DESIGN AND LOAD ANALYSIS OF AND OPTIMIZATION OF COMPOUND EPICYCLIC GEAR TRAINS

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ABSTRACT

A Planetary or Epicyclic Gear Trains comprises of one or more planet gears revolving around a sun gear. Usually, an epicyclical gearing systems are employed to achieve high reduction ratio in a small and power dense package. It is examined that load sharing capability is not equal in the planetary gear train. These Gear Trains are extensively used for the transmission and are the most critical component in a mechanical power transmission system. They play a very vital role in all the industrial areas, any failure in the gear train leads to a total system failure, thus identifying the causes and optimizing to get the best performance is very necessary. The advantages of epicyclic gear trains are higher torque capacity, lower weight, small size and improved efficiency of the planetary design.

Planetary gear transmissions are compact, high power transmitting speed reductions technology. Structural analysis of three stage coupled planetary gear train is reviewed. This analysis depicts the fast and easy determination of the speed ratio, torques, and efficiency and power flow directions of coupled planetary gear trains. Three stage efficiency determined.

3D modeling done in CREO parametric software and analysis is done in ANSYS.

EPICYCLIC GEAR TRAIN:

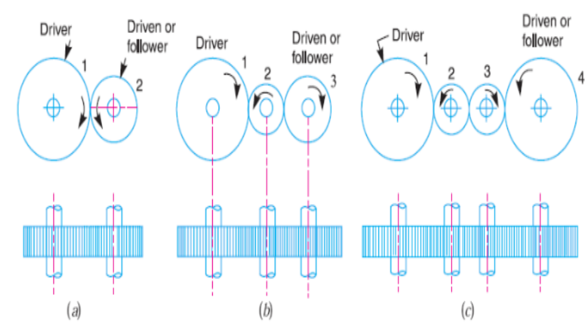
An epicyclic gear train consists of two gears mounted so that the center of one gear revolves around the center of the other. A carrier connects the centers of the two gears and rotates to carry one gear, called the *planet gear*, around the other, called the sun gear. The planet and sun gears mesh so that their pitch circles roll without slip. A point on the pitch circle of the planet gear traces an epicycloid curve. In this simplified case, the sun gear is fixed and the planetary gear(s) roll around the sun gear.

An epicyclic gear train can be assembled so the planet gear rolls on the inside of the pitch circle of a fixed, outer gear ring, or ring gear, sometimes called an *annular gear*. In this case, the curve traced by a point on the pitch circle of the planet is a hypocycloid.

SIMPLE GEAR TRAIN:

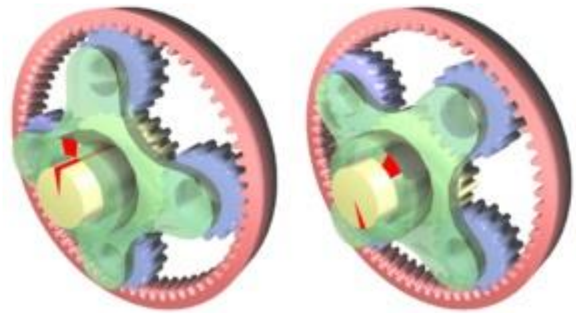
The simple gear train is used where there is a large distance to be covered between the input shaft and the output shaft. Each gear in a simple gear train is mounted on its own shaft.

When examining simple gear trains, it is necessaryto decide whether the output gear will turn faster, slower, or the same speed as the input gear. The circumference (distance around the outside edge) of these two gears will determine their relative speeds.



The speed ratio is given by, (N1/N2) = -(T2/T1), where, N1 is the speed of the driver, N2 is the speed of driven gear, T1 is the no of teeth on driver gear and T2 is the no of teeth on driven gear.

An epicyclic gear train consists of two gears mounted so that the center of one gear revolves around the center of the other. A carrier connects the centers of the two gears and rotates to carry one gear, called the planet gear, around the other, called the sun gear. The planet and sun gears mesh so that their pitch circles roll without slip. A point on the pitch circle of the planet gear traces an epicycloid curve. In this simplified case, the sun gear is fixed and the planetary gear(s) roll around the sun gear.An epicyclic gear train can be assembled so the planet gear rolls on the inside of the pitch circle of a fixed, outer gear ring, or ring gear, sometimes called an annular gear. In this case, the curve traced by a point on the pitch circle of the planet is a hypocycloid.



Epicyclic gearing or **planetary gearing** is a gear system consisting of one or more outer gears, or planet gears, revolving about a central, or sun gear. Typically, the planet gears are mounted on a movable arm or carrier, which itself may rotate relative to the sun gear. Epicyclic gearing systems also incorporate the use of an outer ring gear or annulus, which meshes with the planet gears. Planetary gears (or epicyclic gears) are typically classified as simple or compound planetary gears. Simple planetary gears have one sun, one ring, one carrier, and one planet set. Compound planetary gears involve one or more of the following three types of structures: meshed-planet (there are at least two more planets in mesh with each other in each planet train), stepped-planet (there exists a shaft connection between two planets in each planet train), and multi-stage structures (the system contains two or more planet sets). Compared to simple planetary gears, compound planetary gears have the advantages of larger reduction ratio, higher torque-to-weight ratio, and more flexible configurations.

APPLICATIONS:

Gears are applied in various services and products. We cannot imagine the world without them. Some of the applications are listed below:

1. Lathe
2. Auto-mobiles
3. Conveyors
4. Aircraft
5. Prime movers
6. Ship-hulls
7. Injection moulding machines
8. Commercial machines
9. Robotics field
10. Various transportation systems

ADVANTAGES OF AN EPICYCLIC GEAR:

1. Envelope size (smaller than parallel shaft for same power)

2. Low weight

3. Lower Pitch Line Velocity for comparable parallel shaft unit

4. Coaxial Shafts (in line system) resulting in more compact installation

5. low cost for entire train layout

DISADVANTAGES:

Include high bearing loads, constant lubrication requirements, inaccessibility, and design complexity. The efficiency loss in a planetary gear trains 3% per stage. ... The load in a planetary gear train is shared among multiple planets; therefore torque capability is greatly increased.

LITERATURE SURVEY

In the 2nd century AD treatise Almagest, Ptolemy used rotating deferent and epicycles that form epicyclic gear trains to predict the motions of the planets. Accurate predictions of the movement of the Sun, Moon and the five planets, Mercury, Venus, Mars, Jupiter and Saturn, across the sky assumed that each followed a trajectory traced by a point on the planet gear of an epicyclic gear train. This curve is called an epitrochoid. Epicyclic gearing was used in the Antikythera Mechanism, circa 80 BCE, toadjust the displayed position of the moon for its elasticity, and even for the precession of the ellipticity. Two facing gears were rotated around slightly different centers, and one drove the other not with meshed teeth but with a pin inserted into a slot on the second. As the slot drove the second gear, the radius of driving would change, thus invoking a speeding up and slowing down of the driven gear in each revolution.

INTRODUCTION TO CAD

Computer-aided design (CAD) is the use of computer systems (or workstations) to aid in the creation, modification, analysis, or optimization of a design. CAD software is used to increase the productivity of the designer, improve the quality of design, improve communications through documentation, and to create a database for manufacturing. CAD output is often in the form of electronic files for print, machining, or other manufacturing operations. The term CADD (for Computer Aided Design and Drafting) is also used.

INTRODUCTION TO CATIA

CATIA (an acronym of **computer aided three-dimensional interactive application**) is a multi-platform software suite for computer-aided design (CAD), computer-aided manufacturing (CAM), computer-aided engineering (CAE), PLM and 3D, developed by the French company Dassault Systems.

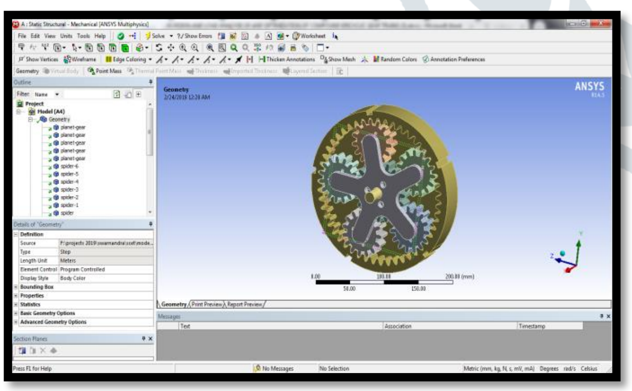
INTRODUCTION TO FEA

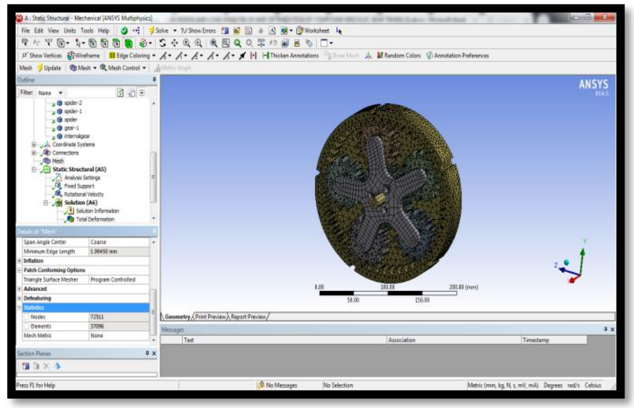
Finite element analysis is a method of solving, usually approximately, certain problems in engineering and science. It is used mainly for problems for which no exact solution, expressible in some mathematical form, is available. As such, it is a numerical rather than an analytical method. Methods of this type are needed because analytical methods cannot cope with the real, complicated problems that are met with in engineering. For example, engineering strength of materials or the mathematical theory of elasticity can be used to calculate analytically the stresses and strains in a bent beam, but neither will be very successful in finding out what is happening in part of a car suspension system during cornering.

ANSYS Mechanical

ANSYS Mechanical is a finite element analysis tool for structural analysis, including linear, nonlinear and dynamic studies. This computer simulation product provides finite elements to model behavior, and supports material models and equation solvers for a wide range of mechanical design problems. ANSYS Mechanical also includes thermal analysis and coupled-physics capabilities involving acoustics, piezoelectric, thermal–structural and thermo-electric analysis.

STATIC ANALYSIS OF EPICYCLICAL GEAR TRAINS





Select static structural right click → insert → select rotational velocity and fixed support → Select displacement → select required area → click on apply → put X,Y,Z component zero →

Select force → select required area → click on apply → enter rotational velocity

Select solution right click → solve →

Solution right click → insert → deformation → total → Solution right click → insert → strain → equivalent (von-mises) →

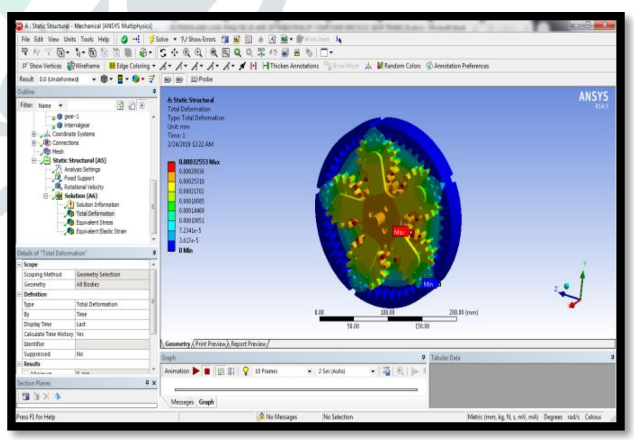
Solution right click → insert → stress → equivalent (von-mises) →

Right click on deformation → evaluate all result

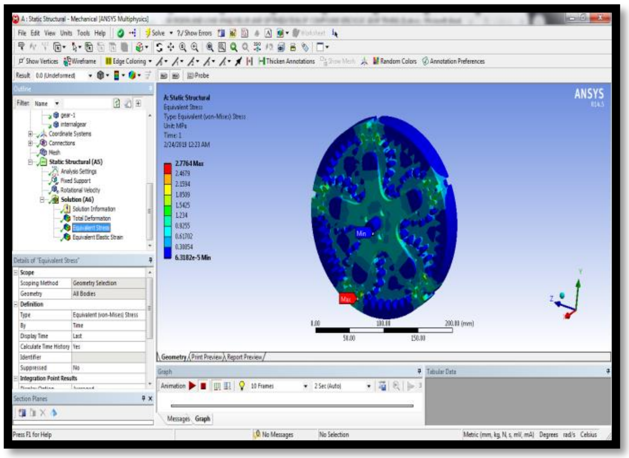
ROTATIONAL VELOCITY 209rad/s

MATERIAL – steel

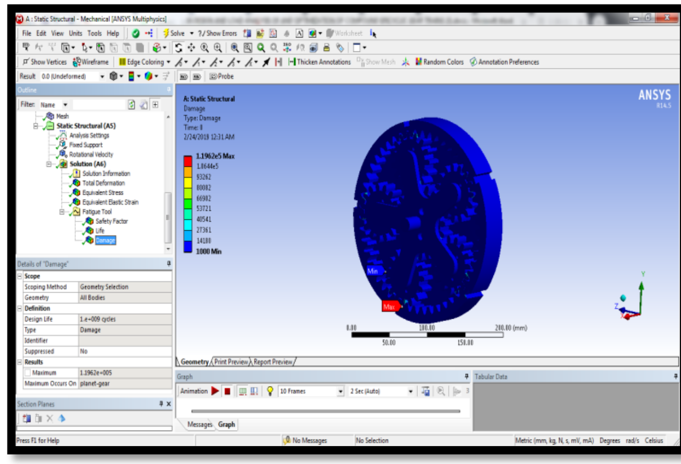
Deformation



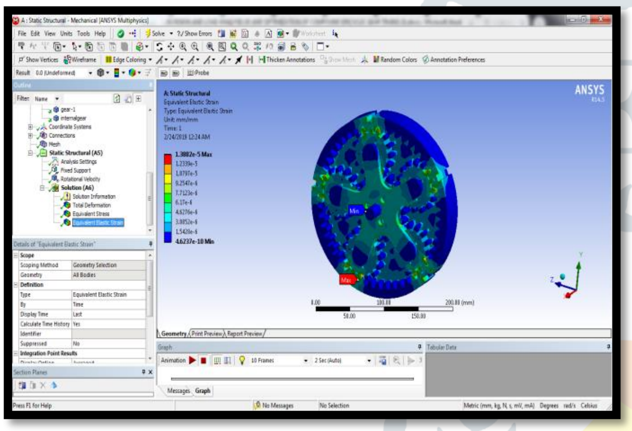
Stress



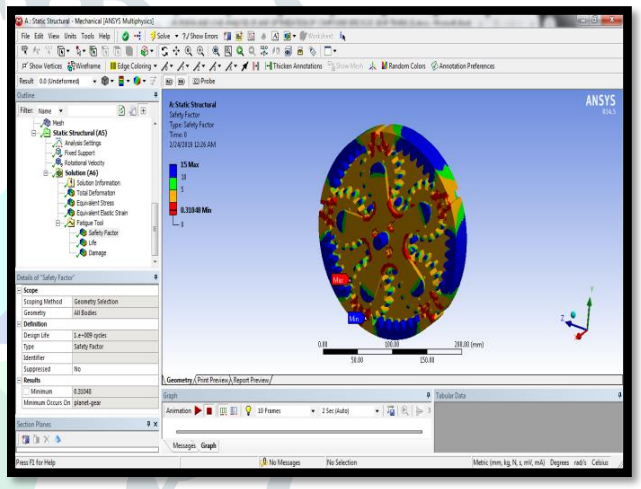
DAMAGE



Strain

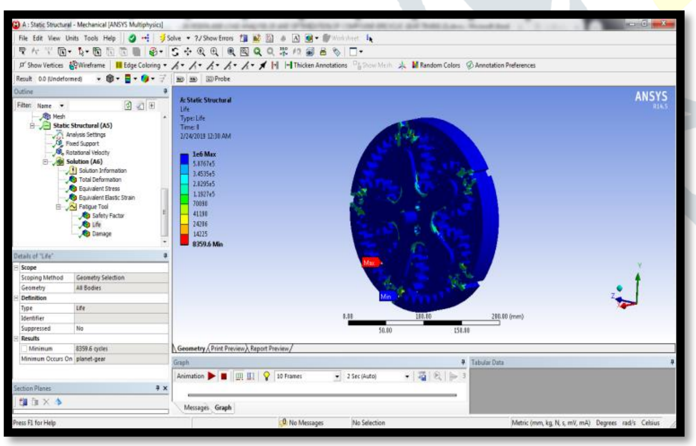


SAFETY FACTOR



FATIGUE ANALYSIS OF EPICYCLIC GEAR TRAINS

LIFE

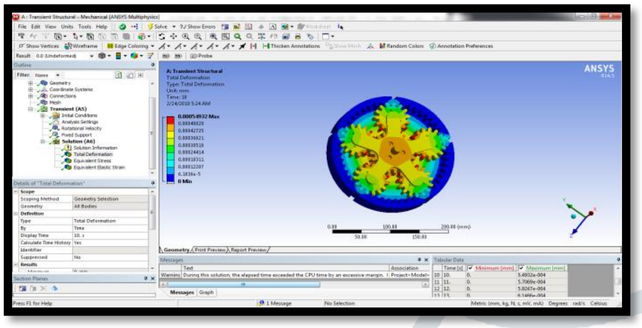


DYNAMIC ANALYSIS OF EPICYCLICAL GEAR TRAINS

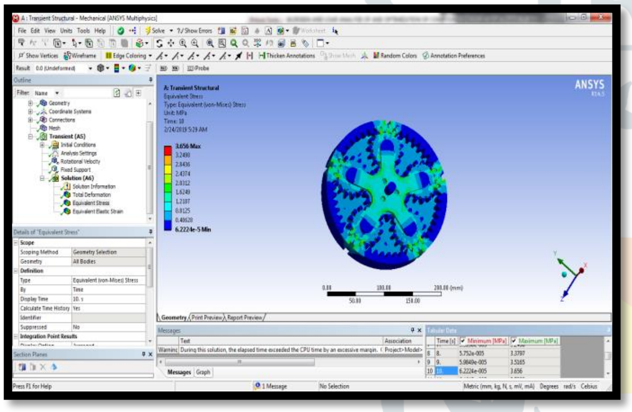
Taken material stainless steel, this material was taken from which is the best material in static analysis results

At 10 sec

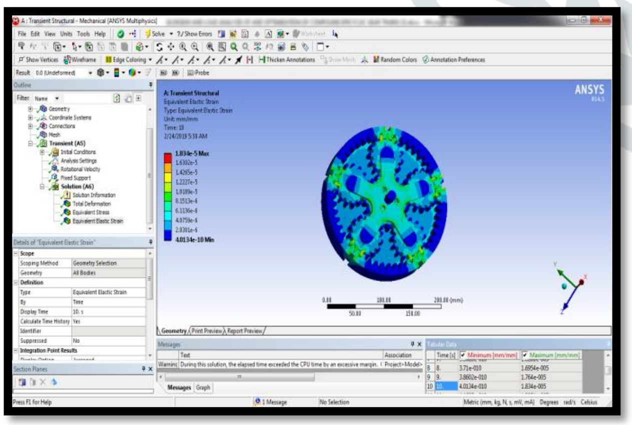
Deformation



Stress

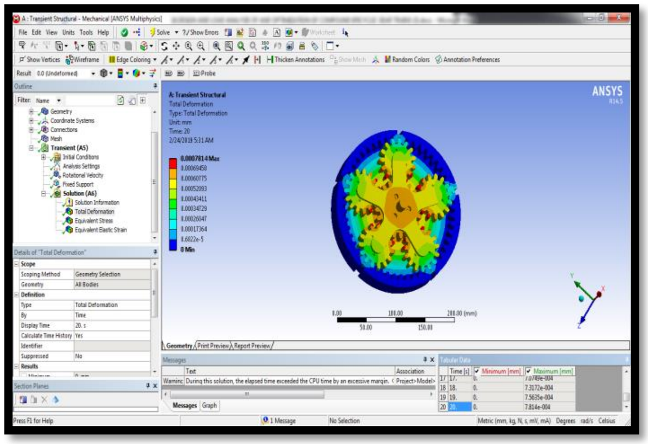


Strain

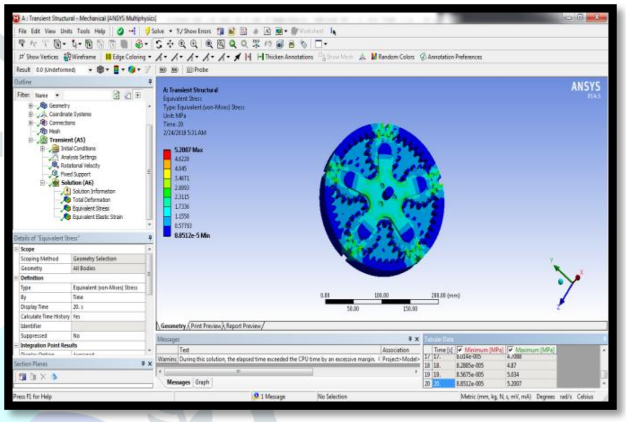


At 20 sec

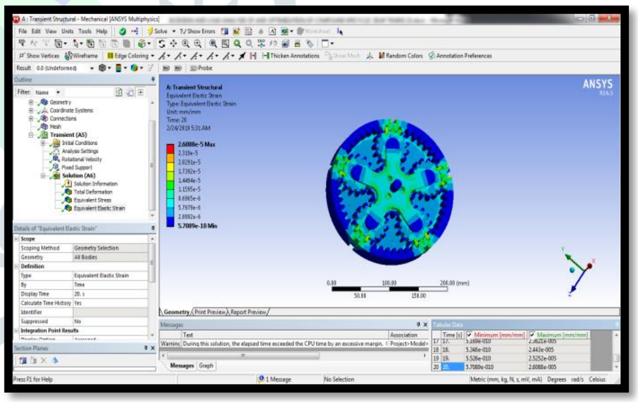
Deformation



Stress



Strain



RESULTS TABLE

STATIC ANALYSIS

At 209rad/sec

Material	Deformation	Stress(pa)	Strain	Safety factor
STEEL	0.00032553	2.7764	1.3882E-5	0.31048
STAINLESS STEEL	0.00033158	2.7211	1.4099E-5	0.31679

At 350 rad/sec

Material	Deformation	Stress(pa)	Strain	Safety factor
STEEL	0.00069668	6.0903	2.9709E-5	0.14154
STAINLESS STEEL	0.00072367	5.9387	3.077E-5	0.14515

Dynamic analysis result table

Time (sec)	Deformation (mm)	Stress (MPa)	Strain
10	0.00054932	3.656	1.834e-5
20	0.0007814	5.2007	2.6088e-5

Conclusion

Planetary gear transmissions are compact, high power transmitting speed reductions technology. Structural analysis of three stage coupled planetary gear train is reviewed. This analysis depicts the fast and easy determination of the speed ratio, torques, and efficiency and power flow directions of coupled planetary gear trains. Three stage efficiency determined. 3d modeled done in catia software and analysis is done in ansys.

By observing the static analysis the stress values are increases by increasing the rotational velocity. The stress values more for steel and less for stainless steel.

So it can be concluded the stainless steel material is better material for epicyclical gear trains.

REFERENCES

[1]Hemanth Naveen Dumpala

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