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DESIGN AND STRUCTURAL ANALYSIS OF A PLANETARY DRIVE SPEED REDUCER USING ANSYS WORKBENCH

Ms. Mekala Shirisha[*1], Mr. Ramavath Dathu[*2], Mr. D. Harish Reddy[*3], Ms. Berry Prasanna Laxmi[*4], Mr. Md. Tousif Ahmed*[5], Mr. Mohammed Abdul Hafeez*[6]
[*1,2,3,4,5] B.Tech Student, [*6] HOD & Assistant Professor, Dept. of Mechanical Engineering.
Sree Visvesvaraya Institute of Technology and Science, Mahbubnagar, Telangana, India

Abstract: *A planetary drive or planetary speed reducer is a mechanism for reducing the speed of an input shaft by a certain ratio. Planetary speed reducers are capable of high ratios in compact sizes. The input shaft drives an eccentric bearing that in turn drives the planetary disc in an eccentric, planetary motion. The perimeter of this disc is geared to a stationary ring gear and has a series of output shaft placed through the face of the disc. These output shafts directly drive the output shaft as the planetary disc rotates. The radial motion of the disc is not translated to the output shaft. Rotational force analysis is to carry out based on the calculated rpms at gears and pulleys. Gravity analysis is carried out for checking the acceleration inside the components. This project is about gear calculation and dimensioning, of the elements in a planetary stage of a speed reducer. The idea is to use the results from this project and go into production of such reducer to cover another segment of the market. The companies are interested in supplying transmissions for robust systems and for various industrial purposes, where large ratios of speed reduction are needed. For the determination of forces on the elements, models and drawings are to be made in CAD software like CATIA V5 and analysis by Ansys software. The quality mesh is prepared in converged solution and the solver set as analysis package with high optimizing results. The resultant calculation process can be used for designing the geometry and determination of the properties regarding the planetary reducer.*

CHAPTER 1
INTRODUCTION

It is least demanding to think about a speed reducer as a rigging or arrangement of apparatuses joined in such a way to build the torque of a motor. Fundamentally, the torque of a motor increments in guide extent to the diminishment of the motors pivots every moment. On the off chance that you diminish the turn without backing off the motor, you increment the power produced. The idea of utilizing gears returns a huge number of years, and utilizing riggings to control torque.

1.1. Effects of Speed Reducers

The reason for a speed reducer isn't simply to expand torque, however to achieve the perfect torque for the machine being used. This is finished by decreasing the speed input turn to a proportion of "1/X." For this situation, "X" speaks to the lessening proportion. The variable "X" is then increased against the torque of the unreduced motor. This gives you the torque of the motor after a speed reducer has been connected to it. That torque would now be able to be connected to drive whatever machine it is planned for.

1.2. Types of Speed Reducers

The kind of speed reducers utilized relies upon the sort of motor. There are the same number of sorts of speed reducers as there are kinds of riggings. Cases of the sorts gears used to make speed reducers are:

Goad outfits: a rigging wheel having spiral teeth parallel to the hub.

Worm outfits: a turning screw that cross sections with the teeth of another apparatus on a slanted plane.

Slant and winding slope equips: an apparatus wheel that lattices with another at an edge in the vicinity of 90^0 and 180^0.

The sort utilized is subject to the kind of motor, and when supplanting a ragged-out apparatus, it is vital to supplant the reducer with a similar kind utilized by the first gear producer, or look for master guidance.

1.3. Speed reducer assortments

Various diverse sorts of gearboxes and speed reducers to suit the application are given beneath:

- Bevel Gearboxes
- Miter Gearboxes
- Helical Gear Assemblies
- Worm and Wheel Assemblies
- Right Angle Drives
- Geneva Mechanisms
- Servo Gearboxes
- Gear Heads
- Gear Trains
- Planetary Gear Sets

1.4. Speed reducer applications

Speed Reducers are utilized as a part of any industry that utilizations hardware, regardless of whether it is pressure driven or electric. A few cases of employments of speed reducers are in running transport lines, therapeutic machines, nourishment processors, printing gadgets, PCs, car motors and development related apparatus. Our speed reducers and gearboxes are utilized as a part of numerous intriguing applications. Basic ventures, capacities, and items include:

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1.5. Description of the Problem

The principle target of the task is to outline and break down a planetary drive speed reducer. SwePart Company who fabricates speed reducers comprises of two phases. Planetary and Planetary speed reducers. To start with arrange includes speed decrease via planetary apparatus speed reducers and second stage includes speed lessening via planetary rigging speed reducers.

1.6. Design of Speed Reducers

Configuration part is tied in with making the genuine reducer with the given information. The outline of speed reducer was finished by considering pace of information shaft as 1420 rpm in order to lessen the speed to constrain.

The Planetary rigging profile is a type of toothed apparatus utilized as a part of mechanical tickers, instead of the involutes shape utilized for most different apparatuses. The apparatus tooth profile depends on the epicycloids and hypocycloid bends, which are the bends produced by a hover moving around the outside and within another circle, separately.

1.7. Background and Purpose

The venture has been performed in a plan to outline a gearbox, which can supplant a model of a cycloid gearbox, utilized as a part of numerous enterprises, for example, vigorous frameworks, mines, metallurgy, synthetic, and material and in circumstances where fast diminishment is required. The high proportion is given as a result of the planetary and cycloid phases of speed diminishment. The undertaking is partitioned in two sections did by various gatherings. In this paper section one is displayed, extreme a few information has been utilized from the other gathering's counts. Fundamentally, is to find out about the general conditions for ascertaining the properties of the second lessening stage (e.g. Planetary stage).

1.8. The Analysis Model

This undertaking includes mechanics for push investigation, and unbending body elements for estimation of removals.

The displaying center is around formation of joints and bodies. Ansys requires that the two networks be utilized to characterize revolute joints – one lattice on every one of the bodies. The frameworks that characterize the joints should be on the pivot of turn, for a revolute joint. Since there may not be components at the coveted area, we make liberal utilization of "unbending" components. This approach enables us to characterize the frameworks for the joints at areas that are right from the perspective of the multi-body solver.

The objective of Gear Reducer creators and makers is to acquire least effectiveness, joined with satisfactory quality. Inordinate quality requires extra weight which brings down the proficiency of the Gear Reducer by decreasing its speed and the measure of helpful load it can convey.

CHAPTER 2
PROJECT LIFE CYCLE MANAGEMENT
(Conventional Design Process)

2.1. Introduction

There are two distinctive lifecycles that work in conjunction with each other over the span of each task. The undertaking lifecycle portrays the assignments that must be finished to create an item or administration. Distinctive undertaking lifecycles exist for particular items and administrations. (For instance, the existence cycle took after to fabricate another outline model of machine is altogether different from the lifecycle took after to build up a product bundle.) The venture administration lifecycle characterizes how to deal with an undertaking. It will dependably be the same, paying little mind to the undertaking lifecycle being utilized.

In Project Origination an individual proposes a venture to make an item or build up an administration that can take care of an issue or address a need in the Performing Organization. The Performing Organization at that point presents the proposition to an assessment and choice process. On the off chance that chose, a financial plan or further administration responsibility for the undertaking may likewise be required before a Project Manager is really appointed and the task is approved to advance to Project Initiation. Contingent on the measures and practices of the Performing Organization, a period delay between the venture's proposition and choice and its real commencement may happen.

CHAPTER 3
LITERATURE SURVEY

3.1. Introduction to Gears (SPUR GEARS)

Meaning OF SPUR GEAR

A sort of apparatus that has straight, level topped teeth set parallel to the pole. Goad gears are the most well-known sort of riggings utilized as a part of industry. A gearwheel with teeth anticipating parallel to the wheel's pivot.

The slipping of a belt or rope is a typical marvel, in the transmission of movement or power between two shafts. The impact of slipping is to lessen the speed proportion of the framework. In exactness machines, in which a characterize speed proportion is of significance, the main positive drive is by methods for outfit or toothed wheels. A rigging drive is likewise given, when the separation between the drive and the adherent is little.

A contact wheel with the teeth cut on it is known as toothed wheel or rigging.

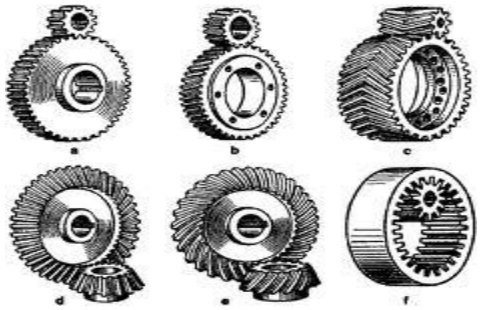

Fig: 3.1: Types of Gears Meshing

Points of interest and hindrances:
Points of interest:
- It transmit correct speed proportion.
- It might be utilized to transmit vast power.
- It has high effectiveness.
- It has solid administration.
- It has minimal design.

Detriments:
- The makes of riggings require exceptional devices and gear.
- The blunder in cutting teeth may cause vibrations and commotion amid activity.

3.2. How a Gear Box Operates

As said, the reducer unit comprises of four essential parts: the fast information shaft, a solitary planetary rigging, an unconventional bearing and a moderate speed yield shaft. In Figure is demonstrated the detonated perspective of the get together. In a great deal of cases the outline and wording of the segments can shift .On this figure are likewise demonstrated alternate parts like the protecting, the bearing, spacer, the ring gear lodging additionally the moderate shaft (yield shaft). The info shaft is associated with the offbeat cam, through a key association. This inflexible association makes the offbeat cycloid apparatus revolution i.e. cycloid movement. This movement makes the circles move over the ring gear, mounted in the ring gear lodging (additionally later alluded). The yield shaft is associated with the cycloid plate by means of shaft orientation. From the figure it can be watched that the pole orientation are arranged into the cycloid plate's edge openings (take a gander at Figure).

As indicated by Darali drives and Sumitomo drives, single stage effectiveness approaches 93%, twofold phase 86% and the lessening rate of a solitary stage reducer is up to 199:1 and twofold phase up to 7569:1.

3.3. Classification of toothed wheels

The riggings or toothed wheels might be named takes after:

3.3.1. According to the situation of tomahawks of the poles: The tomahawks of the two shafts between which the movement is to be transmitted, might be

a) Parallel,
b) Intersecting, and
c) Non-converging and non-parallel.

The two parallel and co-planar shafts associated by the riggings. These apparatuses are called goad gears. These apparatuses have teeth parallel to the pivot of the wheel. Another name given to the goad equipping is helical outfitting.

3.3.2. According to the peripherals speed of the apparatuses: The riggings, as indicated by the peripherals speed of the apparatuses might be delegated:
a) Low speed, b) Medium speed, and c) High speed.

The apparatuses having speed under 3 m/s are named as low speed riggings and apparatuses having speed in the vicinity of 3 and 15 m/s are known as medium speed gears. On the off chance that the speed of apparatuses is in excess of 15 m/s, at that point these are called fast riggings.

3.3.3. According to the sort of adapting: The apparatuses, as per the kind of outfitting might be delegated:
a) External outfitting, b) Internal outfitting, and c) Rack and pinion.

In outside adapting, the apparatuses of the two shafts work remotely with each other. The bigger of these two wheels is called goad haggle littler wheel is called pinion. In an outside equipping, the movement of the two wheels is constantly dissimilar to. In inner equipping, the riggings of the two shafts work inside with each other. The bigger of these two wheels is called annular haggle littler wheel is called pinion. In an inner outfitting, the movement of the two wheels is constantly similar to.

3.3.4. According to position of teeth on the apparatus surface: The teeth on the rigging surface might be:
a) Straight,
b) Inclined, and
c) Curved.

3.4. Terms utilized as a part of Gears

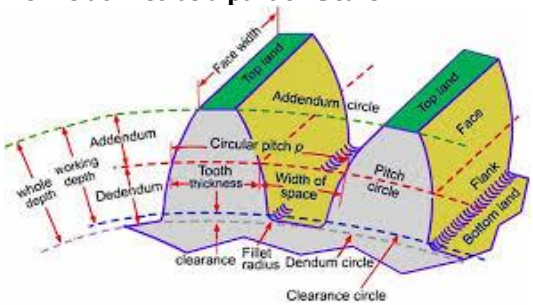

Fig: 3.3: Gear Teeth Structure

The information shaft drives a planetary rigging that thus drives the planetary plate in an unconventional, planetary movement. The edge of this plate is adapted to a stationary ring gear and has a progression of yield shaft pins or rollers set through the substance of the circle. These yield shaft sticks straightforwardly drive the yield shaft as the Planetary circle turns. The outspread movement of the circle isn't meant the yield shaft.

3.5. TYPES OF GEAR TRAINS

Following are the diverse kinds of rigging trains, contingent on the plan of wheels:

1. Straightforward apparatus prepare,
2. Compound apparatus prepare,
3. Returned outfit prepare, and
4. Epicyclic apparatus prepare.

Straightforward rigging train: where there is just a single apparatus on each pole, it is known as basic apparatus prepare. At the point when the separation between the two shafts is little, the two riggings 1 and 2 are made work with each other to transmit movement from one shaft to the next, since the apparatus 1 drives the rigging 2, thusly adapt 1 is known as the driver and the apparatus 2 is known as the determined or supporter. It might be noticed that the movement of the determined apparatus is inverse to the movement of driving rigging.

Speed proportion: It is the proportion of the speed of the driver to the speed of the determined or supporter.

Speed proportion = N1/N2 = T2/T1
Prepare esteem = N2/N1 = T1/T2

Model of Spur Gear

Pinion adapt use to diminish the quantity of unrest of goad equip this proportion ought to be 1:10 proportion is will move toward becoming while at the same time giving the information capacity to the pinion outfit.

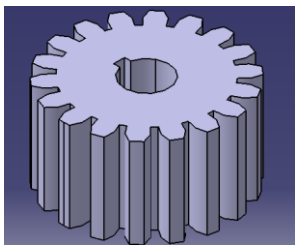

Fig: 3.4(a): 3D-Model Spur Gear Fig: 3.4(b): Sample Physical Model of Spur Gear

3.6. THEORY OF OPERATION

The information shaft is mounted unpredictably to the metal roller, making the Planetary plate move around. The Planetary plate will freely pivot around the bearing as it is pushed against the ring gear. This is like planetary riggings, and the course of pivot is inverse to that of the info shaft.

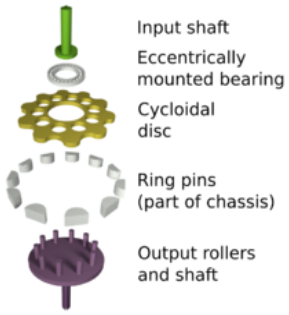

Fig: 3.5: Parts of a 10:1 Planetary speed reducer component

The quantity of pins on the ring gear is bigger than the quantity of pins on the planetary plate. This makes the Planetary plate turn around the bearing quicker than the info shaft is moving it around, giving a general revolution toward the path contradicting the pivot of the information shaft.

3.8. Features of Planetary Drive Speed Reducer

The Planetary Drive Speed Reducer is having High decrease proportion and high proficiency when Cyclo drive speed reducer embraces single stage transmission, the lessening proportion can reach up to 1:87 and the productivity is more than 90%. In the event that this transmission hardware embraces multi-organize drive, the diminishment proportion will be bigger. It is extremely smaller in structure and little in measure, Cyclo drive speed reducer embraces planetary drive guideline, and the info shaft and yield shaft are in a similar hub line, so the rigging reducer is little in estimate. It is Stable running and low running commotion. It gives a Reliable execution and long administration life; the primary segment parts of Cyclo drive speed reducer are produced using extinguished high-carbon chromium steel materials and consequently are of high quality. Besides, the moving grinding of some tooth contacts makes the apparatus reducer tough. This Planetary drive speed reducer is normally composed and is anything but difficult to gather and keep up, as an expert Cyclo drive speed reducer maker in China, we can create Cyclo drive speed reducers, as well as top notch aluminum case worm gearboxes, curve adapt round and hollow worm gearboxes, in line helical gearboxes, in line helical rigging reducers, and other transmission hardware.

CHAPTER 4
MATHEMATICAL CALCULATIONS OF PLANETARY DRIVE SPEED REDUCER

4.1. Design of Input Shaft for Planetary Gear

Shafts frame the critical components of machines. They are the components that help pivoting parts like riggings and

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pulleys and thusly are themselves bolstered by course resting in the inflexible machine lodgings. The poles play out the capacity of transmitting power starting with one turning part then onto the next upheld by it or associated with it. Therefore, they are subjected to torque because of intensity transmission and bowing minute because of responses on the individuals that are bolstered by them. Shafts are to be recognized from axles which likewise bolster pivoting individuals however don't transmit control. Axles are along these lines subjected to just twisting burdens and not to the torque.

Goals

In the wake of concentrate this unit, you ought to have the capacity to

- describe kinds of shafts,
- take choices to choose the materials for shaft,
- Estimate shaft measurements in various portions along length, and
- Design couplings for shafts

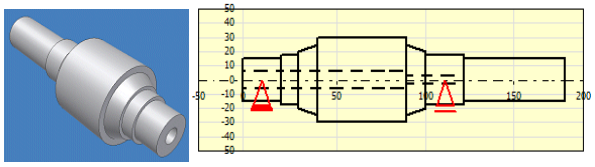


Fig: 4.1: Model of Shafts

4.1.1. Materials for Shafts

From the above dialog the materials for the pole would be required to have

- High quality,
- Low indent affectability,
- Ability to be warm treated and callous to build wear obstruction of diaries
- Good machinability

4.1.2. Mathematical Calculations of Input Shaft

Shaft Diameter (Ds) = [(H.P) * 321000]] 1/3
[(N) * (Ts)]

$$\text{Shaft Diameter } (D_s) = \left[\frac{[(H.P) * 321000]}{[(N) * (T_S)]}\right]^{1/3}$$

$$\text{Shaft Diameter } (D_s) = \left[\frac{[(0.5) * 321000]}{[(1420) * (340)]}\right]^{1/3}$$

Shaft Diameter (D_s) = **0.692 inches * 25.4 mm**

Note: According to Mathematical figurings the pole distance across required is 17.595 mm and the breadth taken underway is 20mm.

4.2. Design of Gears

An apparatus or cogwheel is a pivoting machine part having cut teeth, or pinions, which work with another toothed part so as to transmit torque, as a rule with teeth on the one rigging of indistinguishable shape, and regularly additionally with that shape (or if nothing else width) on the other apparatus. At least two riggings working pair are known as a transmission and can create a mechanical preferred standpoint through an apparatus proportion and in this manner might be viewed as a straightforward machine. Adapted gadgets can change the speed, torque, and bearing of a power source. The most widely recognized circumstance is for an apparatus to work with another rigging; in any case, an apparatus can likewise work with a non-turning toothed part, called a rack, in this way delivering interpretation rather than revolution.

Fig: 4.2: Gear prepare transmission framework

In transmissions which offer various apparatus proportions, for example, bikes and autos, the term adapt, as in first rigging, alludes to a rigging proportion as opposed to a genuine physical rigging. The term is utilized to depict comparable gadgets notwithstanding when the rigging proportion is persistent instead of discrete, or when the gadget does not really contain any apparatuses, as in a ceaselessly factor transmission.

CHAPTER 5
DESIGN METHODOLOGY OF PLANETARY DRIVE SPEED REDUCER

This PLANETARY DRIVE SPEED REDUCER is composed utilizing CATIA V5 programming. This product utilized as a part of vehicle, aviation, buyer merchandise, substantial building and so forth it is intense programming for planning entangled 3d models, utilizations of CATIA Version 5 like part configuration, get together outline.

The same CATIA V5 R20 3d display and 2d drawing model is appeared beneath for reference. Measurements are taken from. The plan of 3d demonstrate is done in CATIA V5 programming, and after that to do test we are utilizing underneath said software's.

Generation of the geometry and FEA work of the segment

Displaying consolidated three-dimensional geometry, strain and pressure stacking, symmetry conditions and different parts of planning. A 3-D demonstrate is outlined in CATIA V5 and after that imported in to Altair Hyper work, in the wake of finishing preprocessing we fathomed utilizing ANSYS.

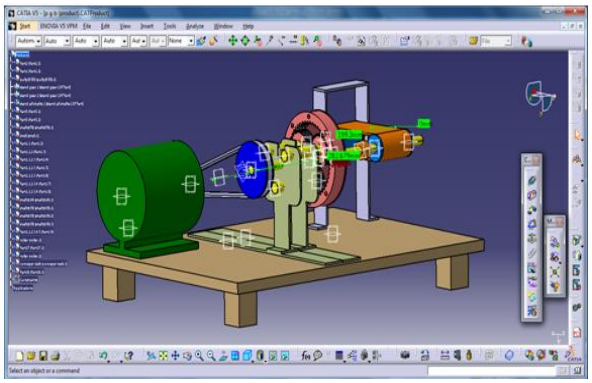


Fig: 5.2: Model plan in CATIA-V5

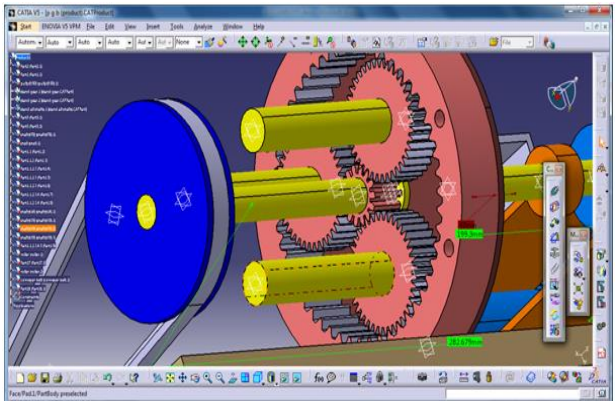


Fig: 5.3: Model game plan of riggings in CATIA-V5

Get together Modeling of Planetary Drive Speed Reducer

In this demonstrating every last segment get collected together with the methods for limitations, happenstance, contact, counterbalance, edge, settle part, adaptable, control, and so on.

Control: This charge is utilized to control/turn/pivot the segment in any requried heading according to the need/reasonable limitations are to be connected on the segment.

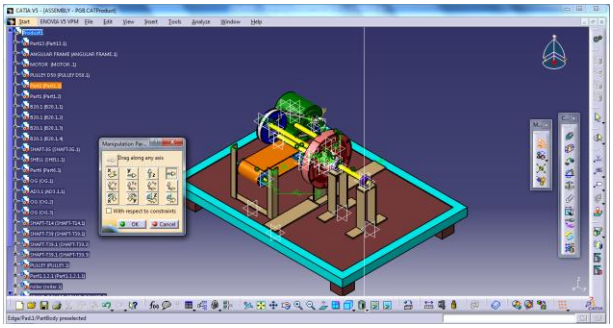


Fig: 5.27: Using Manipulate Command

Multi View: This is the order in which every one of the perspectives of the segment/model can be shown on the screen at a same time, they can be altered under the workbench.

Fig: 5.28: Using Multi View Command

CHAPTER 6
FINITE ELEMENT ANALYSIS

6.1 Procedure for FE Analysis Using ANSYS:

The investigation of the Gear Teeth, Pulleys, and shafts are finished utilizing ANSYS. For contend get together isn't required, engine and connected apparatus framework is to did by applying minutes at the turn area along which hub we have to specify. Settling area is base legs of apparatus gathering machine.

6.2 Preprocessor

In this stage the accompanying advances were executed:

- **Import record in ANSYS window**

Record Menu > Import> STEP > Click alright for the flew up exchange box > Click

Peruse" and pick the record spared from CATIAV5R20 > Click alright to import the document

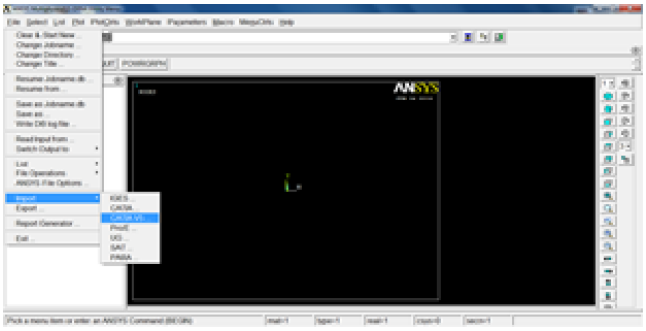


Fig.6.1: Import board in Ansys.

Material Properties of Mild Steel

Material	Density (kg/m^3)	Young's modulus (MPa)	Poisson's ratio
Mild steel	7860	2.1e5	0.27

Table: 6.1: Materials Basic Properties

Compound 1018 is the most regularly accessible of the cool moved steels. It is for the most part accessible in round pole, square bar, and square shape bar. It has a decent mix of the greater part of the average attributes of steel - quality, some flexibility, and relative simplicity of machining. Synthetically, it is fundamentally the same as A36 Hot Rolled steel, however the cool moving procedure makes a superior surface complete and better properties.

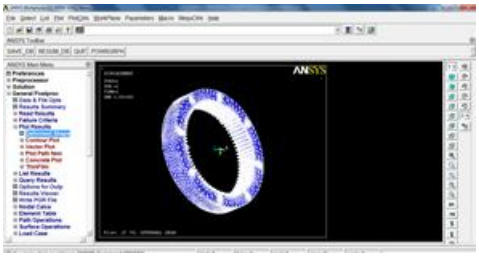


Fig.6.16: Deform

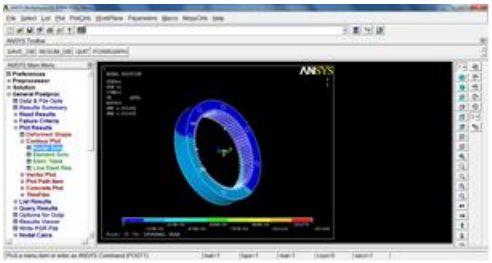


Fig.6.18: Displacement

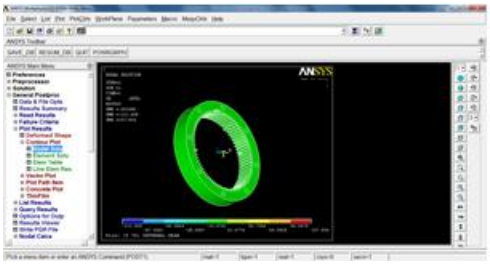


Fig.6.19: Stress

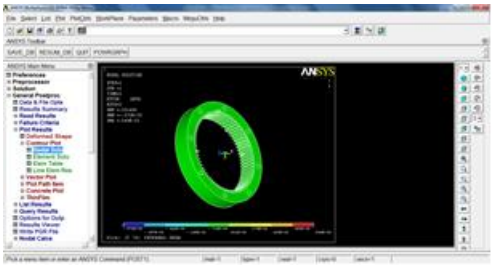


Fig.6.20: Strain

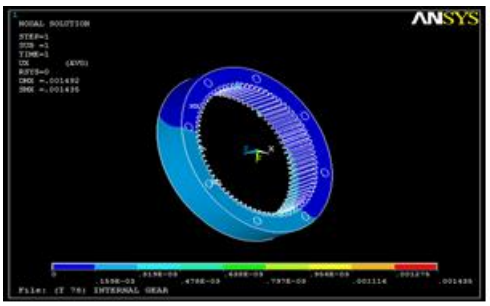
These parts are displayed with 1d components for shafts and appeared as above and gathered with adjoining segments. Hardly any segments are explained utilizing Force Analysis for checking the pressure and relocations while pivoting.

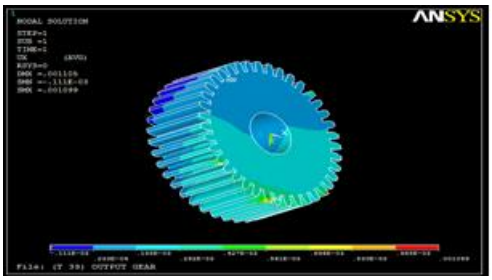
In the wake of finishing the cross section of every get together segments next is to do examination in view of the OEM (Original Equipment of Manufacturer) application. So every one of the models which are pivoted along which hub that we have to specify in the Analysis programming to get precise outcomes according to the first segment. A portion of the parts are should have been tackled utilizing static investigation.

Load is connected and settling at the base key area of Motor, Was approved in the second recreation. Approval The tooling comprised of curve kick the bucket, and weight bite the dust. The material and geometric properties are recorded. The tooling comprised of twist bite the dust, weight kick the bucket.

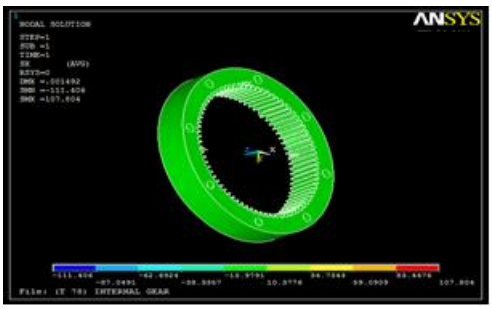
CHAPTER – VII
DISCUSSION ON ANALYSYS RESULT

7.1 Results of Displacement investigation:





7.2 Results of Stress investigation:



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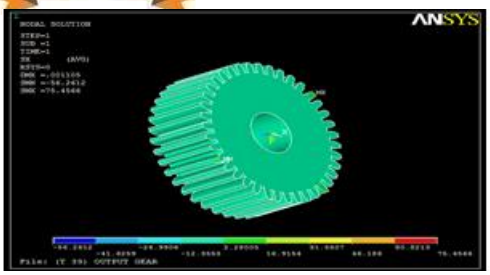
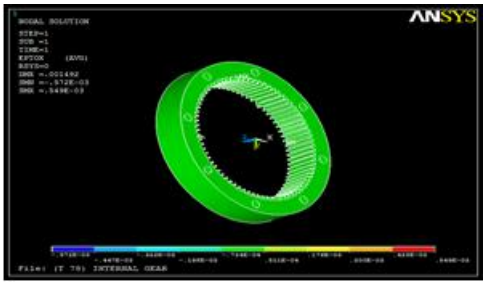
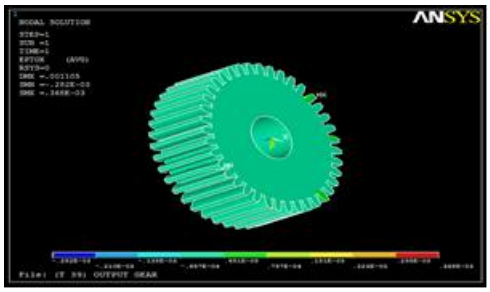


7.3 Results of Strain investigation:





CHAPTER 8
CONCLUSIONS

Stress and dislodging is appeared above according to the outcomes uprooting, push is least. Every one of the outcomes are in restrain, the fem investigation is required for demonstrating through examination comes about. As appeared above outcomes the pressure and removals are in constrain. Stress esteem is underneath the yield purpose of material, uprooting is beneath. so gathering examination is unraveled and it is passed.

Dislodging and worries for both the outlines are appeared in results and discourses. Show is having more quality while adapt enclose is movement, in light of the fact that on the off chance that we examine the redirection and stresses – strains of model.

This Planetary Drive Speed Reducer can be recommended in to the market for the effective lessening of speed in numerous applications.

Gravity Analysis and Force Analysis is done and tried for checking the increasing speeds in every one of the three bearings x, y and z.

The gravity examination comes about are taken in to thought and checked the dislodging, stresses. Which are less, the qualities in yield are underneath the yield point esteem and removal is in the breaking point.

Subsequently the Stress and Displacement examination gives us victories; as the qualities in the outcomes are underneath the yield point esteem and the uprooting is inside the cutoff; with the goal that the outline is in safe condition.

At last, I report that get together plan is fine and limited component demonstrate comes about indicated same outcomes. There is no disappointment in investigation.

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