ISSN 2395-1621

Design and optimization trough weight reduction of spiral bevel gear for wood working machinery

#1N.P.Deokar, #2Prof.N.D.Padwale

1nanadeokar01@gmail.com
2niranjan_padwale@yahoo.com

#1Dr. D. Y. Patil Institute of Engineering and Technology, Ambi, Pune, India

ABSTRACT

Wood working machines are used to cut wood work-piece in furniture making, Casting pattern making, wooden seat design, wood prototyping etc. They use a set of spiral bevel gears for transmission of power from motor to tool in the application. The weight of the hand held tools and subsequent vibrations makes it difficult to operate the machine for longer time and so also power consumption per unit cut has been found to be very high , and vibrations lead to inaccuracy in cutting and error in profile shape. Thus methodology used in study is to carry out test on three sets of bevel gears namely plain(ie no weight reduction), secondly weight reduction done by providing recess on the face of the gear , an thirdly by providing even number , equi-spaced holes on the face. Comparative analysis of the performance of the gears by load so as to derive the optimal performance of the gears .. By optimization of spiral bevel gear we can reduce weight of bevel gear and thereby cost of product or gear is depending on manufacturing process & material used for it.

Keywords— Weight reduction, Face recess, Face holes, optimal performance characteristic

ARTICLE INFO

Article History

Received :18th November 2015

Received in revised form :

19th November 2015

Accepted : 21st November , 2015

Published online :

22nd November 2015

I. INTRODUCTION

Gears are used in most types of machinery and vehicles for the transmission of power. Bevel gears are widely used because of their suitability towards transferring power between nonparallel shafts at almost any angle or speed. Spiral bevel gears have curved and sloped gear teeth in relation to the surface of the pitch cone. As a result, an oblique surface is formed during gear mesh which allows contact to begin at one end of the tooth (toe) and smoothly progress to the other end of the tooth (heel) The design of gears is highly complicated involving the satisfaction of many constraints such as strength, pitting resistance, bending stress, scoring wear, and interference in involutes gears etc. 3-D modelling of set-up using Unigraphix Nx-8.0, CAE of critical component and meshing using Ansys.ie the pre-processing part. Mechanical design validation using ANSYS. Critical components of the system will be designed and validated Validation of strength calculations of critical for both modal and strength analysis Optimization of the recess groove dimensions and hole sizes for maximum weight reduction , optimal strength

I. FEA

The proposed method utilizes software in the FEA domain for analysing the effects of the variation in the values of the design parameters influencing the modal behaviour. Also the computational approach will give the results more close to practical values through simulation. The FEM method is used to analyse the stress state of an elastic body with complicated geometry, such as gear. By FEA method calculate the maximum stress and deformation of spiral bevel gear at different condition. We are going to analyse the spiral bevel gear for plain gear and weight reduced by hole

II. DESIGN AND ANALYSIS OF SPIRAL BEVEL GEAR

A) Spiral bevel gear : plain

By considering plain bevel gear without any weight reduction. geometry of gear as shown below.

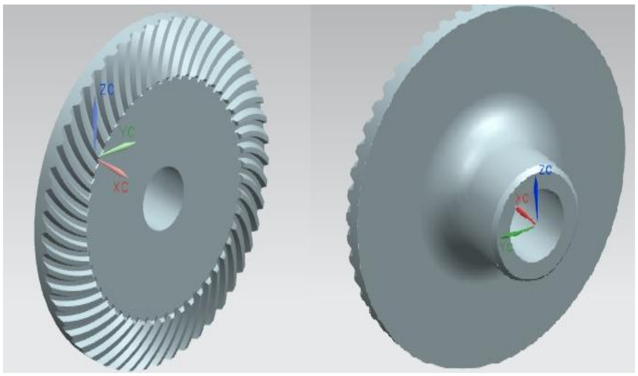

Fig.1 3D model of plain spiral bevel gear

1) Gear Specifications :

No. Of Teeth = 50
Pressure angle = 20^0
Ration m_G = Ng/Np = 50 /18 =2.78
Shaft angle = 90^0
Gear Pitch angle = 19.8^0
Diametral pitch = 2.3 mm
Face width = 13mm

2) Measurement Mass Properties

Displayed Mass Property Values
Volume = 33973.292562912 mm^3
Area = 13530.367141434 mm^2
Mass = 0.266032624 kg
Weight = 2.608891183 N
Radius of Gyration = 24.020538835 mm

3) Specifications of motor for power tool.

TABLE:I
Specifications of motor for power tool

VOLTAGE	230 V	
POWER	450 WATT	
SPEED	15000 RPM	
REDUCTION GEAR BOX	SPIRAL BEVEL REDUCTION	1:2.78
WEIGHT	2.1 KG	

4) Design torque = 0.29 x 2.78 = 0.81 N-m.

5) Design of spiral bevel gear ---Theoretical method

Material selection:

TABLE:II
Material selection

Designation	Ultimate Tensile strength N/mm^2	Yield strength N/mm^2
EN 24	800	680

As Per ASME Code;

$\Rightarrow fs_{max} = 108\ N/mm^2$

Check for torsional shear failure:-

$$T = \frac{\Pi \times fs_{act}}{16} \times \left[\frac{Do^4 - Di^4}{Do}\right]$$

$$0.81 \times 10^3 = \frac{\Pi \times fs_{act}}{16} \times \left[\frac{24^4 - 15^4}{24}\right]$$

$\Rightarrow fs_{act} = 0.35\ N/mm^2$

As; $fs_{act} < fs_{all}$

$\Rightarrow$ Gear is safe under torsional load

6) Analysis of spiral bevel gear -plain

I. Geometry :

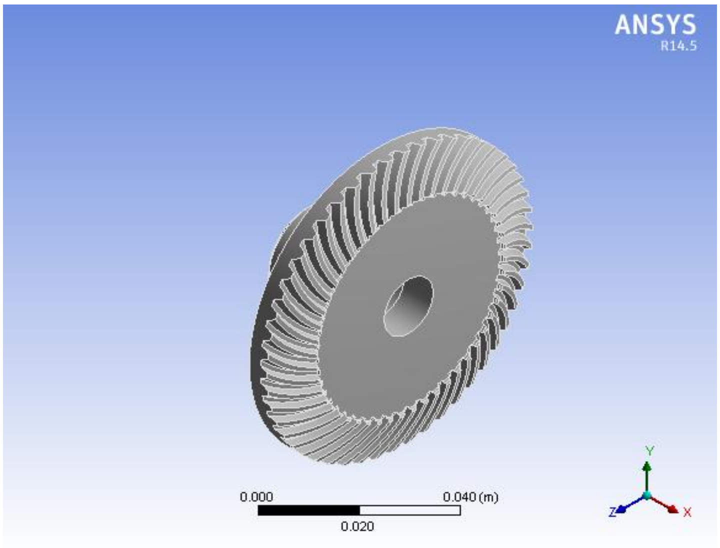

Fig.2 Geometry of spiral bevel gear

II. after Meshing

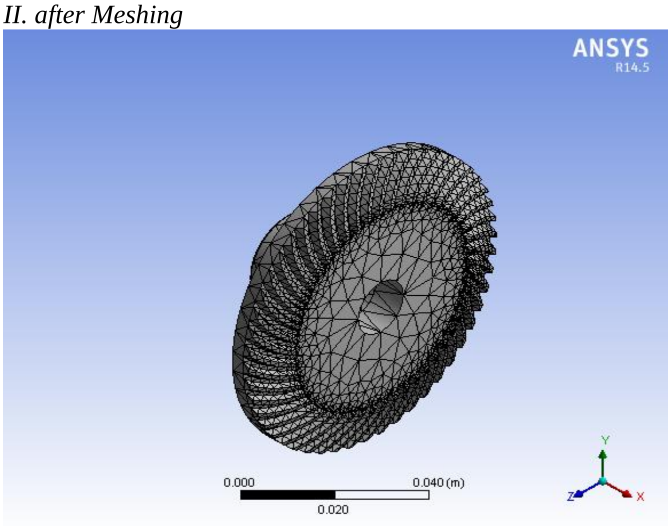

Fig.3 After Meshing

III. Boundary condition:

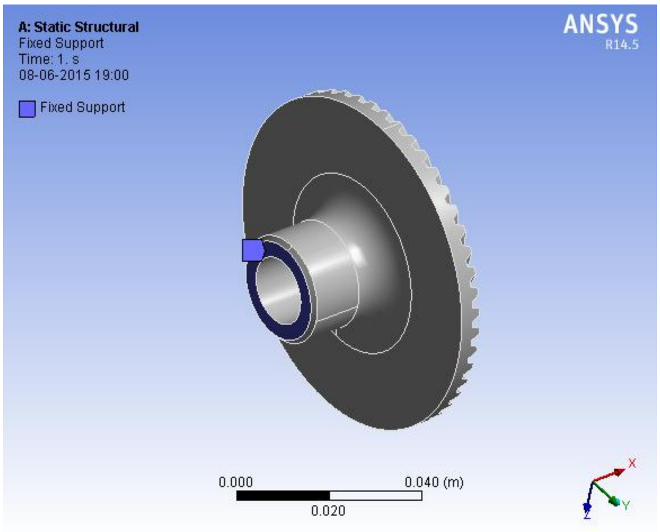

Fig.4 Applying Boundary condition

III. Loading

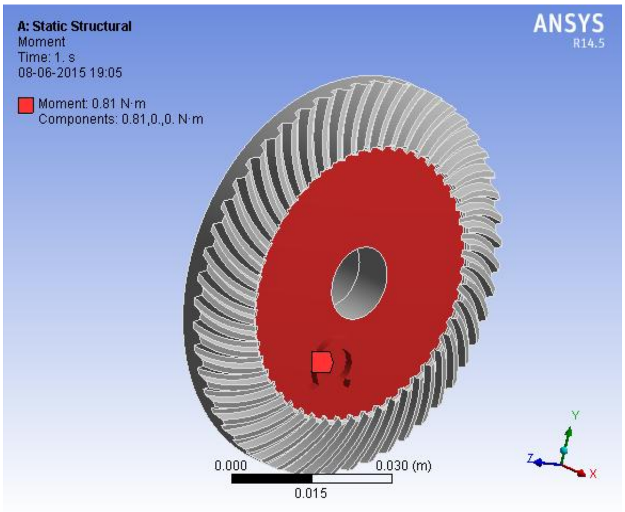

Fig.5 Applying Load

IV. Results:

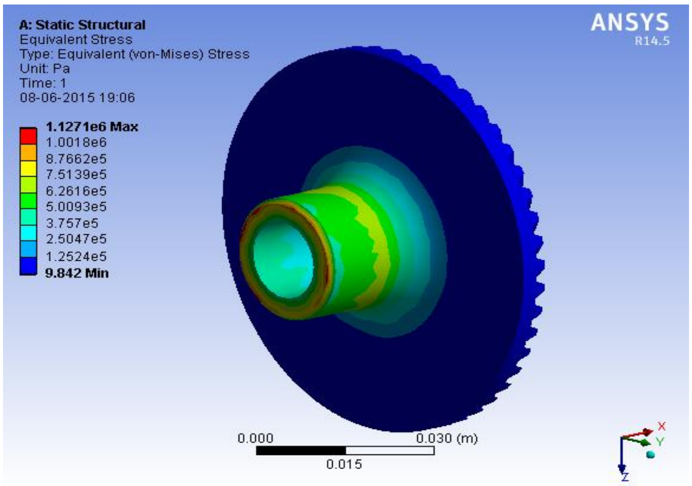

Fig.6 Static structural Equivalent stress

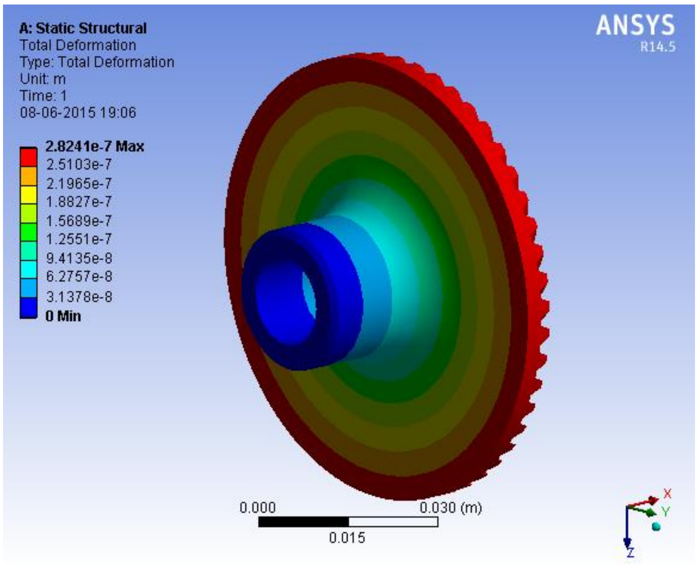

Fig.7 Static structural total deformation.

1. Maximum stress induced in the gear is 11.271 N/mm^2 < allowable stress 108 N/mm^2 the gear is safe .
2. Maximum deformation is 2.82 x 10^{-7} mm

B) Spiral bevel gear : hole

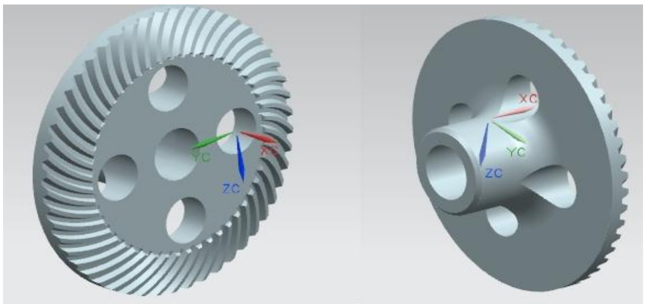

Fig 8 Spiral bevel gear: hole

1) Gear Data :

No. Of Teeth = 50
Pressure angle = 20 ^{0}
Ration m_G = Ng/Np = 50 /18 =2.78
Shaft angle = 90 ^{0}
Gear Pitch angle = 19.8 ^{0}
Diametral pitch = 2.3 mm
Face width = 13mm

2) Measurement Mass Properties

Displayed Mass Property Values
Volume = 30261.187506049 mm^3
Area = 13879.209484242 mm^2
Mass = 0.236964465 kg
Weight = 2.323829671 N
Radius of Gyration = 24.614748843 mm

Weight reduction = 11.5 %

B) Analysis of bevel gear-hole

I. Geometry

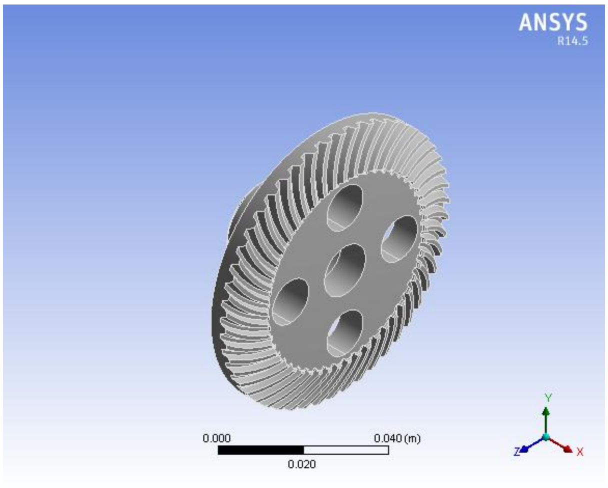

Fig.9 Geometry of spiral bevel

II. Meshing

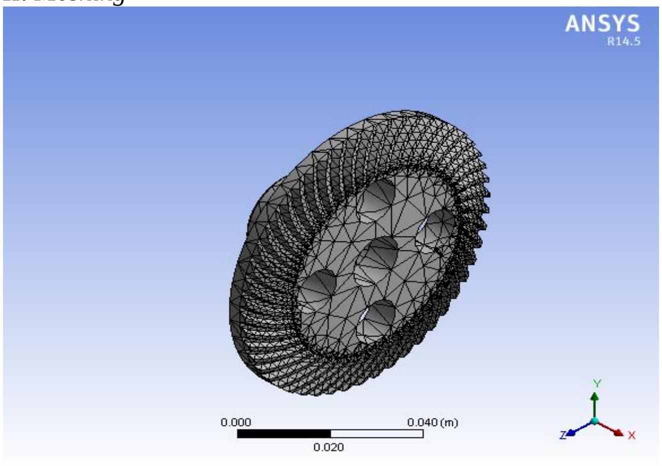

Fig.10 After Meshing.

III. Boundary condition:

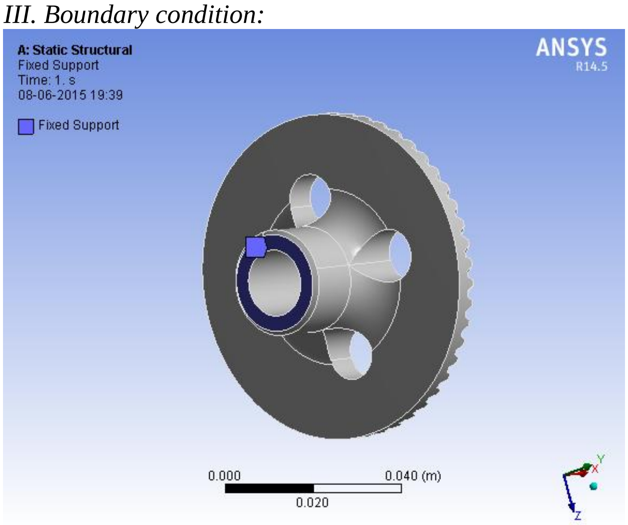

Fig.11 Applying Boundary condition

IV. Loading:

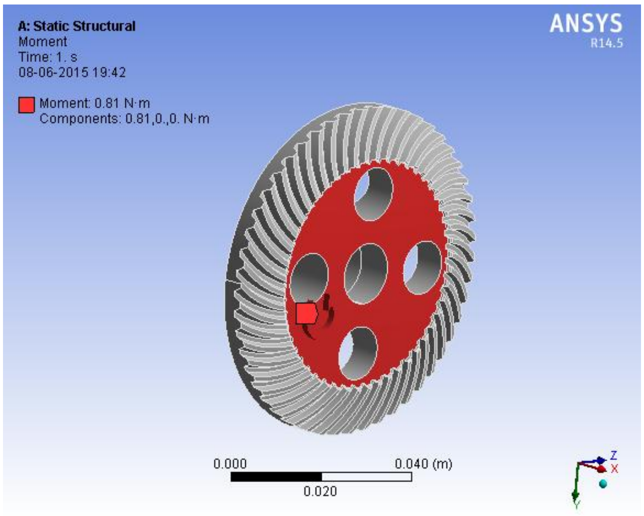

Fig.12 Applying Load

V. Results:

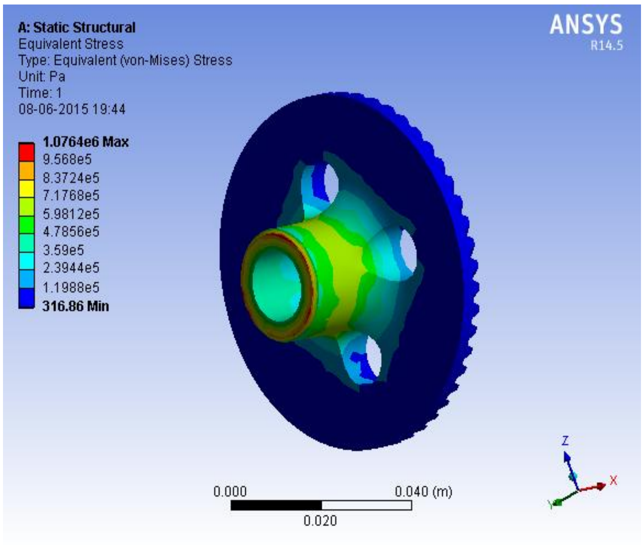

Fig.13 Static structural Equivalent stress.

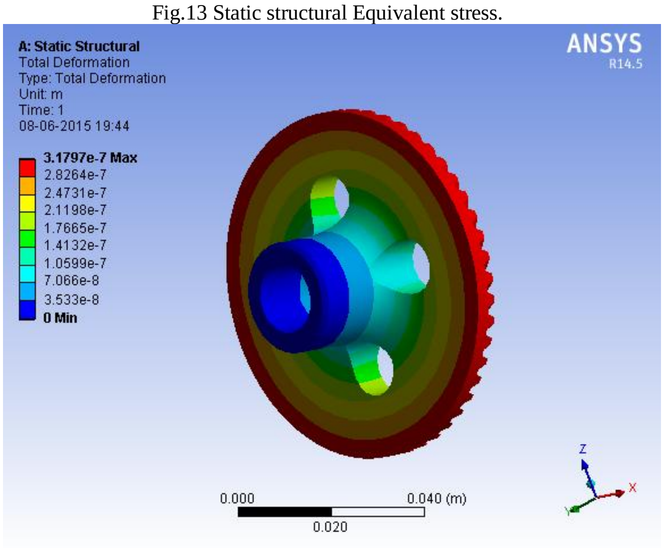

Fig.14 Static structural total deformation.

1. Maximum stress induced in the gear is 10.71 N/mm^2 < allowable stress 108 N/mm^2 the gear is safe .
2. Maximum deformation is 3.18 x 10^{-7} mm

C) Result & discussion

Bevel gear type	Mass of Gear kg	Percentage Weight reduction	Maximum stress N/mm^2	Maximum deformation Mm
Plain	0.2660326	-	11.27	2.82×10^{-7}
Hole-reduction	0.23696	11.5	10.71	3.18×10^{-7}

V. Conclusions

Maximum weight reduction is achieved by hole reduction 11.5 %. Minimum stress is observed in case of Bevel gear as hole reduction. Maximum stress in all conditions is well below the allowable limit hence weight reduction by hole methods is recommended.

Acknowledgment

My profound thanks to my guide Prof. N.D.Padwale sir, I am thankful to Prof. S.K. Bhor sir Head of Department of Mechanical Engineering for his invaluable advice and constant encouragement to complete this Paper in a successful manner.

I am thankful to our ME coordinator Prof. P R Sonawane sir for his kind support and providing all facilities and academic environment for my Research paper work. I would like to express my gratitude to our esteemed Principal Dr. R J Patil sir for his encouragement.

References

[1]Ramgir M.S," Achieving mass reduction in the spur gear using topology optimization for design evaluation and analysis" International Journal of Scientific Research and Management Studies, ISSN: 23493771 Volume 1 Issue 8, pg: 270-274.(2012).

[2] Márk lelkes, Daniel play and János marialigeti, "cutting parameters definition for kinematic optimization of spiral bevel gears," periodica polytechnic ser.transp.Eng. VOL. 30, NO. 1–2, PP. 93–109 (2010).

[3] Fritz Klockea, Markus Brumma," Influence of Gear Design on Tool Load in Bevel Gear Cutting",sciencedirect,Procedia CIRP 166 – 71(2012)

[4] P. Prabhakar, M. Parameshwaran" Weight reduction of planetary gearbox pedestal using finite element analysis" sastech journal, Volume 12, Issue 2, (2013).

[5] A.V.Ramana Rao, CH.Bhanu Prakash,"Parametric Modeling of Straight Bevel Gearing system and Analyze the Forces and Stresses by Analytical Approach" International Journal of Engineering Trends and Technology (IJETT) – Volume 4 Issue 9-(2013).

[6]Jixin Wang, Long Kong,"The Mathematical Model of Spiral Bevel Gears - A Review" Strojniški vestnik - Journal of Mechanical Engineering 60, 93-105(2014).

1.1