International Journal of Sciences and Innovation Engineering
(Peer-Reviewed, Open Access, Fully Refereed International Journal)
website: www.ijsci.com
Volume 3 Issue 2 , Feb 2026
OPEN ACCESS
E-ISSN : 3049-0251
DOI: https://doi.org/10.70849/ijsci03022658341

DESIGN AND FINITE ELEMENT ANALYSIS OF SPUR GEAR

Dr.Sunil Kumar Patel[1], Supreet Mahdeokar[2], Sandeep Kashyap[3], Rohit Sahu[4], Ankur Vishwakarma[5]
[1,2,3,4,5] *Assistant Professor, Departmental of Mechanical Engineering, Baderia Global institute of Engineering& Management, Jabalpur, 482002, India.*

Article Info

Article History:

Published:04 Feb 2026

Publication Issue:
Volume 3, Issue 2
February-2026

Page Number:
28-36

Corresponding Author:
Dr.Sunil Kumar Patel

Abstract:

This paper proposes a method for the design of spur gear tooth profiles using parabolic curve as its path line of action. A mathematical model, including the equation of the line of action and the characteristics of the gear profile designed by the proposed method are analyzed. A comparative study on the different root fillet radii with the involutes gear profile. The function of undercutting condition is derived from the model. The effects of the two design parameters, that present the size (or shape) of the parabolic curve relative to the gear size, are the shape of tooth profiles and the contact ratio are also studied through the design of spur gear drive. The strength, including the contact stresses and life of cycle, of the gear drive designed by using the proposed method and CAD model generated CATIA –V5 and is analyzed by an FEA simulation with ANSYS 14.0. A comparison of the above characteristics of the gear drive designed with the involutes gear drive is also carried out in this work. The results confirm that the proposed design method is more flexible to control the shape of the tooth profile by changing the parameters of the parabola curve.

Keywords: Spur Gear, Hertz Stress Calculation, Contact Stress, total deformation & fatigue life Finite Element Analysis

1. INTRODUCTION

Gears are one of the very effective approaches transmitting power and rotary motion from the foundation to its application without or with change of speed or direction. They can be applied between two shafts which are, Collinear, Parallel, and intersecting, Perpendicular and, inclined at any arbitrary angle in a m e c ha ni c al p o we r t r an sm i s si on arrangement, Gear devices can change the torque, speed, and direction of a power function. Gears almost always produce a change in torque, creating a mechanical advantage, through their gear ratio, and thus may be considered a simple machine. The teeth on the two meshing gears all have the same shape. Two or more meshing gears, working in a sequence, are called a gear train or a transmission. The gears in a transmission are analogous to the wheels in a crossed belt pulley system [6]. An advantage of gears is that the teeth of a gear prevent slippage. When two gears mesh, if one gear is bigger than the other, a mechanical advantage is produced, with the rotational speeds, and the torques, of the two gears differing in proportion to their diameters.

2. CLASSIFICATION OF GEARS

Gears are classified according to the shape of the tooth pair and disposition into spur, helical, double helical, straight bevel, spiral bevel and hypoid bevel, worm and spiral gears and this is shown in Figure 1

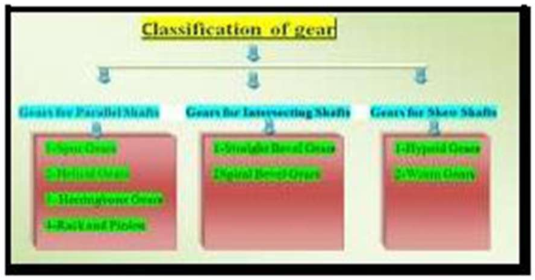


Figure. 1 Classification of Gears

Spur Gear

Straight Spur gear are the simplest form of gears having teeth parallel to the gear axis. The contact of two teeth takes place over the entire width along a line parallel to the axes of rotation. As gear rotate, the line of contact goes on shifting parallel to the shaft [6].

Figure. 2 Spur Gear [7]

Working of Gear

Gears are one of the very effective approaches transmitting power and rotary motion from the foundation to its application without or with change of speed or direction.

They can be applied between two shafts which are, Collinear, Parallel, and intersecting, Perpendicular and, inclined at any arbitrary angle in a mechanical power transmission arrangement, Gear devices can change the torque, speed, and direction of a power function.

Gears almost always produce a change in torque, creating a mechanical advantage, through their gear ratio, and thus may be considered a simple machine.[7]

Applications of Gear

Gears are used in all applications where power transfer is required, such as automobiles, industrial equipment, airplanes, helicopters, aerospace industry, wind turbine industry and marine vessels. [7]

Undercutting and Interference of Gear

The profile of the tooth inside the base circle is radial, if the addendum of the mating gear is more than the limiting value, it interferes with the dedendum of the pinion and two gears are locked.

If cutting rack having similar teeth is used to cut teeth in the pinion it will remove that portion of the pinion tooth which would have interfered with the gear.

When the actual gear meshes with the undercut pinion on interference occur.

Undercutting will not take place if the teeth are designed to avoid interference.[7].

3. LITERATURE REVIEW

There has been great deal of research on spur gear analysis, and a large body of literature on gear modeling has been published. The teeth contact analysis, bending stress and fatigue life of spur gear with different fillet radius, constant load and pressure angle.

Ming-haung tsai et al. (1998)

A method of designing high-contact-ratio spur gears using quadratic parametric tooth profiles for the shorter addendums and no undercut. A design procedure is developed and a simplified derivation of the mathematical model of parametric tooth profiles is presented the tooth root stresses and the static transmission errors [5].

Andrzej Kawalec et al.(2006)

Comparative analysis of tooth-root strength evaluation methods used within is and standards and verifying them with developed models and simulations using the finite element method (Fem). future

improvements and/or unifications of gear standards [1]

Fatihkarpat et al.(2008)

To use dynamic analysis to compare conventional spur gears with symmetric teeth and spur gears with a symmetric teeth .the secondary objective is to optimize the asymmetric tooth design in order to minimize dynamic loads. This study offers preliminary results to designer's founder standing dynamic behavior of spur gears with asymmetric teeth[2].

Jian wang et al. (2010)

A design procedure is developed and a simplified derivation of the mathematical model of tooth profiles is presented. The characteristics of the gear drive designed by the proposed method are analyzed. A comparison study on the sliding coefficient with the involute gear drive is also carried out in this work[3].

Jian Wang et al.(2013)

This paper proposes a method for the design of gear tooth profiles using parabolic curve as its line of action. A mathematical model, including the equation of the line of action, the equation of the tooth profile, and the equation of the conjugate tooth profile, is developed based on the meshing theory. The influences of the two design parameters, that present the size (or shape) of the parabolic curve relative to the gear size, The strength, including the contact and the bending stresses analyzed by an FEA simulation. A comparison of the above characteristics of the gear drive designed with the involute gear drive is also carried out in this work [4].

4. PARAMETER OF SPUR GEAR

In this thesis work the dimensions were taken for modeling the involute spur gear from journal. Modeling of the spur gear is done by CATIA-V5 and analysis has been done using ANSYS 14.0. For analysis

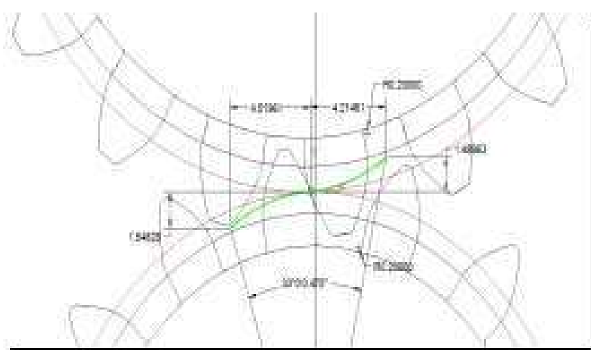
static structural solver is used in ANSYS 14.0. Modeling of spur gear in CATIA– V5.

Table 1 Dimension of Existing spur gear

Sr.	Parameter	Value
1	Circular pitch (P_c)	6.28mm
2	Base Pitch (P_b)	6.066mm

3	Gear radius	15mm
4	Pinion radius	18mm
5	Diametral pitch (P_d)	0.5mm
6	Pressure angle(ϕ)	20^0
7	Gear modules (m)	2mm
8	Addendum diameter	34mm
9	Dedendum diameter	27.5mm
10	Clearance	0.314mm
11	Center distance(a)	33mm
12	Working depth	4mm
13	Whole Depth	4.5mm
14	Circular tooth thick-ness	3.142mm
15	Width of land	0.5mm
16	Transverse pitch	6.3039mm
17	Face width	12.5mm

Figure 3 Shows the geometry involute profile parameter of spur gear.



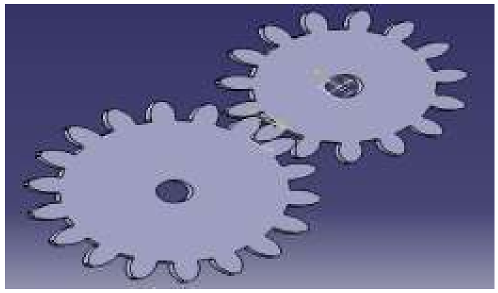


Figure 4 Model of spur gear which generate solid molding in CATIA-V5

Material Property

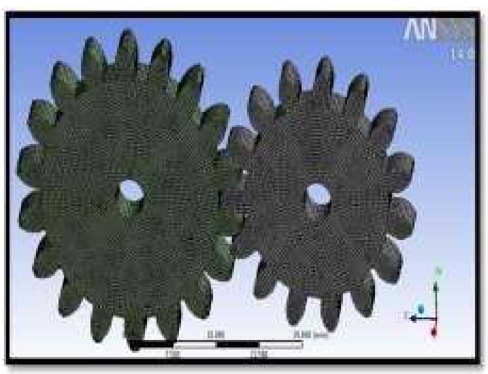
General gear material are steel, we also consider the parameter of gear material. Material properties of steel are 1998 ASME BPV code, which have density of material 7850 kg/m$^{3.}$ The property of material shown in table.

Table 2 Mechanical Properties of material

Density (kg/m^3)	Young's modules (MPa)	Passion ratio (µ)	Bulk modules (MPa)	Shear modules (MPa)	Tensile yield strength (MPa)	compressive yield strength (MPa)	Tensile ultimate strength (MPa)
7850	$2E^{+5}$	0.3	$1.66E^{+5}$	$7.69E^{+4}$	250	250	460

5. MESHING OF THE SPUR GEAR MODEL

In the present thesis work meshing of the model has been done using default meshing type and quad method. During analysis default meshing is taken in Spur Gear in ANSYS 14.0.



Boundary Condition

Moment in center of gear axis X and Z-axis moment are zero.

Give the first cylindrical support-1 for gear, the radial are free, axial & tangential fixed.

Give the first cylindrical support-1 for pinion, the radial are free, axial & tangential fixed.

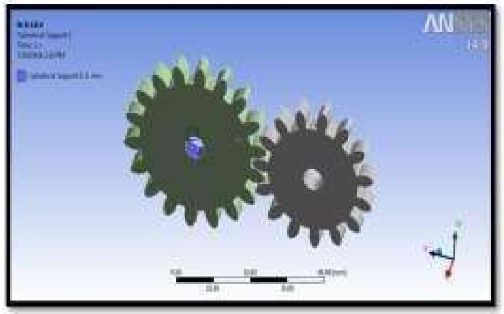


Figure 6 Cylindrical support-2for pinion, the radial are free, axial & tangential fixed

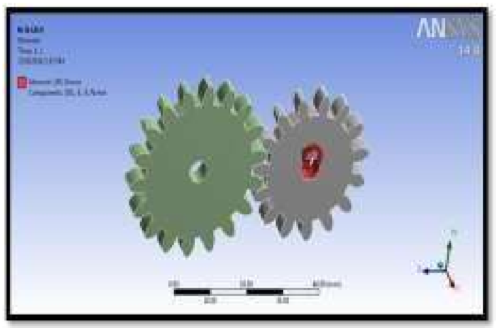


Figure 7 Moment in center of axis, X & Z- axis moment are zero.

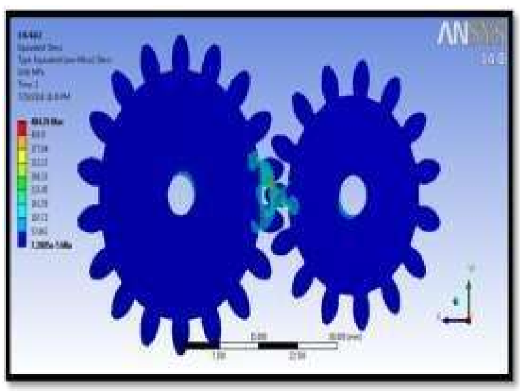
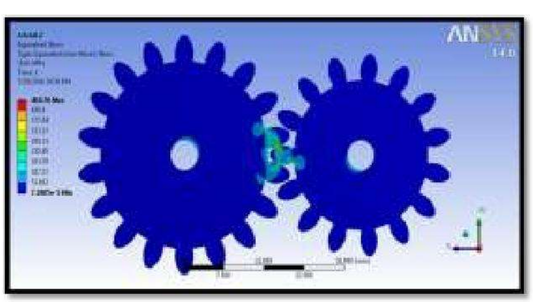


Figure 7 Moment in center of axis, X & Z- axis
moment are zero.



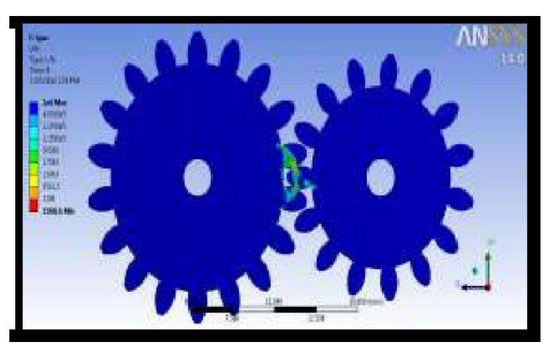


Figure 8 Equivalent Von-Mises Stress at fillet radius 0.4mm & 0.2 mm gear & pinion.

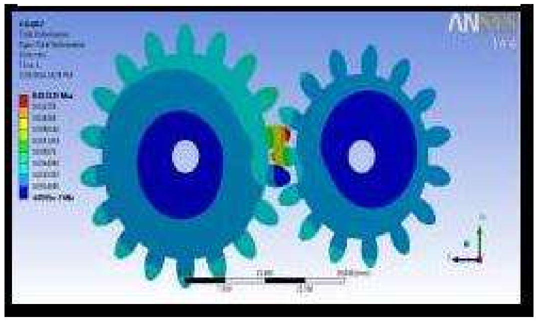


Figure 9 Total deformation at fillet radius 0.4mm & 0.2mm gear & pinion.

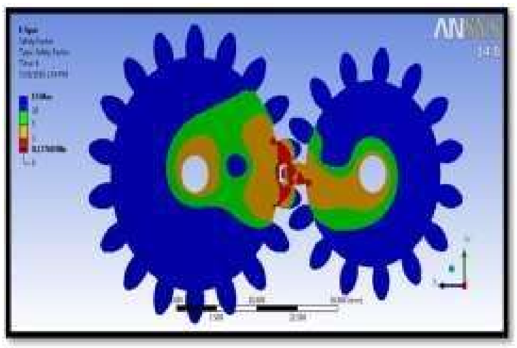


Table 3 Equivalent Von-Mises Stress, Total Deformation, Maximum Shear Stress & Strain and stress intensity for different fillet radii [Gear and Pinion]

S.NO	Fillet radius		Moment (N-mm)	Result				
	K1	K2		Von-Mises Stress	Total Defor-mation	Shear Stress	Shear Elastic Stain	Stress Intensity
1	0	0		453.16	0.04093	22.366	29.07*10e-5	514.64
2	0.2	0.2		485.14	0.012731	21.349	27.75*10e-5	522.94
3	0.2	0.3		587.33	0.01409	20.825	27.07*10e-5	660.75
4	0.2	0.4		584.32	0.013598	20.68	26.88*10e-5	657.33
5	0.3	0.2	105	486.49	0.013124	23.952	31.13*10e-5	530.08
6	0.3	0.3		516.41	0.014183	20.233	26.30*10e-5	577.27
7	0.3	0.4		548.9	0.03879	19.215	24.98*10e-5	608.25
8	0.4	0.2		484.76	0.013225	23.224	30.19*10e-5	528.2
9	0.4	0.3		533.07	0.012907	20.769	27.00*10e-5	601.9
10	0.4	0.4		550.35	0.013994	19.064	11.04*10e-5	609.79

Table 4 Compared the Mathematical, F.EA. & error with different fillet radii. [Gear and Pinion]

S.NO.	K_1(mm)	K_2(mm)	Von Mises Stress		Error
			Mathematical (MPa)	F.E.A (MPa)	
1	0	0	534.91	453.16	17.38
2	0.2	0.2	518.56	485.14	6.89
3	0.2	0.3	631.96	587.33	7.6
4	0.2	0.4	559.12	516.41	8.2
5	0.3	0.2	524.92	486.49	7.9
6	0.3	0.3	587.44	548.96	7.01
7	0.3	0.4	520.34	484.76	7.4
8	0.4	0.2	527.9	484.76	8.9
9	0.4	0.3	571.98	533.07	7.3
10	0.4	0.4	583.92	550.35	6.1

Table 5 Contact ratio ε of the gear drive under different parameters of K1 and K2.

S.NO.	K_1 (mm)	K_2 (mm)	X_1	Y_1	X_2	Y_2	**Ψ**	**ε**
1	0	0	3.812	1.47691	-3.99874	-1.48701	31.98	1.1407
2	0.2	0.2	4.21461	1.48932	-4.51961	-1.54828	33	1.375
3	0.2	0.3	4.21461	1.48963	-5.59207	-1.79067	35.34	1.472712
4	0.2	0.4	4.21461	1.48963	-6.41423	-2.05072	37.5958	1.56649
5	0.3	0.2	4.86648	1.57243	-4.51961	-1.54828	35.196	1.5498
6	0.3	0.3	4.86648	1.57243	-5.59207	-1.79067	39.2556	1.63565
7	0.3	0.4	4.86648	1.57243	-6.41423	-2.05072	42.4757	1.76982
8	0.4	0.2	5.26034	1.82318	-4.51961	-1.54828	37.1187	1.546612
9	0.4	0.3	5.26034	1.82318	-5.59207	-1.79067	40.274	1.67808
10	0.4	0.4	5.26034	1.82318	-6.41423	-2.05072	43.4928	1.812204

6. CONCLUSIONS

From the mathematical and FEA results, the maximum von mises stress of the proposed gear is reduced by about 11.34% in comparison with the involute gear by FEA function.
Contact ratio of the proposed drive is less than that of the involute gear drive or other profile of gear.
Easily to balance the profile of the addendum and the profile of the dedendum between the driving and driven gears. The results obtained from analytical method gives very close results as obtained from FEA.

Future Scope of the Project

We also apply this method in the helix angle gear profile, on parallel axis profile gear.

This method used in cycloid gear profile, and compared the result with involute profile.
Application of this method on different pressure angle gear profile.

Compared the result different fillet root profile with different helix angle.

References

1. Andrzej Kawalec, Jerzy Wiktor, Dariusz Ceglarek, Comparative analysis of tooth-root strength using ISO and AGMA standards in spur and helical gears with fem-based verification, Journal of Mechanical Design 2006 128 / 1141, ASME.
2. Fatihkarpat, stephenekwaro-osire , kadircavdar, fatihc .babalik, Dynamic analysis of involute spur gears with asymmetric teeth, Journal of Mechanical Sciences, 50 (2008) 1598–1610, Elsevier Ltd .
3. Jian Wang, Shanming Luo, Yue
4. Wu, A method for the preliminary geometric design of gear tooth profiles with small sliding coefficients, Journal of Mechanical Design 2010 132 / 054501-1 ASME.
5. Jian Wang, Liang Hou, Shanming Luo, Ray Y. Wu, Active design of tooth profiles using parabolic curve as the line of action Journal of Mechanism and Machine Theory 2013, Elsevier Ltd.
6. Ming-haung tsai and ying-chien tsai, Design of high-contact-ratio spur gears using quadratic parametric tooth profiles, Journal of Mechanism and Machine Theory 551-564, (1998)Elsevier Ltd.
7. Robret L. Norton “Machine design” second edition 2003.
8. Pearson Education New Delhi.
9. R.S. Khurmi & J.K.Gupta, machine design, eurasia publishing house (pvt.) Ltd. Ram nagar, New Delhi-110 055.
10. S.S. ratan, theory of machine, TaTa McGraw-Hill education (PVT.) LTD. 7 west patel nagar, NEW DELHI-110 055.