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Effect of applied rotational velocity in finite element analysis

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ABSTRACT

Highly important research issue in this modern world is stress on the connecting shaft when a rotational velocity is applied to one of the gears connected to the shaft. This project aims on finding the variation in stress, deformation, and fatigue when two different rotational velocities are acted on the gear. The finite element analysis method takes at one place a single complicated shape with an approximately equivalent network of simple elements. The overall pattern of elements is referred to as a finite element mesh. For the solution to be uniquely defined the boundary conditions are to be specified. In the given project an end of shaft is fixed to get the deformation of the assembly after rotational velocity is applied. The components were modeled and assembled in FUSION 360 and the analysis was done in ANSYS software workbench interface.

Keywords: *Boundary Conditions, Fatigue, Finite element analysis, Mesh Size*

1. INTRODUCTION

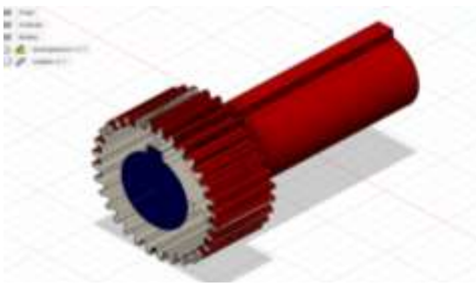
In finite element analysis the initial step is to design the mesh. The accuracy of the calculations depends on the number of elements we choose to have in the mesh. The more elements we have the smaller each one will be and the more accurate the results. But more elements mean more calculations, so we need to choose just enough elements to give adequate accuracy within a reasonable time. Gear is a rotating cylindrical wheel having teeth cut on it and meshes with another toothed part to transmit power or torque to the shaft. In this project we external spur gear is considered. The teeth of spur gear are parallel to the shaft producing radial reactions. For uniform motion between driving and driven member, the surface of teeth is used. Spur gears have constant velocity ratios and thus are reliable to transmit large amount of power. They are used in gear motor, gear pump, marine engine, steel industries. Shaft is a rotating machine element which receives and transmits power. There is a rectangular key used to connect and lock the shaft and gear and is subjected to shearing and crushing. The material of key and shaft in the project are same (stainless steel density: 7850kg/m^3). Static structural analysis has been performed and results of stress, strain, deformation, and fatigue are calculated.

- **Problem Statement**

For analysis gear, key and shaft assembly is taken. All the three components are separately modeled and assembled in Fusion 360.

Material Properties of Structural Steel

Young’s modulus (GPa)	210
Poisson’s ratio	0.3
Yield Strength (MPa)	433
UTS (MPa)	460



Model from Fusion 360

The material used is structural steel. The static structural analysis is done in Ansys. One end of the shaft is fixed, and the gear is given two different rotational velocities of 100 rad/sec and 200rad/sec respectively. The variation in total deformation, maximum principal stress, maximum principal strain, fatigue (life, damage, and safety factor) are calculated.

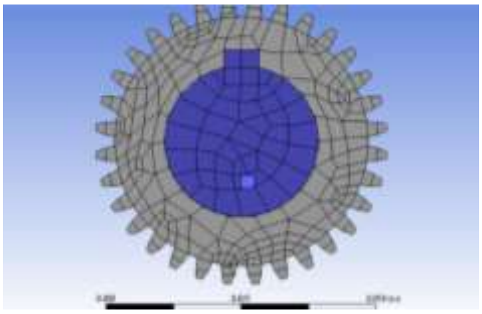
2. METHODOLOGY

- Modeling

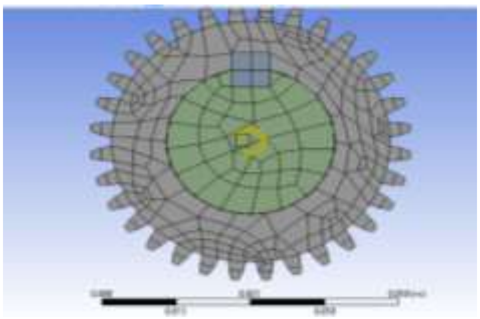
The dimensions given to the gear are the inner radius r=14.29cm the outer radius R=23.41cm the thickness t=25.40cm and the key slot of depth d=3.30cm and width w=6.35cm. The shaft which is to be fitted in the gear is of diameter D=28.58cm and length L=100cm.The third component is a machine element used to connect a rotating machine element (here the spur gear) to the shaft. The key is of length l=100cm (same as shaft) and area A=6.35*6.60cm^2

- Static Structural Analysis

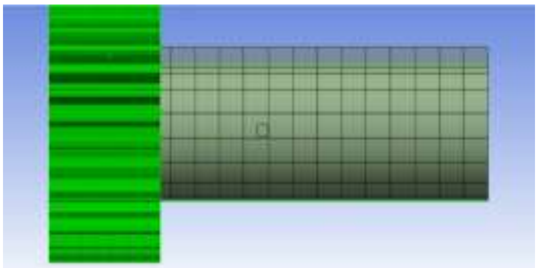
During the static structural analysis, the free end of shaft is fixed without any suppressing force and clockwise rotational velocity seen from the front face of gear is applied.



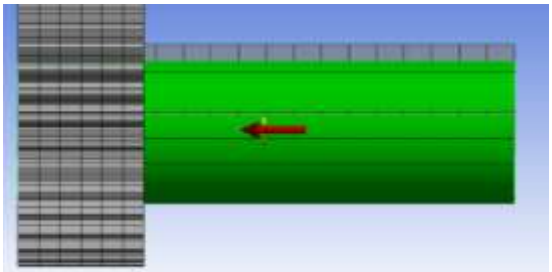
Fixed face



Rotational velocity application (clockwise)

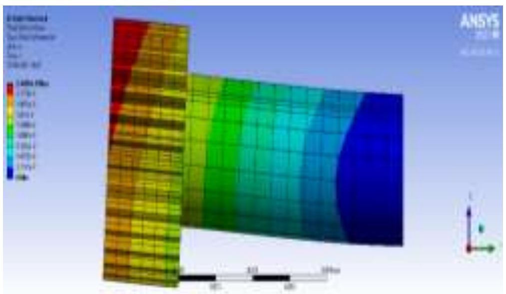


Application of rotational velocity

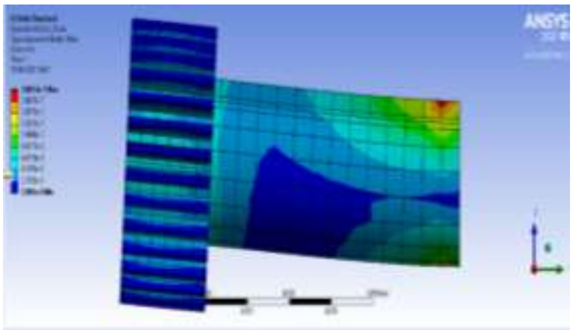


Selection of axis for rotation

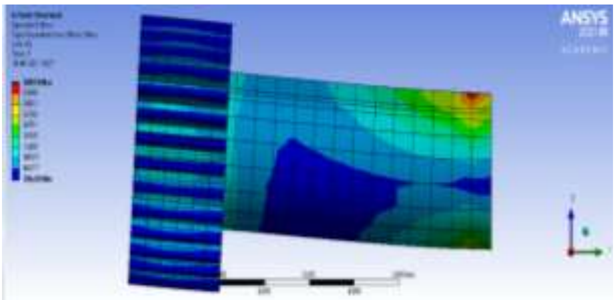
Results Iteration 1:
Rotational velocity=100rad/sec
The part under rotational velocity: Gear
Axis of rotation: Shaft
(Towards the front face of gear)



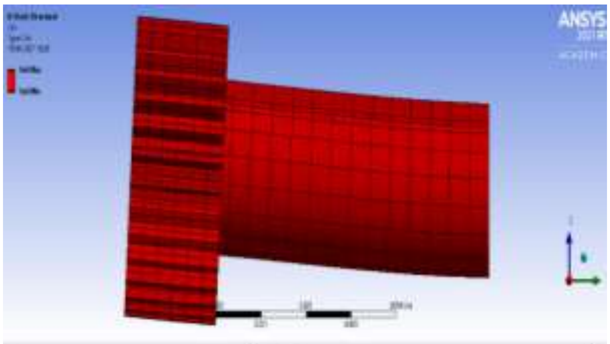
Total deformation



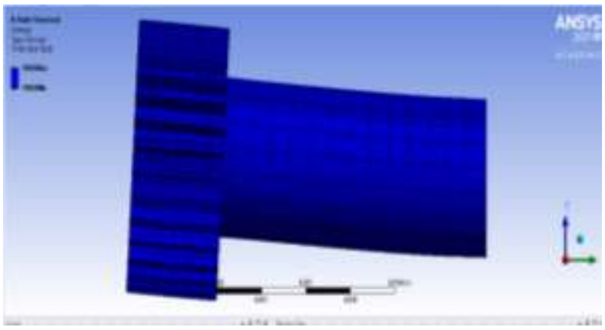
Equivalent Elastic Strain



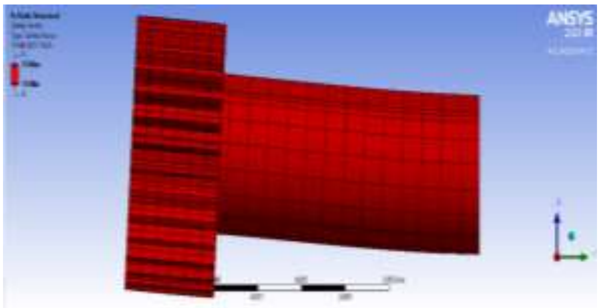
Equivalent Stress (Von Mises)



Fatigue life

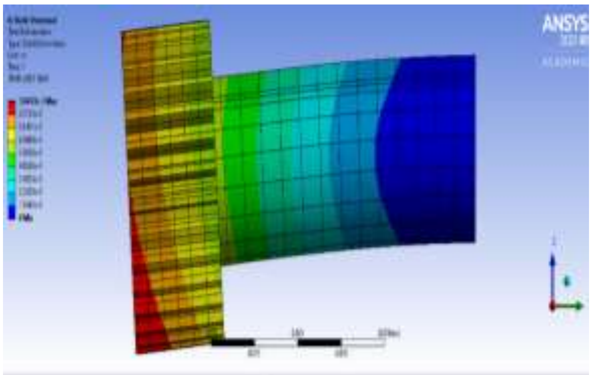


Fatigue damage

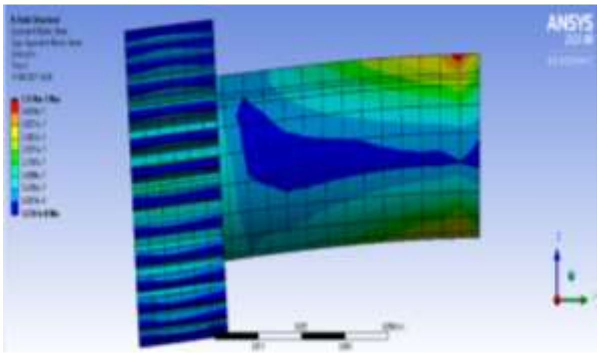


Safety factor

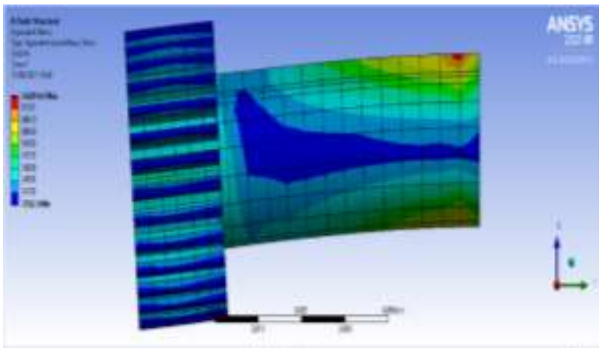
Results iteration 2:
Rotational velocity=200rad/sec
The part under rotational velocity: Gear
Axis of rotation: Shaft
(Towards the front face of gear)



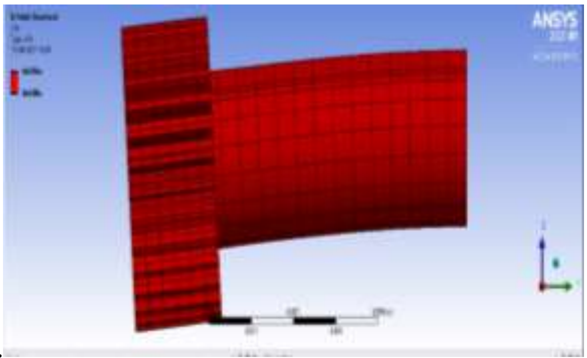
Total deformation



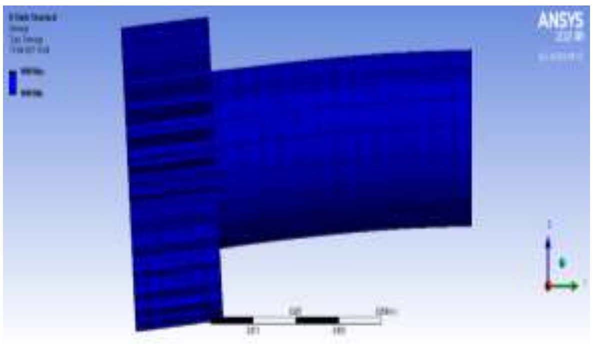
Equivalent Elastic Strain



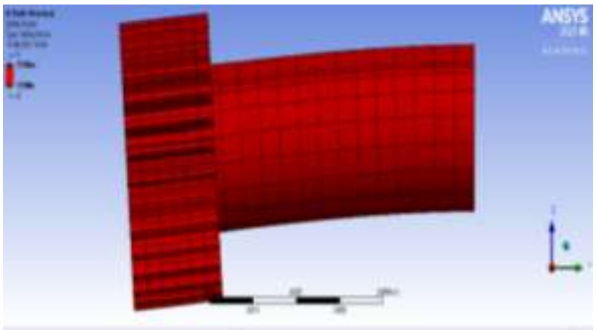
Equivalent Stress (Von Mises)



Fatigue life



Fatigue damage



Safety factor

Results comparison:

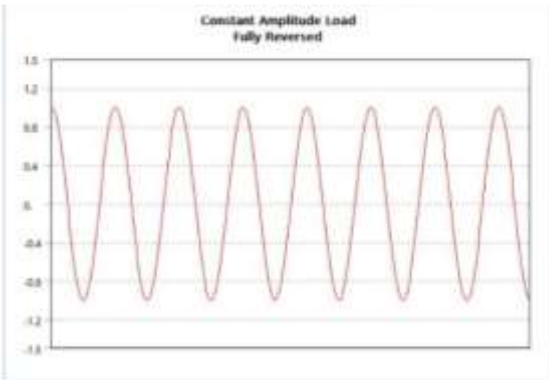
Iteration 1

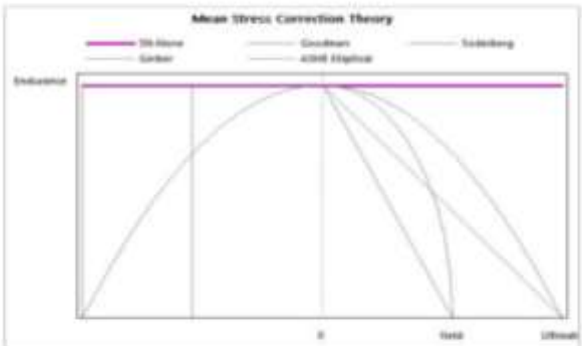
Type	Total Deformation	Equivalent Elastic Strain	Equivalent (von-Mises) Stress
Minimum	0m/m	2.985e-009 m/m	596.99 Pa
Maximum	2.4496e-008 m	1.8657e-007 m/m	36874 Pa
Average	1.6239e-008 m	4.5101e-008 m/m	8930.5 Pa

Iteration 2

Type	Total Deformation	Equivalent Elastic Strain	Equivalent (von-Mises) Stress
Minimum	0. m	1.2761e-008 m/m	2552.3 Pa
Maximum	1.0477e-007 m	5.1746e-007 m/m	1.0291e+005 Pa
Average	6.69e-008 m	1.5867e-007 m/m	31405 Pa

Fatigue





Fatigue results:

1. Fatigue life

Rotational velocity	Minimum	Maximum	Average
100rad/sec	1.e+006	1.e+006	1.e+006
200rad/sec	1.e+006	1.e+006	1.e+006

2. Fatigue tool damage

Rotational velocity	Minimum	Maximum	Average
100rad/sec	1000	1000	1000
200rad/sec	1000	1000	1000

3.Safety factor

Rotational velocity	Minimum	Maximum	Average
100rad/sec	15	15	15
200rad/sec	15	15	15

CONCLUSION

- The end of gear goes more total deformation, equivalent elastic strain and Von-mises stress than the end of the shaft which is fixed.
- As the magnitude of velocity applied increases the average and maximum deformation stress and strain also increases.
- The fatigue factors remain constant for both the iterations for the whole body.
- The shaft can sustain the applied rotational velocity and does not undergo breakage.

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