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Finding the Stresses and Deflection of a Snag Crane Sun Spur Gear Using Fea Package

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ABSTRACT

Gears are machine elements that transmit motion by means of successively engaging teeth. The stresses are developed when two gears are mated. Two spur gear teeth in action are generally subjected to two types of stresses. One is bending stresses which are developed by fatigue bending another one is contact stress causing contact fatigue. These two types of stresses may not get their maximum values at the same point of contact fatigue. These types of failures can be minimized by careful analysis of the problem during the design stage and creating proper tooth surface profile with proper manufacturing methods.

This project investigates the various stresses and deflection developed in sun gear tooth of sun gearbox which is used in Snag Crane. In this study, perform the calculation for sun gear tooth to calculate bending, shear, wear & deflection using theoretical method.The model was created using modeling software and the analysis is done using ansys. Here the analysis is performed on the root fillet of the spur gear tooth. The analysis is done two conditions as circular root fillet and actual root fillet of a gear tooth. The results of the analyses from ANSYS are compared with the theoretical values. Comparison of ANSYS results in circular root fillet & actual root fillet also carry out. In addition to the project we are changing the material of the sun gear and comparing the results. In the addition of this project we are finding the contact stresses of the mating gears. The theoretical values which are formed from the Hertz equation are compared with the Fea values which are generate from ansys. For the analysis, steel and grey cast iron are used as the materials of spur gear. The results show that the difference between maximum contact stresses obtained from Hertz equation and Finite Element Analysis is very less and it is acceptable. The deformation patterns of steel and grey cast iron gears depict that the difference in their deformation is negligible.

Keywords: Ansys, Planetary gear, Pro-e, Sun gear, Snag Crane.

1. INTRODUCTION

The main purpose of gear mechanisms is to transmit rotation and torque between axes. The gear wheel is a machine element that has intrigued many engineers because of numerous technological problems arises in a complete mesh cycle. In order to achieve the need for high load carrying capacity with reduced weight of gear drives but with increased strength in gear transmission, design, gear tooth stress analysis, tooth modifications and optimum design of gear drives are becoming major research area. Gears with involute teeth have widely been used in industry because of the low cost of manufacturing. Transmission error occurs when a traditional non-modified gear drive is operated under assembly errors. Transmission error is the rotation delay between driving and driven gear caused by the disturbances of inevitable random noise factors such as elastic deformation, manufacturing error, alignment error in assembly. It leads to very serious tooth impact at the tooth replacing point, which causes a high level of gear vibration and noise. At the same time, edge contact often happens, which induces a significant concentration of stress at the tooth edge and reduces the life time of a gear drive.

Many researchers have proposed modified shapes for traditional gears to localize the bearing contact thereby avoiding edge contact. In the present work, involute spur gear teeth for the selected module, gear ratio, centre distance and number of teeth is taken for analysis. Two more sets of differently crowned involute spur gear teeth are also considered for stress and tooth contact analysis. The procedure followed to create the 3D models of teeth in mesh is described. Proportions of contact ellipses are determined. Their performance behavior is studied by assuming loading at pitch point under static load and frictionless hypothesis. In order to handle critical profile variations, the analyses are done in three dimensions with face contact model. surface Contact Stress (SCS), Root Bending Stress (RBS), and Tooth Deflection (TD) calculations of the pair of spur gears with and without lead crowning are carried out through FEM.

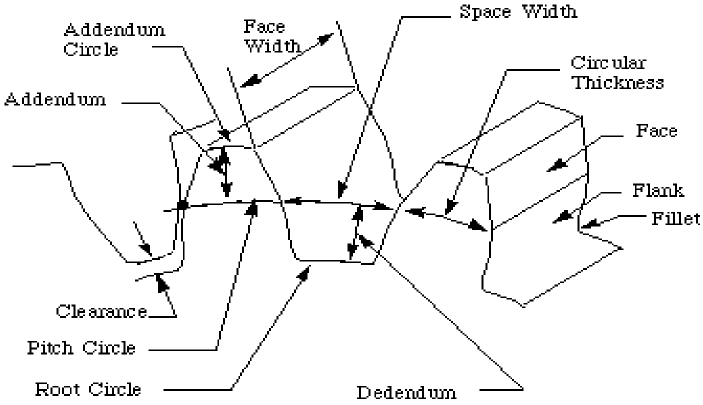


Fig 1. Spur Gear nomenclature

II. MODELING BY USING PRO-E

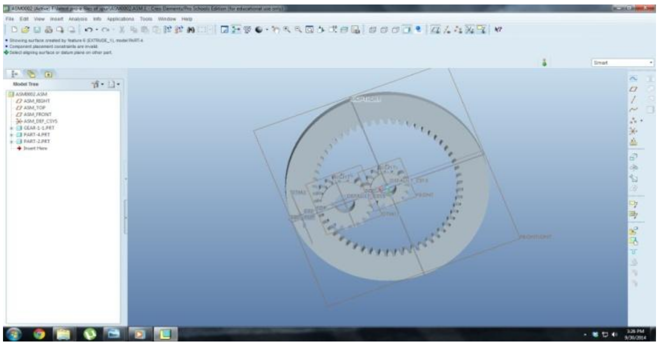
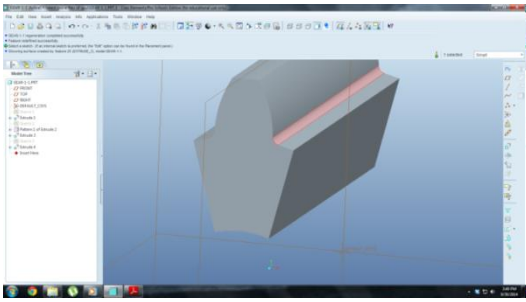


Fig 2. Assembly model in pro-e



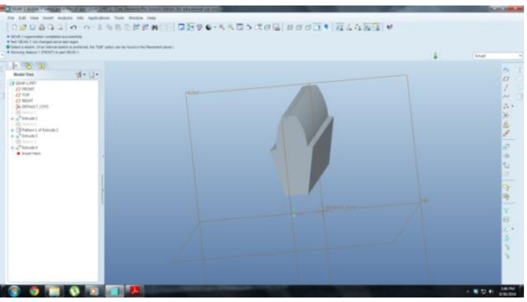


Fig 3. Circular fillet tooth profile **Fig 4. Actual fillet tooth profile**

III. RESULTS & DISCUSSION

3.1. Shear stress

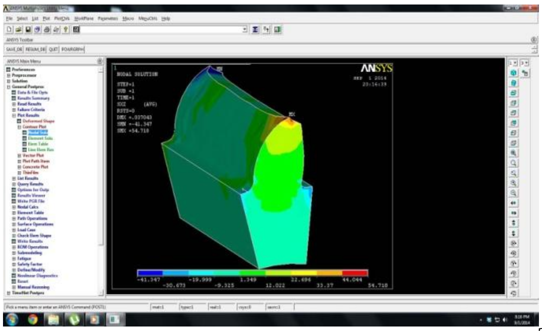


Fig 5. Circular fillet result σ_s =54.71 N/MM^2

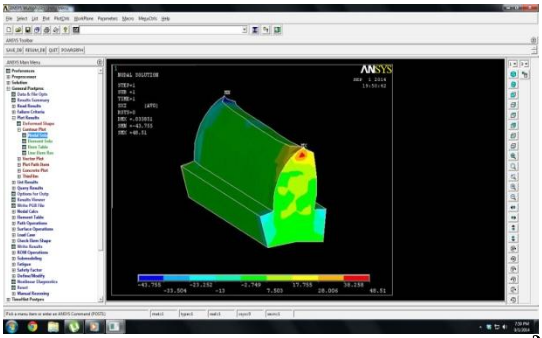


Fig6.Actual fillet result σ_s =48.51 N/MM^2

1.2. Bending Stress

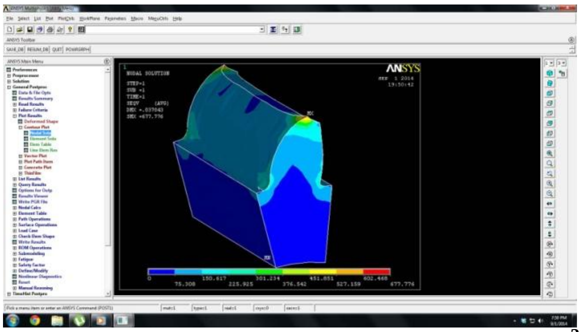


Fig 7.Circular fillet result σ_b =677.776 N/MM^2

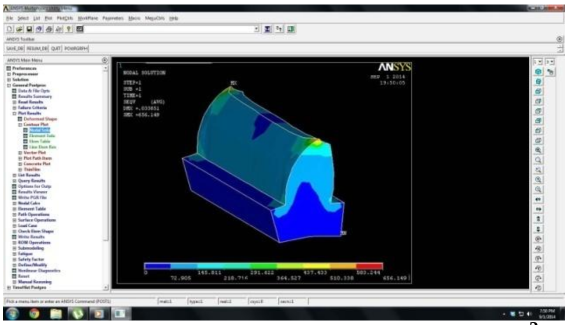


Fig 8.Actual fillet result σ_b =6561.49N/MM^2

1.3. Deflection

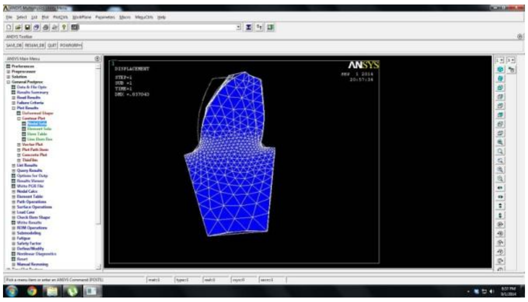


Fig 9.Circular fillet deflection = 0.037043 mm

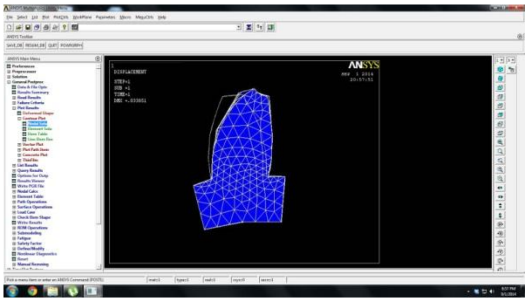


Fig 10. Actual fillet deflection = 0.033851 mm

3.4. Wear stress

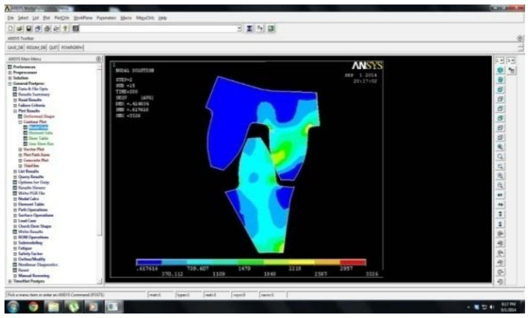


Fig 11.circular fillet result σ_c = 1848 N/MM^2

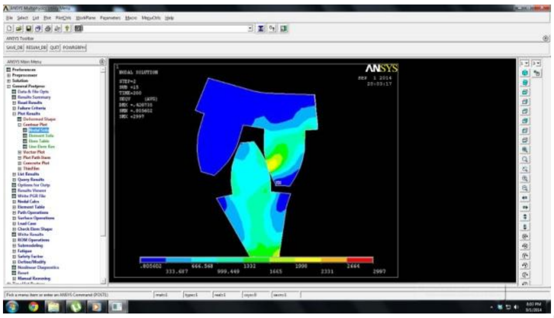


Fig 12. actual fillet result σ_c = 1998 N/MM^2

3.5. Calculation of Contact Stresses by Ansys

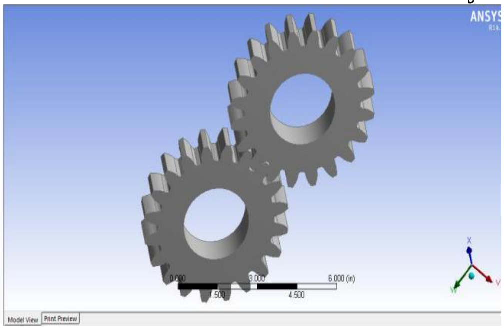


Fig 13. Assembly of Spur Gears

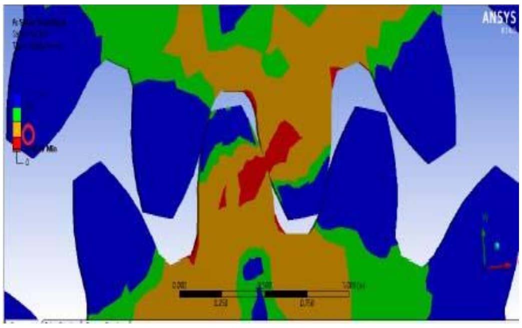


Fig 14. Safety Factor for Grey Cast Iron

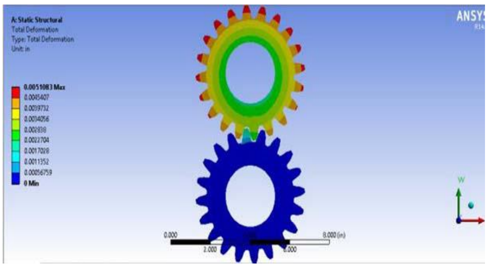


Fig 15. Deformation pattern for Steel gear

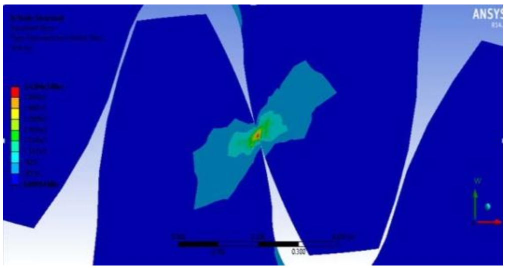


Fig 16. Stress distribution Grey Cast Iron gear

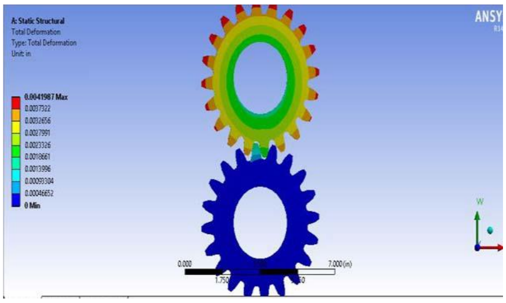


Fig 17.Deformation pattern for Grey Cast Iron gear

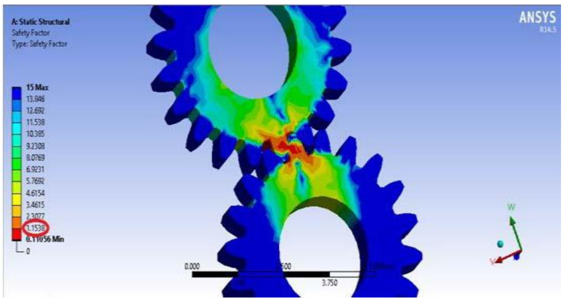


Fig 18. Safety Factor for Steel Gear

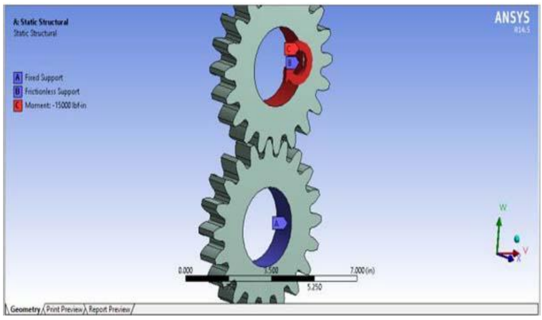


Fig 19.Boundary Condition

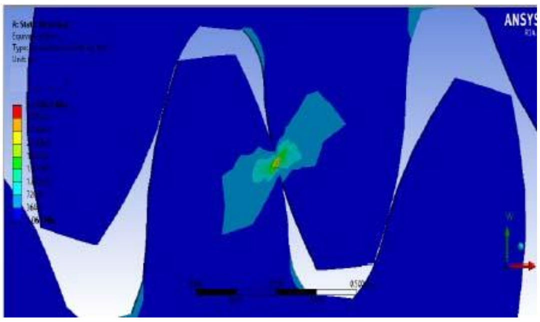


Fig 20.Stress distribution in Steel gear

ANALYSIS	THEORETICAL VALUES	FOR ACTUAL FILLET RADIUS	FOR CIRCULAR FILLET RADIUS
Bending stress(N/mm^2)	532.94	656.149	677.776
Shear stress(N/mm^2)	33.24	48.51	54.71
Wear stress (N/mm^2)	2509.1546	1998	1848
Deflection(mm)	0.0368090	0.033851	0.037043

Table no 1: bending, shear &wear stresses & deflection result

Gear	(Hertz) (MPa)	(ANSYS) (MPa)	Difference (%)
Steel	2254.9821	2261.2052	0.28
Grey CI	2334.6414	2365.1782	1.29

Table no 2: Comparison of maximum contact stress obtained from Hertz equation and ANSYS

IV. CONCLUSION

The analysis process on the sun gear there are three types of stresses are found bending stress, shear stress and wear stress. And also deflection values are found. ANSYS results for various stresses and deflections are nearer to theoretical values for sun gear of planetary gear system of snag crane. The values of bending & shear stress value for actual root fillet design in comparison to that of stresses values in circular root fillet design are reduced. Also there is increase in wear stress value for actual root fillet design in comparison to that of stresses values in circular root fillet design. And also it is observed that the deflection in actual root fillet is also less comparing to the circular root fillet gear tooth.

Therefore from the analysis it is also found that the circular fillet design is more optimum for lesser number of teeth in pinion & actual fillet design is more suitable for higher number of teeth in gear and whatever may be the pinion speed. In addition to that the ANSYS results indicates that the gears with actual root fillet design will result in better strength, reduced bending stress & also improve the fatigue life of gear material. Finally we conclude that circular fillet design is more optimum compared to actual fillet design.

The theoretical maximum contact stress is calculated by Hertz equation. Also the finite element analysis of spur gear is done to determine the maximum contact stress by ANSYS. It was found that the results from both Hertz equation and Finite Element Analysis are comparable. From the deformation pattern of steel and grey cast iron, it could be concluded that difference between the maximum values of steel and grey CI gear deformation is very less.

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