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Stress Analysis for Different Material on Double Helical Gear

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***Abstract*:- The work is intended to focus upon the stress analysis of double helical gears for different material. Gears being one of the prime components involved in the power transmission process are subjected to failure because of the bending and surface stresses incurred at their teeth which causes a surface fatigue failure known as pitting. The specific category of gear systems selected for the work is the double helical gears, wherein the FEA analysis has been carried out to determine the stresses so induced at the time of meshing of gears with involute profile in the commonly used materials for gear which are EN24, Aluminium bronze and chromium stainless steel. 3D modeling and analysis have been performed to determine the contact stresses on finite element software packages (Ansys). The results have been then compared for different materials.**

Keywords: Double helical gears, EN24, Aluminum bronze, chromium stainless steel, stress

INTRODUCTION

Gears mesh with one another and transmit torque and power, in other words, meshing of the gear teeth permit motion transmission or alter the change in speed or direction. Gear drives are more prominent in various industries like automobile, marine and aviation more than belt or chain drives because of their wider range of operating torque, better load holding capacities and longer design lives. To achieve better overall efficiency out of the gear drive, the transmission system needs to be more effective which is achieved by using reliable and light weight gears.

Gear failure occurs primarily due to bending and pitting of gear teeth. Bending failure occurs when the bending loads are large, and is determined via comparison of theoretically and experimentally obtained fatigue values within working limits. When the surface of gear is subjected to repeated contact stresses of high magnitudes while transmitting power, pitting of gear tooth takes place. In machine design, failures are observed when two members having curved surfaces deform on pressing against one another thus exposing the patch area to the compressive stresses.

However, on considering the downsides of employing single helical gears, it is observed that these gears tend to exert undesired axial forces on the shaft to which they are attached. These axial forces produce unwanted thrust on the end bearings. In order to eliminate these axial forces, there is a requirement of another equal and opposite force in the axial direction to nullify the undesired forces. This is achieved by having another single helical gear whose helix is the mirror image profile of the former gear. Such unison of two single helical gears of same module, pitch circle diameter, number of teeth but opposite hand of helix forms a double helical gear. The axial forces exerted by the two helices of the double helical gear are balanced, thus nullifying the overall axial thrust. This results in higher capacities of power transmission. The drawbacks are the sophisticated manufacturing processes involved and the time consumed by the process. Also, double helical gears are slightly heavier than single helical gears.

Helical gears are normally preferred to work under heavy load efficiency. When silent operation or functioning such as in automobile applications, helical gears are preferred as such gears work silently and smoothly. Areas of applications of helical gears are very large but below are the few applications where helical gears are preferred to use-

1. Helical gears are used in fertilizer industries, Printing industries and earth moving industries
2. Helical gears are also used in steel, Rolling mills, section rolling mills, power and port industries.
3. Helical gears are also used in textile industries, plastic industries, food industries, conveyors, elevators, blowers, compressors, oil industries & cutters.

The properties of the different materials which are commonly used in the manufacturing of gears which are chromium stainless steel, aluminium bronze, EN 24 are compared in the following table.

Table 1: Material Properties

	EN 24	Chromium Stainless steel	Aluminium Bronze
Elastic Modulus(N/m^2)	2.05e+11	2e+11	1.1e+11
Poisson's Ratio	0.285	0.28	0.3
Shear Modulus(N/m^2)	8e+10	7.7e+10	4.3e+10
Mass Density(kg/m^3)	7850	7800	7400
Yield Strength(N/m^2)	470000000	172339000	275742000

The 3D model of the gear has been analyzed for the stresses involved while loading the double helical gears, and its variations with respect to the design parameters of the gear including helix angle, face width, etc.

Deva Ganesh et al. (2015)studied that the meshing between two gears contact stresses are evolved, which are determined by using analyzing software called ANSYS. Finding stresses has become most popular in research on gears to minimize the vibrations, bending stresses and also reducing the mass percentage in gears. These stresses are used to find the optimum design in the gears which reduces the chances of failure. The model is generated by using Catia and ANSYS is used for numerical analysis. The analytical study is based on Hertz,s equation. Study is conducted by varying the geometrical profile of the teeth and to find the change in contact stresses between gears. It is therefore observed that more contact stresses are obtained in modified gears. Both the results calculated using ANSYS and compared according to the given moment of inertia.

Sarfraz Ali N. Quadri and Dhananjay R. Dolas (2015) experimented with an attempt to summarize about stresses developed in a mating spur gear which has involute teeth. A pair of spur gears are taken from a lathe gear box and progressed onward to calculate stresses. Conventionally the analysis is carried out analytically using Lewis formulae and then Finite Element Analysis is used for the same. Some stress relieving features have been incorporated in the teeth to know their effect on the stress concentrations. A finite element model of teeth is considered for analysis and geometrical features of various sizes are introduced at various locations and their effect is analyzed**.**

EXPERIMENTAL SETUP

Table 2: Dimensions for helical gear

Constraint	**Value**
Number of teeth on small gear	17
Number of teeth on large gear	52
Pitch Diameter of small gear(mm)	234
Pitch Diameter of large gear(mm)	675
Module	12
Pressure Angle (deg.)	20
Helix Angle (deg.)	150
Face Width (mm)	100
Width of gear (mm)	229
Shaft bore diameter(mm)	75
Torque transmitted(N-m)	156000
Number of Nodes (mesh)	111706
Number of elements(mesh)	65466

The following steps were gone through while modeling and analysis of the gear-
Step 1: Model the gears as per the dimensions and making assembly of two gears to make one reduction stage using SolidWorks.
Step 2: The 3D model was imported in Ansys Workbench.
Step 3: Material Property was defined in Engineering Data in Ansys Workbench.
Step 4: Frictional contact was specified between the faces of the gears mating each other and the shaft bore.
Step 5: The shaft bore of small gear was fixed and moment was applied at shaft bore of large gear. A moment of 156,000 N-m was applied at shaft bore.
Step 6: Analysis solution was performed and stress values were checked for the gears. Von Misses stress and total deformation was used to compare the results.
Step 7: The gear geometry was modified in Solid Works and all the steps from Step 1 to Step 6 were performed again for different material and were then compared.

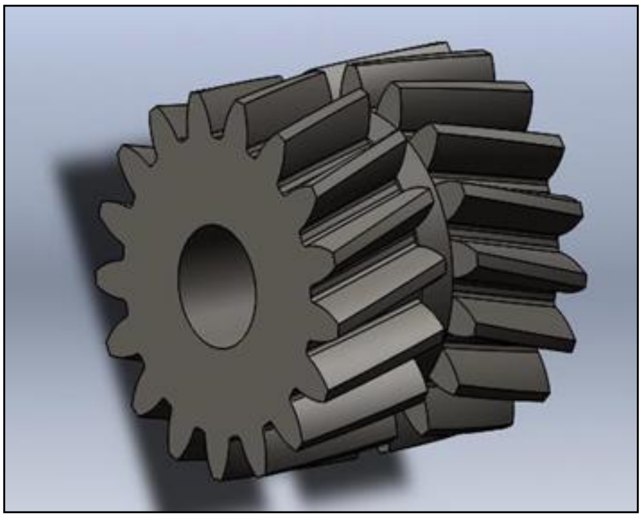

Fig 1: Small Gear

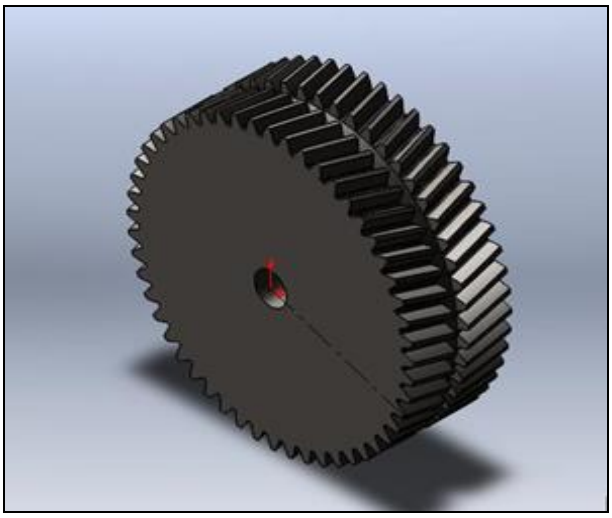

Fig2: Large Gear

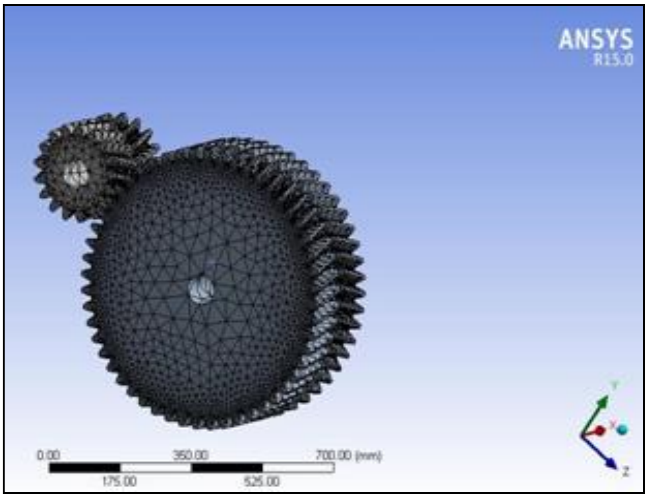

Fig 3: Gears after meshing

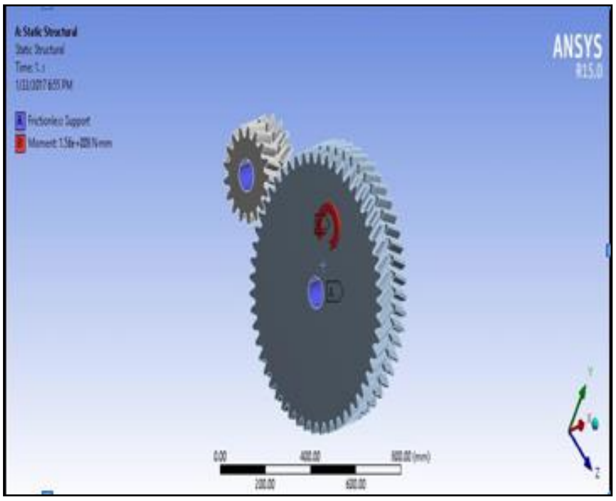

Fig 4: Applying Boundary conditions

RESULTS

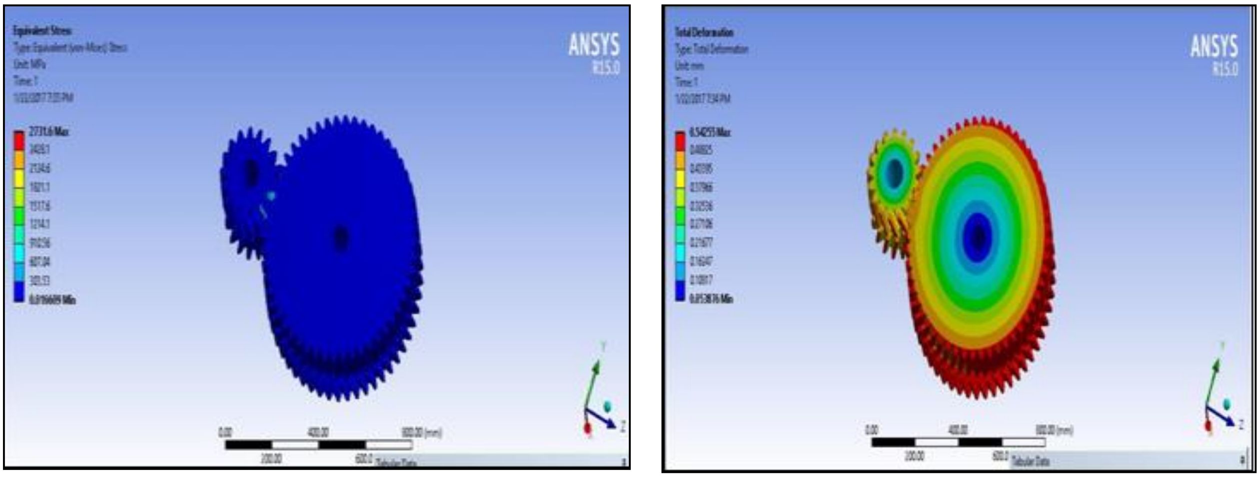

Fig 5: Von-mises stress distribution and deformation for ***chromium stainless steel***

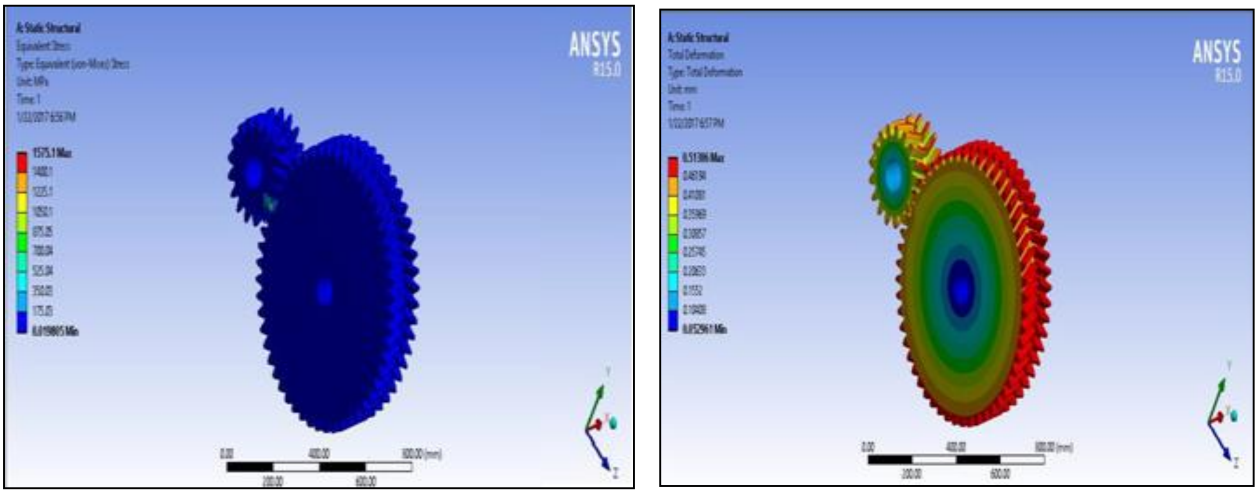

Fig 6: Von-mises stress distribution and deformation for EN24

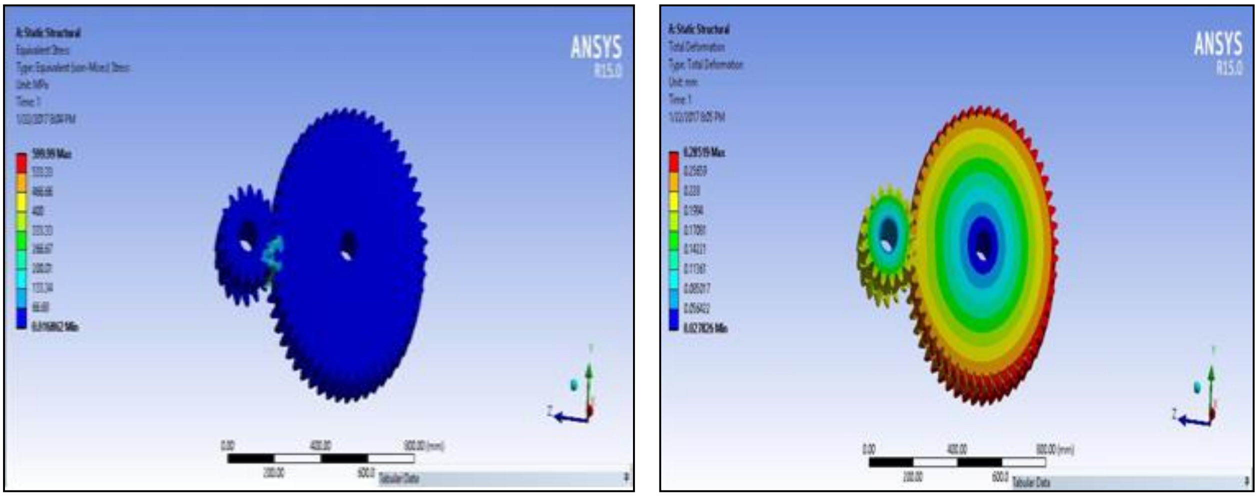

Fig 7: Von-mises stress distribution and deformation ***for Aluminium Bronze***

Table 3: Simulation Results

	EN24	**Aluminium Bronze**	**Chromium Stainless steel**
Max. Von-Mises Stress (MPa)	1575.1	599.99	2731.6
Max. Total Deformation (mm)	0.510	0.28	0.54

CONCLUSION

Gear designing involves study of bending stresses. However, study of helical gears and particularly double helical gears involve contact stress analysis. The study essentially attempts to compare these stress values on the double helical gears under defined constraints with the help of 3D modeling and simulation tools. Within necessary considerations, finite element model was created and analyzed by meshing of the gears. Number of elements was finalized when noticeable changes in values of stress and deflection were seen for each of the selected gear materials. The variations in the induced stresses, along with the occurring deformation were examined by changing the applied material for constant double helical gear geometry and then carrying out the FE analysis. These simulation results were then compared with one another for their induced stresses and deformations.

Additionally, it is also observed that both helix angle and face width are a critical factor while computing the induced stresses. An increase of helix angle and a decrease of face width imply an increase in the induced bending and contact stresses. Increase in helix angle causes the contact length to increase while an increase in face width causes a decrease in root area which bears the stress. Hence, both these geometric parameters are crucial in gear designing.

Thus, if selection of high strength material for a gear of required helix angle is chosen as the design criterion, a higher value of face width shall be preferable in the gear geometry.

Maximum stress is observed for chromium stainless steel and the minimum for aluminum bronze but since the cost of chromium stainless steel is very high and aluminum wears out easily and in shorter duration compared to other materials, the commonly used material for gear is EN24.

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