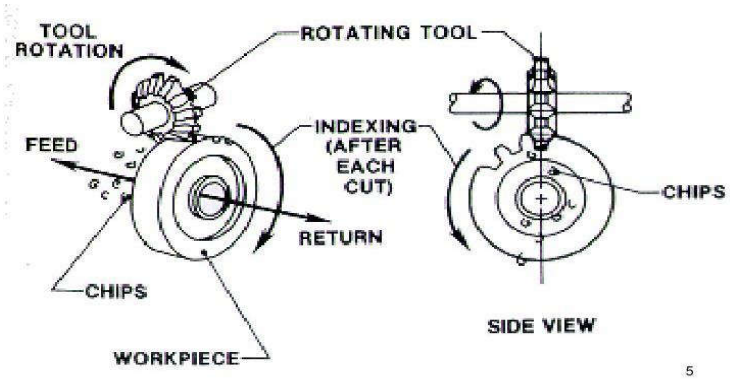

Fig.2 Gear Cutting by Milling Process

1.3 Gear Terminology:

1. **Pitch Circle Diameter**: It is the diameter of the circle at which pure rolling action will generate same as toothed gear wheel.

2. **Module**: It is the ratio of Pitch circle diameter (D) to no. of teeth. (N)

3. **Tooth Thickness**: Thickness of tooth measured at pitch circle.

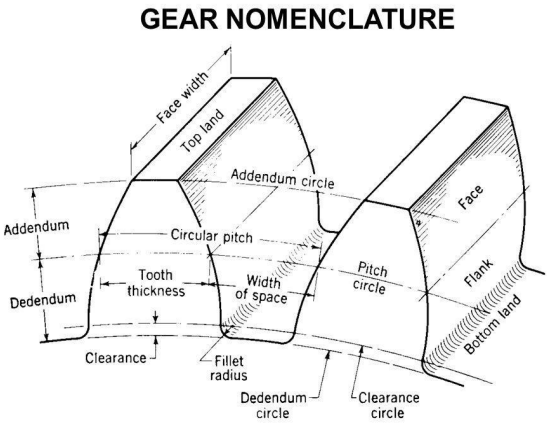

Fig.No.3 Gear Nomenclature

2. Procedure of Chordal thickness measurement

Methods of Chordal Thickness measurement are

i) The Constant chord method
ii) The Chordal thickness method
iii) The Base tangent method
iv) The Comparator method

Chordal thickness of spur gear tooth is measured by gear tooth vernier caliper. It is ordinary caliper used in routine linear measurement. Principle of measurement is same as ordinary vernier. The construction of gear tooth caliper is different than ordinary caliper. In gear tooth caliper two beams are perpendicular to each other and makes right angle. Vertical and horizontal beams are calibrated with main and sliding vernier scale.

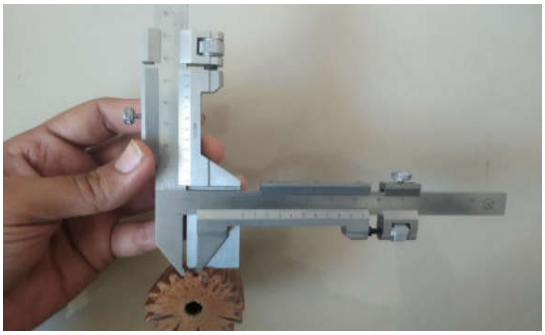

Fig.No.4 Measurement of tooth thickness with Gear Tooth Vernier Caliper

The arc of tooth thickness is varies at every point. so it is required to measure the chordal thickness at some specific point. Generally the tooth thickness is measured at pitch circle called pitch points. The sliding tongue of caliper is adjusted at which the jaws of gear tooth caliper will touch at pitch points of tooth flanks. After adjusting the sliding tongue on vertical scale the value of tooth thickness is taken on Horizotal beam. Here chordal thickness method is used to measure chordal thickness.

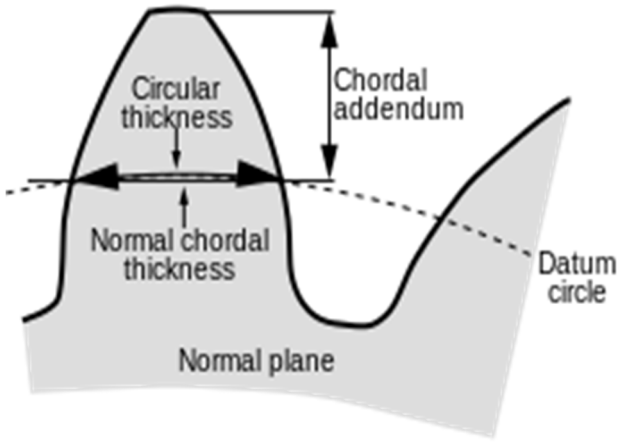

Fig.No.5 Chordal Thickness

2.1 Specification of Gear:

Table 1 Specification of Gear

Sr.No.		Detail
1	Gear Type	Spur
2	Material	Wooden
3.	No. of teeth	25
4.	Module	2
5.	P.C.D	50

2.2 Specifications of Gear Tooth Vernier Caliper:

Table 2 Specifications of Gear Tooth Vernier Caliper

Sr.No.		Detail
1	Least Count	0.02 mm
2	Material	Chrome Steel
3	Horizontal Bram measuring capacity	100 mm
4	Vertical Bram measuring capacity	80 mm

2.3 Calculations Required for Chordal thickness measurement

Module m = $\frac{D}{N}$ = 2 mm

Where D= Pitch circle Diameter

N = No. of Teeth

Addendum=1.157 ×m = 2.314 mm

Dedendum = 0.3683× Circular Pitch = 2.32 mm

Circular Pitch = $\pi \times m = 6.28$ mm

Clearance =0.05 × Circular Pitch = 0.314 mm

Working depth = 2×module = 4 mm

W= N. m. $sin\left(\frac{90}{N}\right)$ (1)

$= 25\times 2 \times \sin\left(\frac{90}{25}\right)$

$= 3.13$ mm

Where,

W= Chordal Thickness

N= Total no. of Teeth

m= Module

$$h = \frac{N.m}{2}\left[1 + \frac{2}{N} - cos\left(\frac{90}{N}\right)\right] \quad (2)$$

$$= \frac{25\times 2}{2}\left[1 + \frac{2}{25} - cos\left(\frac{90}{25}\right)\right]$$

= 2.25 mm

h= Height to be set on vertical jaw of Gear tooth Caliper

2.4 Results of Chordal thickness Measurement:

Table 3 Results

Tooth No.	Actual Value of Chordal Thickness in mm Wa	Standard Value in mm Ws	Error in mm Ws-Wa	Error in % $\frac{Ws - Wa}{Wa} \times 100$
1	3.18	3.13	-0.05	1.57
2	3.16	3.13	-0.03	0.94
3	3.20	3.13	-0.07	2.18
4	3.22	3.13	-0.09	2.79
5	3.18	3.13	-0.05	1.57
6	3.16	3.13	-0.03	0.94
7	3.12	3.13	0.01	0.32
8	3.10	3.13	0.03	0.96
9	3.18	3.13	-0.05	1.57
10	3.16	3.13	-0.03	0.94
11	3.14	3.13	-0.01	0.32
12	3.16	3.13	-0.03	0.94
13	3.18	3.13	-0.03	1.57
14	3.12	3.13	0.01	0.32
15	3.18	3.13	-0.05	1.57
16	3.18	3.13	-0.05	1.57
17	3.20	3.13	-0.07	2.18
18	3.18	3.13	-0.05	1.57
19	3.16	3.13	-0.03	0.94
20	3.18	3.13	-0.05	1.57

21	3.14	3.13	-0.01	0.32
22	3.16	3.13	-0.03	0.94
23	3.18	3.13	-0.05	1.57
24	3.20	3.13	-0.07	2.18
25	3.16	3.13	-0.03	0.94

2.5 Result discussion:

i) Actual measured value is not match with standard value of Chordal thickness.
ii) Measurement indicates that there is some chordal thickness error in gear teeth.
iii) Teeth are not accurate and not properly manufactured.

3. Causes of chordal thickness error/ Reasons behind chordal thickness error

i) Incorrect profile of cutting tool.
ii) Incorrect Positioning of cutting tool with gear blank that includes proper angle, proper orientation not given during machining operation.
iii) Incorrect indexing of the gear blank.
iv) Improper orientation of cutting tool and gear blank.
v) Errors in the relative motion of the hob and gear blank during generating operation.
vi) Improper selection of Proper feed, depth of cut and cutting speed.
vii) Unskilled operator performs the machining.
viii) Machine tool vibration.
ix) Tool Chatter.
x) Improper Surface roughness of cutting tool and work piece.

4. Elimination of Chordal thickness error:

To eliminate Chordal thickness error following precautions should be followed

i) Do proper indexing on milling machine.
ii) Set cutting parameters like depth of cut, cutting speed and feed accordingly.
iii) Always allocate a skill operator for machining of Gear.
iv) Identify proper cutting tool geometry and tool angles.
v) Reduce the vibration of machine tool. The foundation should be rigid.
vi) Use proper Cutting fluid.
vii) Select proper cutting tool material.

5. Conclusion:

Chordal thickness error is generated due to improper process parameters and improper indexing during machining. machine vibration and improper cutting tool angle are also responsible for chordal thickness error .Chordal thickness can be eliminated by proper precautions during manufacturing process.

6. References:

6.1 Book

1) *Shri Y.G.Bhatt,Shri A.P.Trivedi and Shri J.P Patel.,Metrology and Instrumentation, Learning Recourses Development Centre,TEB,Gujarat.Edition*
2) *Er.R..KRajput-Author.,Mechanical Mearsurements and Instrumentation,S.K Katariya & Son-,Publisher,Katson Books,New Delhi.Edition july 2012.*
3) *Shri M.Mahajan-Author,A Text book of Metrology,Dhanpat Rai and company-Publisher,2014*