DESIGN AND STRESS ANALYSIS OF GEARBOX

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Abstract: Gears are used for speed and torque variation. since gears are rotating parts gear teeth tends to wear and thus crack occurs, to overcome this crack and to obtain higher efficiency gearbox can be analyzed before production. Spur gears and the shafts are designed using SOLIDWORKS and then it is subjected to stress analysis in ANSYS. Stress concentration factor is compared under varied loads. The main objective for carrying out this analysis is to improve the life of the gear. After the analysis of gears from existing gearbox the reason for failure was found. The reason for failure of the gear was due to wear of gear teeth edges. This is caused due to high stress concentration along the gear teeth edges. To relieve these stress concentration gear material can be changed so that the resulting stress can be reduced according to the properties of the materials used. The resulting stress of all the materials are compared and the best material is chosen.

Index Terms **- Gears, Stress, ANSYS, Failure.**

I. INTRODUCTION

- Gears are one of the oldest of humanity's inventions. Nearly all the devices we think of as machines utilize gearing of one type or another.
- In the today's world of industrialization Gears are the major means for the mechanical power transmission system, and in most industrial rotating machinery. Because of the high degree of reliability and compactness gears dominates the field of mechanical power transmission. Gearbox is used to convert the input provided by a prime mover into an output.
- A gearbox is also a set of gears for transmitting power from one rotating shaft to another. They are used in a wide range of industrial, automotive and home machinery application. Gearheads are available in different sizes, capacities and speed ratios. Their main function is to convert the input provided by an electric motor into an output of lower RPM and higher torque.

1.1HELICAL GEARS:

Power transmission has always been of high importance. The efficiency of any machine depends on the amount of power loss in the process. One of the best methods of transmitting power between the shafts is gears. Gears are mostly used to transmit torque and angular velocity. There are also a wide variety of gear types to choose from.
Helical gears are currently being used increasingly as a power transmitting gear owing to their relatively smooth and silent operation, large load carrying capacity and higher operating speed. Designing highly loaded helical gears for power transmission systems that are good in strength and low level in noise necessitate suitable analysis methods that can easily be put into practice and also give useful information on contact and bending stresses.

II. PROBLEM DEFINITION:

2.1 Definition of the Problem

Leading manufacturers of gearbox, which are used in various utensil and sugar mill machinery, faced the following problems

- Interference
- Surface
- Fatigue Fracture

The gears fail when tooth stress exceeds the safe limit. Therefore, it is essential to determine the maximum capacity under a specified loading. Analysis of gears is carried to reduce stress that a gear tooth is subjected to, to figure out so that these can be prevented from failure.
When failure occurs, they are expensive not only in terms of the cost of replacement or repair but also the cost associated with the downtime of the system of which they are a part.

2.2 METHODOLOGY:

The modeling and stress analysis of the gearbox has been done in solid works and ANSYS respectively.

2.3 APPROACH FOR THE PROBLEM:

The following steps are used for solving of the problem,
Step I: Modeling of all the parts of the gearbox correctly.
Step II: Assembly of all the parts of the gearbox.
Step III: Drawings of all the parts and assembly.
Step IV: Stress analysis of all the gears mounted in the gearbox.
Step V: Design modifications to be made to reduce the stresses below the safe.

III. Stress Analysis of Gearbox:

3.1 Part modeling of the Gear Box:

All the components of the gearbox were done in the assembly mode of solid works. The placement (or assembly) constraints were used to rigidly bind the components of the gearbox to their respective positions in the assembly.

3.2: Design parameters:

3.2.1. Design calculations:

INPUT SHAFT

- Diameter- 54 mm
- Length 425 mm
- Gear 1,2,3,4 are assembled in this shaft at a distance

Assume,

- Input Shaft Power = 10KW
- Speed Of Input Shaft Np = 1250rpm
- Speed Of Input Shaft Ng = 500rpm

Gear Ratio I = Np/Ng
=1250/500
= 2.5

Teeth On Gear ,
Zp = 18
i = Zg/Zp
2.5 = Zg/18
Zg = 45

From the No of Teeth Select Pressure Angle,

Pressure angle = 20°
Module = 6

D1 = m x Zg /cosβ
= 6 x 45 /cos 20o
= 287.32 mm

D2 = m x Zp /cosβ
= 6 x 18 /cos 20o
= 114.93 mm

a = (D1+ D2) /2
= 201.125mm

b = φa
= 0.5 x 201.125
= 100.5625

DISTANCE OF GEAR REFERENCE FORM THE INPUT SHAFT	
Gear 1	25mm
Gear2	145mm
Gear3	215mm
Gear4	335mm

S.NO	DIAMETER	TEETH
Gear 1	260mm	45
Gear 2	220mm	38
Gear 3	179mm	31
Gear 4	156mm	27

COUNTERSHAFT:

- Diameter: 45mm
  - Extrude length:440mm
  - Gear 5,6,7,8 are assembled in this shaft

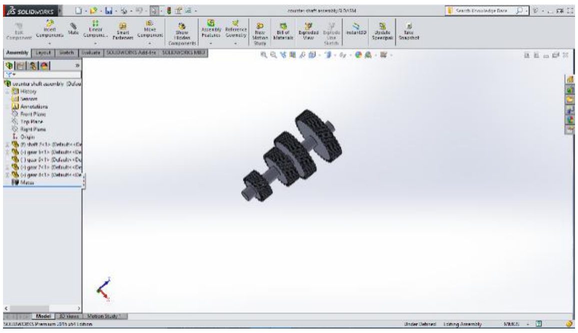
DISTANCE OF GEAR FROM REFERENCE FROM SHAFT	
Gear 5	40mm
Gear 6	160mm
Gear 7	230mm

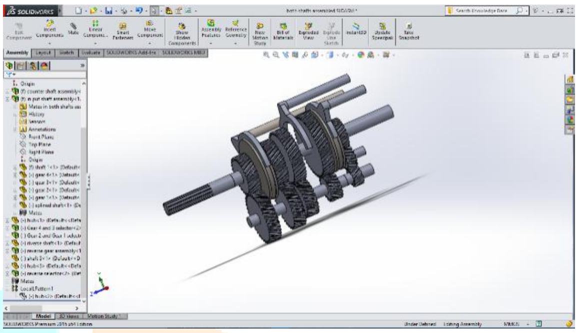
REVERSE GEAR:

Three gears such as

- Gear 11from input shaft
- Ideal gear10
- Gear 9in counter shaft are assembled by mating with their respective position in shaft. Ideal gear has a separate shaft.

The following figure shows the design of gearbox,





3.3 Introduction to Structural (Static) Analysis:

With the widespread adoption of CAE approach to design, finite element analysis became integrated with the design and analysis procedure. Structural (Static) analysis is used to analyze parts and assemblies to find,

- Maximum Stresses
- Deformed Shapes (Deformation)

3.4 Analysis in ansys workbench 16.1:

- **Geometry:**

The modelling done in solidworks is saved in stp format and is imported in ansys software.

- **Automatic Mesh Generation:**

Mesh generation is one of the most critical aspects of engineering simulation. ANSYS Meshing technology provides a means to balance these requirements and obtain the right mesh for each simulation in the most automated way possible

- **Boundary conditions:**

The boundary condition is very important in the finite element calculation. So, here we have considered frictionless support on the input gear to allow its tangential rotation. Moment has applied in the counter clockwise direction as a driving torque.

3.5 Material Properties

A material's properties an intensive often quantitative, property of some material. Quantitative properties may be used as a metric by which the benefits of one material versus another can be assessed, thereby aiding in material selection.

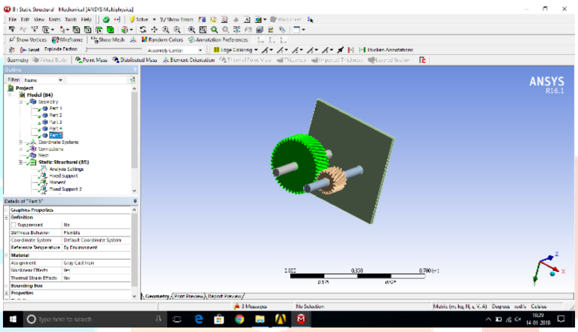
Structural Steel

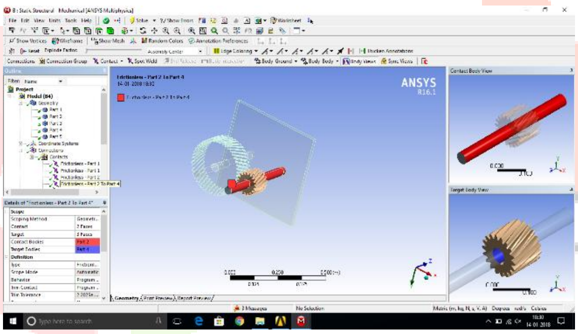
Density	7850 kg m^-3
Coefficient of Thermal Expansion	1.2e-005 C^-1
Specific Heat	434 J kg^-1 C^-1
Thermal Conductivity	60.5 W m^-1 C^-1
Resistivity	1.7e-007 ohm m

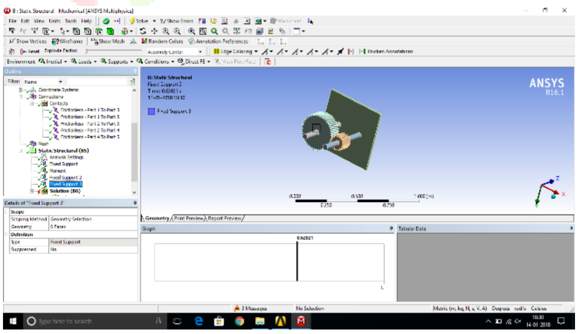
GREY CAST IRON

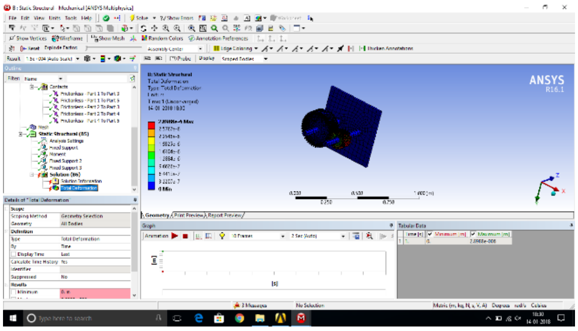
Property	Value in metric unit	
Density	7.06 $*10^3$-7.34 $*10^3$	kg/m³
Thermal expansion	$9.0*10^{-6}$	ºC⁻¹
Specific heat capacity	490	J/(kg*K)
Thermal conductivity	53.3	W/(m*K)
resistivity	$1.1*10^{-7}$	Ohm*m

Following fig shows stress analysis of gears from gearbox:









4. Results and discussion:

4.1 Comparison of Stresses:

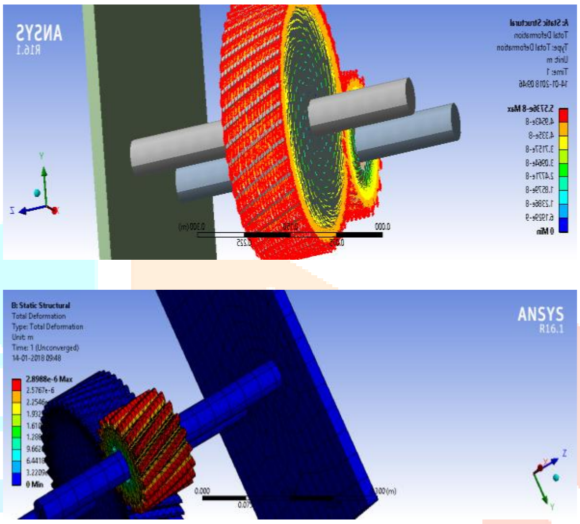


Fig 4.1: Comparison of total deformation

Materials	Stress Probe (NormX) [Pa]
Structural steel	52421
Grey cast iron	50500

Table 4.1: Comparison of stresses

5. CONCLUSION:

- In our project we have designed a gear box for different materials structural steel and grey Cast Iron. Structural analysis is done on the gear box to verify the best material by taking in to account stresses, displacements, weight etc.
- By observing the structural analysis results using Grey cast iron the stress values are within the permissible stress value. So using grey cast iron is safe for gearbox. When comparing the stress values of the materials for all speeds, the values are less for grey Cast Iron than structural steel. Thereby mechanical efficiency will be increased.
- By observing analysis results, grey cast iron is best material for gear box.

6.SCOPE OF FURTHER WORK

- For analyzing stresses induced in the gear teeth using finite element analysis only condition of static loading was applied. But actually the gears are subjected to dynamic loading condition, so there is an ample scope of further work if dynamic loading can also be applied for the analysis.
- As the hole at the root of the gear tooth acts as a stress reliever/reducer, hence its location and size can be optimized further. The number of holes to be made at the root of the gear tooth can also be optimized later on.
- Some other design modifications can be incorporated to minimize the induced stresses on the gear tooth.

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