# FINITE ELEMENT ANALYSIS COMPARISON OF SPUR GEARS BETWEEN STANDARD TOOTH PROFILE AND MODIFIED PROFILE

**Ajinkya Mali[1], Rahul Marne[2]**

[1]PG Student, Department of Mechanical Engineering, AISSMS COE, SPPU, PUNE, India
[2]Professor Department of Mechanical Engineering, AISSMS COE, SPPU, PUNE, India

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**Abstract -** *In gearbox systems, most important objectives is to achieve gears with high efficiency so that to reduce power losses, noise, operating temperatures and wear. This is achievable by making different types of modifications in gearing system. Tooth profile modification plays good role in this. Aim of the work is comparison in spur gear pair strength by modification of top of tooth profile i.e. addendum. Two different gear profiles are used for comparison. One is standard involute profile and other is modified involute. Both cases all other parameters are kept constant. Both profiles are modeled in 3d software and analyzed using FEA. Gear teeth profile modifications are mainly investigated in detail and compared in terms of strength.*

## 1. INTRODUCTION

One of the most efficient and important mechanism is power transmission with gear system in current mechanical industries. These mechanisms are very important in many systems like automobile, aerospace, ships, vehicles having applications of high efficiency, lighter weight, reliability of gears etc. Efficiency of gears is important topic in gear industries. Due to friction results heat generation in between gears, many gear failures like scoring, contact fatigue failures are related to the efficiency of the gear pair.

## 2. DESIGN & MODELLING

In design two separate gear pairs are designed. These gears are designed for specific torque. Design considerations are as shown in Table 1.

**Table -1:** Specifications & Parameters

| Parameters | Value |
|---|---|
| No. of teeth | 17 |
| Module | 1.246 |
| Gear ratio | 1 |
| Pressure angle | $20^0$ |
| Face width | 12.5 mm |
| Pitch diameter | 21.182 mm |
| Torque | 14500 Nmm |
| Addendum | 0.997 mm |
| Dedendum | 1.246 mm |
| Addendum Circle Diameter | 23.18 mm |

Below Fig 1 shows 3d model of gears modelled using involute curve.

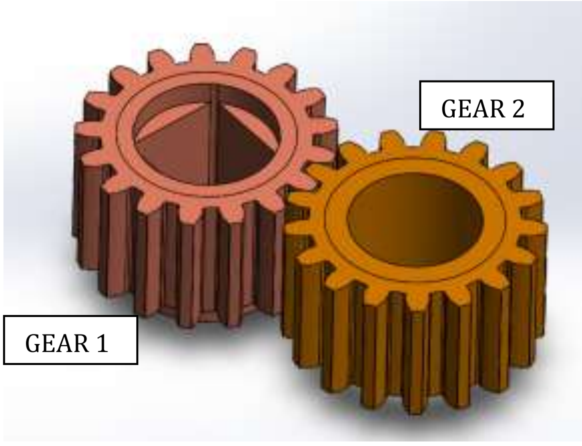


**Fig -1** 3D View of modelled gears

Two parameters are represent profile modification, the normalized amount (height/ depth) of modification ($h_n$) at the gear teeth and normalized length (extent) of modification ($L_n$).
The parameters can be defined as

$$h_n = \left[\frac{h_x}{h_w}\right]$$

$$L_n = \left[\frac{L_x}{L_w}\right]$$

Where
$h_x$ = Amount of profile modification
$L_x$ = Length of profile modification
$L_w$ = Distance from the tip to the highest point of single tooth contact (HPSTC) of gear tooth
$h_w$=Standard amount of profile modification
The minimum tip relief should be equal to twice the maximum spacing error plus the combined tooth deflection evaluated at HPSTC.
here module m= 1.246
$h_w$= 0.02 X 1.246 = 0.025 mm
$L_w$ = 0.6 X 1.246 = 0.747 mm

Modification ratio $L_n$ and $h_n$ for different speeds is defined, From that,
$L_n$ = 0.9 mm
$h_n$ = 0.9 mm
We get followings,
$L_x$ = 0.672 mm
$h_x$ = 0.0225 mm

Modified tooth profile in CAD software also shown in Fig-2

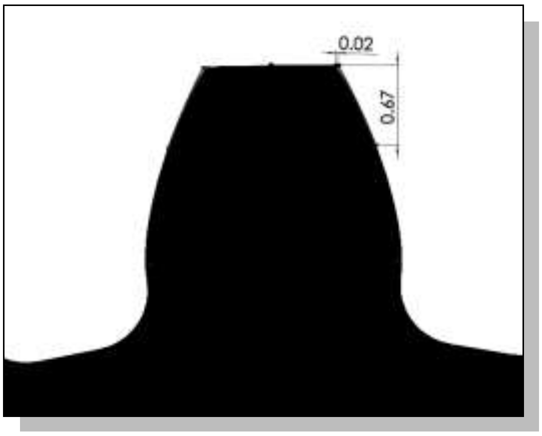


**Fig -2**: Modified tooth profile

## 3. FINITE ELEMENT ANALYSIS

To analyse strength of gears, FEM model is built. In this, a pair of gear model is used to analyse in software. Model is built as per primary parameters shown in table of gear details. Both profiled gears are analysed with following parameters. Both modelled gears are changed with format for analysis software purpose. While starting FEA first type of analysis is selected. Then model is imported. After that meshing, applying boundary conditions and solving is done. Following are results of solver.

3.1 Standard Profiled Gear
Following are results of standard involute gear

- Deformation
  Deformation of this type of gear is maximum upto 0.003 mm as shown in Fig 3

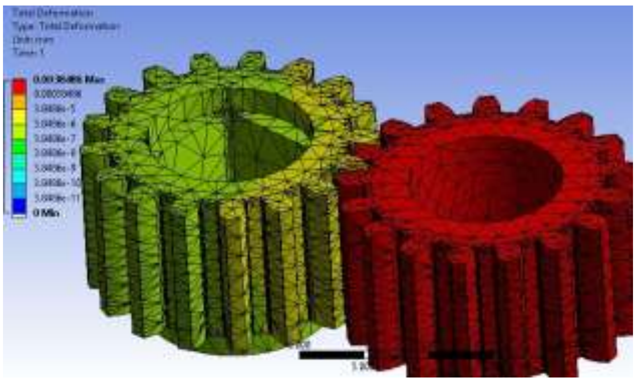

**Fig -3** Deformation of standard involute profile gear

- Equivalent Elastic Strain
  Strain value in this analysis is goes up-to 0.001125

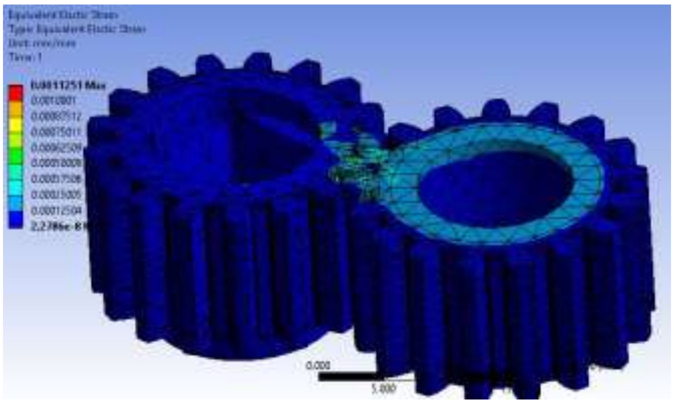

**Fig -4** Equivalent Elastic Strain of standard involute profile gear

- Von-mises Stress
  Equivalent stress value goes maximum upto 201.79 MPa as shown in Fig 5.

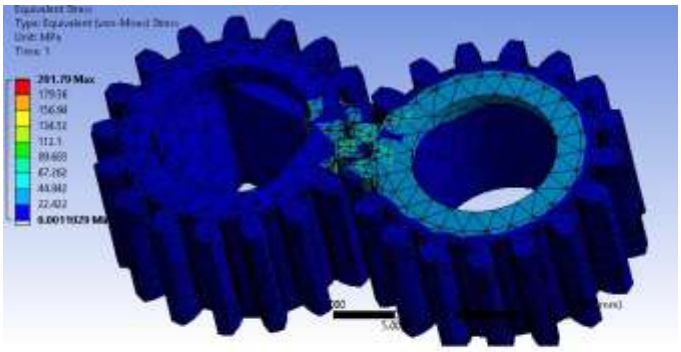

**Fig -5** Von-mises Stress of standard involute profile gear

3.2 Gear with modified involute profile
Following are results of gears with modified involute profile

- Deformation
  Deformation of this type of gear is maximum up-to 0.0042 mm as shown in Fig 6

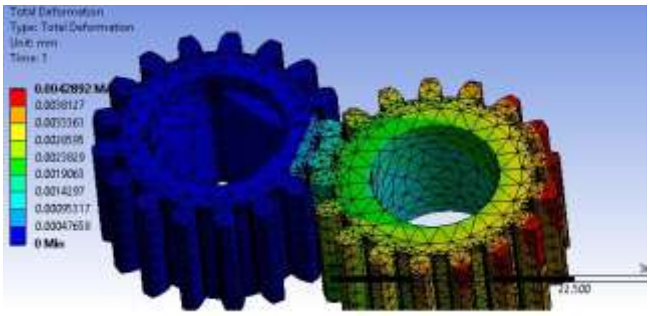

**Fig 6-** Deformation of gears with modified involute profile

- Equivalent Elastic Strain

Strain value in this analysis is goes upto 0.0010

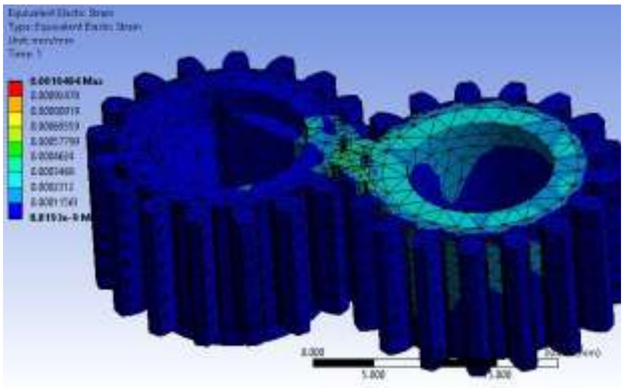

**Fig -7** Equivalent Elastic Strain of gears with modified involute profile

- Von-mises Stress
  Equivalent stress value goes maximum up-to 198 MPa as shown in Fig 8.

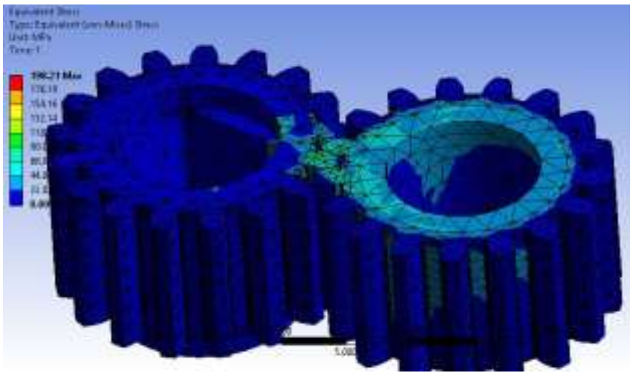

**Fig -8** Von-mises Stress of gears with modified involute profile

## 4. RESULT AND DISCUSSION

Above analysis shows comparison of strengths in between standard involute and modified involute gears. Table 2 shows comparative results of both gear pairs.

**Table -2:** Comparison of Analysis Results

| TYPE | Standard Profile | Modified Profile |
|---|---|---|
| Deformation | 0.003 | 0.0042 mm |
| Eq. Strain | 0.001125 | 0.001 |
| Eq. Stress | 201.79 MPa | 198 MPa |

It seems deformation and stress is higher in standard profile than that of modified tooth profile. Equivalent strain is little bit higher in standard profile than modified profile.

## 5. CONCLUSIONS

Tooth profile modifications helps to reduce noise and vibrations, it also helps to increase gear strength.

- Profile modification doesn't have significant effect on deformations in gear pairs.
- By variation of modification constant and conducting design of experiments (DOE) optimum profile modifications can be found for specific gear pair.
- Stress is also near to same value in modified gear pair.

Modified gears will changes their behavior in dynamic condition, which required continuous optimization.

Further study having scope of work for dynamic analysis of modified spur gear.

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