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# Design and Analysis of Resonance Frequency Behavior of Thin Wall Gear Structure with Different Parameters

`P.Srinivasa Rao
M.Tech Student,
Nova College of Engineering & Technology.

B.Jithendra
Assistant Professor,
Nova College of Engineering & Technology.

Kalapala Prasad
Assistant Professor,
JNTU Kakinada University.

## ABSTRACT:

The present work is a fundamental study on resonance frequency behavior of three-dimensional, thin-walled spur gears from finite element analyses. Effects of gear wall thickness, teeth mesh stiffness and assembly errors on resonance frequency behavior of the thin-walled gears are also investigated in ANSYS and peak speeds of the thin-walled gears are measured. Structural vibrations of the thin-walled gears are also analyzed by using three-dimensional, finite element method (3DFEM) with 4-noded tetrahedron element. It is found that natural frequencies and mode shapes of the thin-walled gear structure calculated by FEM. Effects of tooth module, web thickness, web position, rim thickness, face width and gear hub on natural frequencies of the thin-walled gears are investigated by FEM calculations. It is found that web position and web thickness have greater effects on structural frequencies of the thin-walled gears than other parameters. Tooth module also exerts an effect on the natural frequencies of the thin-walled gears. Finally, bending stresses calculated for individual gear models are well agreement with the ones measured by fem software.

**KEYWORDS:** thin spur gear design, natural frequencies, changing parameters and optimum parameters.

## INTRODUCTION:

Spur gears are used in most types of vehicles and machinery for the transmission of power. The design of spur gears is highly complicated involving the satisfaction of many constraints such as bending stress, strength, scoring wear, pitting resistance, and interference in gears. The concentration is focused on spur gear sets which are used to transmit motion between parallel shafts because of the reason that out of the various methods of power transmission, the toothed gear transmission stands unique due to its high efficiency, reliable service, transmit large power, compact layout and simple operation. Gear design is an art as well as an engineering science. Designer based on his design principles and the knowledge about the gear, lays out a gear for a particular application. The community of engineers now knows that applying engineering principles alone cannot suggest a good design. It is, in many cases that the designer's expertise suggests good design. The problem with the conventional design procedure is that it gives out a single solution and the manufacturing is carried out on that basis.

The most common situation is for a gear to mesh with another gear; however, a gear can also mesh with a non-rotating toothed part, called a rack, thereby producing translation instead of rotation. Also it is used in transmission system so it is known as speed reducer, which consist of a set of gears, shafts and bearing that the factory mounted in a lubricated housing. Spur gears have teeth that run perpendicular to the face of the gear. The spur gear is simplest type of gear manufactured and is generally used for transmission of rotary motion between parallel shafts.

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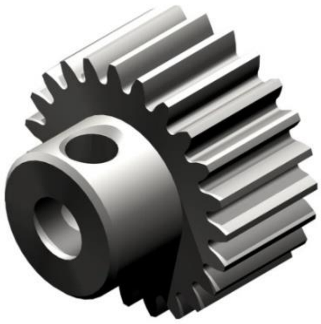

Fig 1.spur gear

The spur gear is the first choice option for gears except when high speeds, loads and ratios direct towards other by using the vibration analysis we can calculate the parameters such as natural frequency and vibration mode. The pinion is made from a harder material than the wheel. Modal oscillation of gearbox housing walls and other elastic structures is very important for the noise emitted by systems into the surroundings. Modal activity of housing walls is in direct relation with the structure and intensity of noise emitted by the gearbox into the surrounding. Therefore, research of modal activities is of general importance for modeling the process of generation of noise in mechanical systems. The noise emitted into the surroundings by the gearbox is mostly the consequence of natural oscillation of the housing. Also the Finite element method is used to analyze the stress state of an elastic body with complicated geometry such as gear.

## LITERATURE REVIEW:

Structural vibrations of the thin-walled gears are also analyzed by using three-dimensional, finite element method (3DFEM)with 20-noded is parametric element. It is found that natural frequencies and mode shapes of the thin-walled gear structure calculated by FEM are well agreement with the ones measured by experiments. Effects of tooth module, web thickness, web position, rim thickness, face width and gear hub on natural frequencies of the thin-walled gears are investigated by FEM calculations. It is found that rim and web thickness have greater effects on structural frequencies of the thin-walled gears than other parameters.

Tooth module also exerts an effect on the natural frequencies of the thin-walled gears [1].Pro E modeling provides capabilities to help the design engineer to perform conceptual and detailed deigns. It is a feature and constrained based solid modeler that allows users to create and edit complex solid models interactively. MSC Nast ran is a powerful general purpose, Finite element analysis solution for small to complex assemblies. A standard tool, in the field of structural analysis for over four decades, Nastranprovides a wide range of analysis capabilities including linear, static's, dynamic, displacement, strain, stress, vibration, heat transfer and more. Nast ran can handle any material type from plastic and metal to composites and hyper elastic materials [2].

Thin-walled gears were originally used in airplanes to meet the need of lightweight. In recent years, these gears have been finding wide applications in general machines for weight reduction and compact design. Though applications of the thin-walled gears are increased in general machines, vibration and dynamic strength design problems of the gears have not been solved so far. three types of thin walled gears are taken by referring to JIS B 1721.here m is used to express gear module, B is used to express face width of the gear,T1 is used to express web thickness of the gears ,T2 is used to express rim thickness of the gears and L is used to express web center position (distant from web center to gear face width center) of the gears.

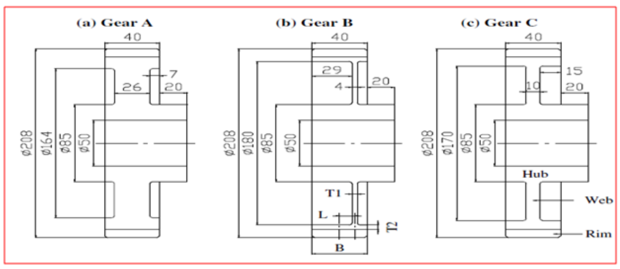


Fig 2: three types of gear with dimensions.

### Thin Spur Gear Design

Pitch circle diameter for gear, d1 = m*z1 mm.

=4*50=200 mm.

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Base circle diameter for gear, db1 = d1*cosα mm.

= 200*cos20=187.9

Tip circle diameter for gear, da1 = d1 + 2m mm

=200+2*4=208 mm

Root circle diameter for gear, df1 = d1 – 2*1.25 mm

=200-2*1.25=197.5

Tooth thickness on pitch circle, S = πm/2 mm

= π*4/2=6.28 mm

Clearance c = 0.25m =0.25*4=1 mm
Total Depth, h = 2.25*m=2.25*4=9mm
Circular pitch, p = πm= π*10=3.14*4=12.5mm
Face width, b = 3*π*m =3*π*4=37.69 mm
Diametrical pitch pd = z/d or 1/m =1/4=0.25.
Design torque=297 N-m
Design speed=3000 RPM

These paper investigations into effects of gearing parameters on structural and natural frequencies of the thin-walled gear Effects of gear module m, web thickness T1, rim thickness T2, web position L, face width B and hub structure on natural frequencies of the thin-walled gear are investigated through performing FEM calculations. Values of m, T1, T2, L and B are given in Table 1and these parameters are used in the investigations.

| MODULE (M) | 2 | 2.5 | 4 | | | |
|---|---|---|---|---|---|---|
| WEB THICKNESS (T1) | 4 | 6 | 8 | 10 | | |
| RIM THICKNESS (T2) | 2 | 4 | 5 | 6 | 7 | 10 |
| WEBPOSITION (L) | 0 | 3 | 6 | 9 | 15 | |
| FACE WIDTH (B) | 10 | 16 | 22 | 28 | 34 | 40 |

**Table1: Structural Parameters Are Considered In Analysis.**

CATIA name is an abbreviation for **C**omputer **A**ided **T**hree-dimensional **I**nteractive **A**pplication. It is user friendly software to create 3d models. CATIA v5 R20 software used to prepare models.27 types of spur gear part files are prepared to run the analysis. Sketch and part modules are used for prepared the gears.

And all model are saved as I.G.E.S format to import into ANSYS.

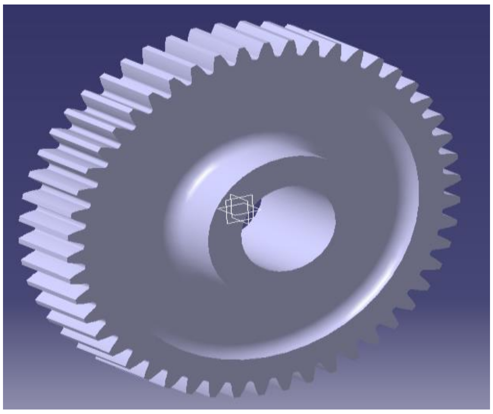

**FIG 3.gear a model created in CATIA**

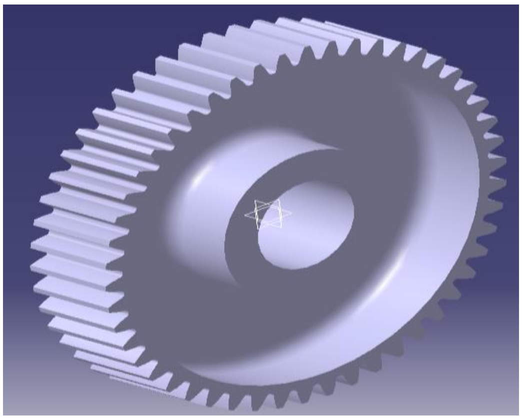

**FIG 3.gear B model created in CATIA**

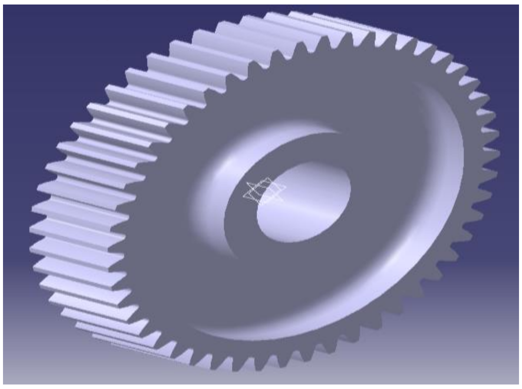

**FIG 3.gear C model created in CATIA.**

The finite element method (FEM) is a numerical technique for finding approximate solutions to boundary value problem .The finite element method has become a powerful tool for the numerical solution of wide range of engineering problems.

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Applications range from deformation and stress analysis of automotive , aircraft, building, and bridge structures .The ANSYS program is self contained general purpose finite element program developed and maintained by Swanson Analysis Systems Inc. The program contain many routines, all inter related, and all for main purpose of achieving a solution to an engineering problem by finite element method. here I.G.E.S. models are imported into ansys ,here the model is having 101151 elements and 166483 nodes. 2970N load is applied on teeth. And analysis results are shown as below for individual gears.

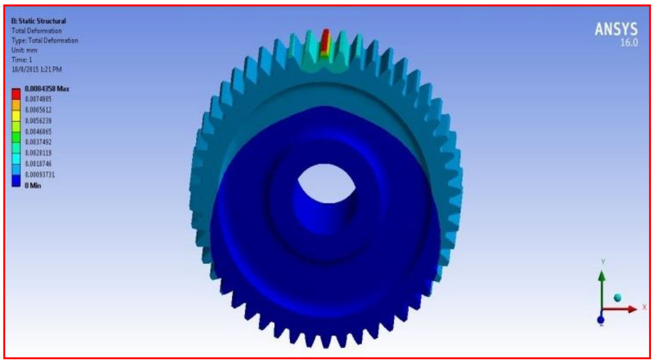



Fig 4. Gear a deformation

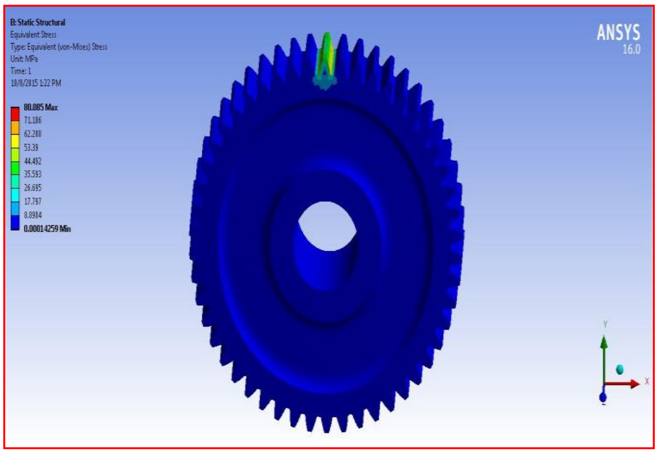
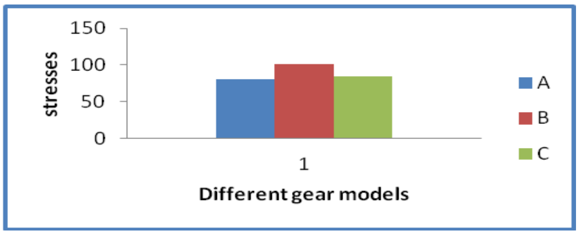
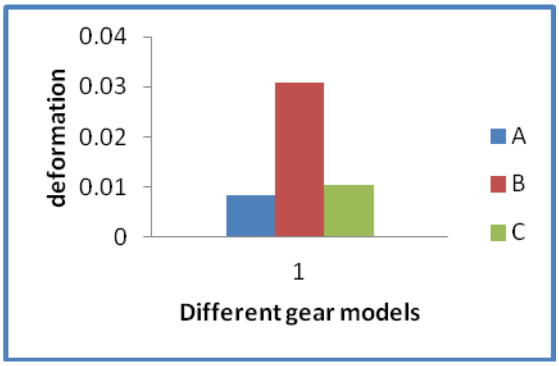



Fig 4. Gear a bending stresses.




Graph 1.deformation of three gears




Graph 2.bending stress of three gears

| FACE WIDTH | STRESS | DEFORMATION |
|---|---|---|
| 10 | 1365.3 | 0.076708 |
| 16 | 849.3 | 0.05413 |
| 22 | 609.46 | 0.044326 |
| 28 | 481.93 | 0.038795 |
| 34 | 396.54 | 0.35318 |
| 40 | 355.49 | 0.032869 |

**Table 2: deformation and stresses with changing face width.**

| MODULE | STRESS | DEF |
|---|---|---|
| 2 | 1365.2 | 0.076708 |
| 2.5 | 851.29 | 0.53208 |
| 4 | 333.55 | 0.037042 |

**Table 3: deformation and stresses with changing module.**

| POSITON | STRESS | DEF |
|---|---|---|
| 0 | 223.33 | 0.014468 |
| 3 | 198.29 | 0.036761 |
| 6 | 199.19 | 0.43036 |
| 9 | 209.85 | 0.051209 |
| 15 | 214.55 | 0.1167 |

**Table 4: deformation and stresses with changing web position.**

| RIM THICKNESS | STRESS | DEF |
|---|---|---|
| 4 | 1415.1 | 0.04795 |
| 5 | 1318.1 | 0.07545 |

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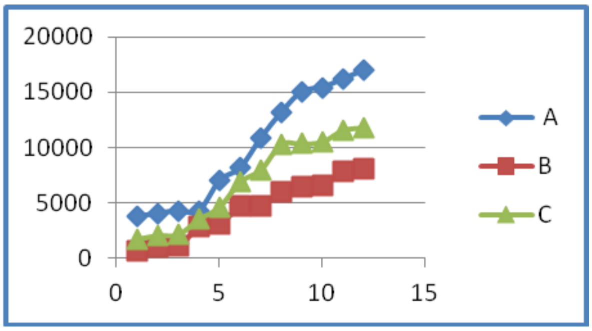
| | | |
|---|---|---|
| 6 | 1339.2 | 0.07441 |
| 7 | 1359.4 | 0.07562 |
| 10 | 1366.3 | 0.07215 |

Table 5: deformation and stresses with changing rim thickness.

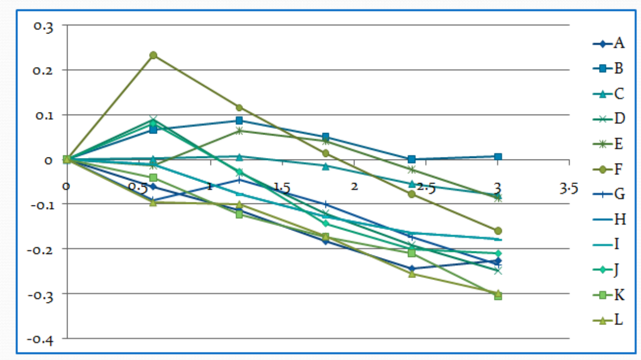
| WEB THICKNESS | STRESS | DEF |
|---|---|---|
| 4 | 1365.2 | 0.07678 |
| 6 | 1341.4 | 0.07073 |
| 8 | 1229.4 | 0.67569 |
| 10 | 1215.4 | 0.065153 |

Table 6: deformation and stresses with changing web thickness.

Any physical system can vibrate. The frequencies at which vibration naturally occurs, and the modal shapes which the vibrating system assumes are properties of the system, and can be determined analytically using Modal Analysis.Modal analysis is the procedure of determining a structure's dynamic characteristics; namely, resonant frequencies, damping values, and the associated pattern of structural deformation called mode shapes.In present work model analysis is performed for three type of gearswith changing parameters. Twelve model shapes are observed And results shown as below in table.




Graph 3: Natural frequencies with gear models.




Graph 4: percentage average of twelve frequencies (different module)

## CONCLUSION:

Vibration behavior of the three-dimensional, thin-walled gears has been investigated in this present work from model analyses. It is found that vibration effect increases with web thickness and web positions.Gear A model is having minimum bending stress as compared to remaining materials and results are same as compared to theoretical results.Even if we change the Face width, rim thickness and modules deviations of vibration are in same.Changing the web thickness and web positions are having more effective parameters to increase the vibrations.All results are in design limit.

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