



Review on Stress and Torque Analysis of A Gear-Rack Mechanism Using ANSYS

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Abstract: This study presents a comprehensive static structural analysis of a gear and rack mechanism using ANSYS, focusing on evaluating stress and torque responses under applied loading conditions. The primary objective is to assess the total deformation, stress distribution, and critical load concentrations within the gear and rack assembly using Finite Element Analysis (FEA). The gear is subjected to a specified torque while the rack is fixed, simulating realistic operational constraints. Results indicate that maximum deformation occurs at the gear tooth tip, while the rack remains largely stable, validating the boundary conditions and meshing quality. The observed stress and deformation patterns align with theoretical expectations, confirming the reliability of the simulation approach. This analysis not only aids in understanding the mechanical behavior of gear-rack systems under load but also highlights the significance of FEA tools like ANSYS in optimizing mechanical design for safety and performance in engineering applications.

Keywords: Gear-rack mechanism, static structural analysis, ANSYS, finite element analysis, stress distribution

I. INTRODUCTION

Gear and rack mechanisms consist of a gear (circular part) and a rack (linear part) that mesh together to transfer motion. The interaction between the teeth of the gear and the teeth of the rack ensures precise movement and control. This mechanism is widely used in devices such as steering systems, conveyor belts, and robotic arms. There are various types of gears, including spur gears, helical gears, bevel gears, worm gears, and planetary gears. Each type has its unique characteristics and applications. Spur gears are commonly used for their simplicity and efficiency in transmitting motion between parallel shafts. Helical gears are preferred for their smooth operation and higher load capacity due to the angled teeth. Bevel gears are utilized for changing the direction of motion between intersecting shafts, while worm gears provide high reduction ratios in compact spaces. Planetary gears are known for their versatility and ability to distribute load evenly. Similarly, racks can be classified into straight racks and helical racks. Straight racks have teeth that are perpendicular to the direction of motion, providing straightforward linear movement. Helical racks, on the other hand, have angled teeth that allow for smoother engagement with the gear, reducing noise and vibration. The history of gear and rack mechanisms dates back to ancient civilizations, where they were used in basic machines for lifting and moving objects. Over time, advancements in materials and manufacturing techniques have significantly improved their efficiency and durability.

II. LITERATURE REVIEW

Neha Pawar, Shweta Khankal, Suraj Lakde, Rushikesh Jadhav; In this paper their aim in this project is to design Gear train for HG 13 gearbox which should not be fail at high speed and high load. For fishing, boats need to stay longer time in the sea so our aim is to operate marine engine efficiently and smooth for different condition, and increases its working life. The required research work has been completed and the validation of project has been proved as well as design is safe is also proved. Hence it can be said that the aim of the project "Design of Gear Train of HG 13 Gearbox used in marine. Rushikesh A Padwe, Prof. A. C. Gawande, Prof. Pallavi S. Sarode(2016)., have discussed about the face gear used in spinning machine to lift the spinning mechanism. The face gear are attach with the heart cam for spinning the yarn about spindle. During the working, the tangential force is acting on face gear, which may cause to break the teeth. The tangential load which is acting on the gear is from pinion. The face gear are working similar to the bevel gear and transmitting the power. The intersection axis of both the pinion and gear at right angle to each other. The failure of the gear is due to low strength of the gear material. Analysis is done in Ansys software by developing the model of the gear and applying loads. At last they have concluded that, the failure of face gear is due to the tooth load .The another load i.e. axial load and radial load is less as compare to tooth load. Due to this tooth load, the stress develop in tooth is more

than the basic stress of gear, that why gear fail. Due to gear fail, the machine is in break down stage, so the production is hampering. To avoid breakdown it is very important to chance the material of gear. Here in this project an analytical calculation and analysis in ANSYS of face gear is done. This show that by changing the material with new material is good for desirable application in spinning machine.

Rufus Ogbuka Chime, Samuel I(2016).,in this paper they have concluded thatCAD combines the characteristic of designer and computer that are best applicable made CAD such as popular design tool. CAD Has allowed the designer to bypass much of the Manuel drafting and analysis. Simulation tools enable us to be creative and to quickly test new ideas that would be much more difficult, time consuming and expensive to test in the lab. (Jeffrey D. Wilson, NASA Glenn Research Centre) It also helps us reduce cost and time-to-market by testing our designs on the computer rather than in the field. Many of the individual tasks within the overall design process can be performed using a computer. As each of these tasks is made more efficient, the efficiency of the overall process increases as well. The computer is well suited to design in four areas, which correspond to the latter four stages of the general design process; Computers function in the design process through geometric modelling capabilities, engineering analysis calculations, testing procedures, and automated drafting, From the result of the testing and the affordability in terms of cost, it can be concluded that the project is successful. Therefore software design should be encouraged in our institution of higher learning base on the following facts, long product development, countless trial and error, and accountability and limited profitability. Dharshini R., Dr. M. Vasundara (2018), in this paper they have considered the bending and contact stresses are considered as the cause of failure on spur gear. The detailed study on modes of failure is made. The load factor is calculated with various angular arrangements. The analysis is carried out with and without considering the external factors. The mathematical model is analysed with Finite Element Analysis (FEA) and compared with the analytical procedure and the percentage error is calculated.at last they concluded the causes for the respective stress and there effect due external factors. Ms. Nileshta U. Patil, Mr. Sunil P. Chaphalkar, Mr. Gajanan L. Chaudhari (2017), The main objective of the present work is to investigate Finite Element Analysis of the spur gear pair for different material in ANSYS software. In this paper A review has been taken for case-I purpose is to design the spur gear and study the weight reduction and stress distribution for cast steel and composite materials and results are observed. And in case-II Static analysis is performed to determine the deformation and Vonmises stresses. Analysis is done by considering different materials for gears like Structural Steel, Grey Cast Iron, Aluminium Alloy and Epoxy E Glass UD, and results are compared. Ahmed Saeed Mohamed , Sadok Sassi , and Mohammad Roshun Paurobally (2018), In this study, a numerical model was developed to analyze the dynamic behaviour of a one-stage gearbox with external spur gears with an involute tooth profile. A set of MATLAB codes were used to generate the gear tooth profiles, perform the contact analysis, and evaluate the contact ratio. The variable gear mesh stiffness with respect to the angular position was obtained by using the FEM. The total mesh stiffness was then used in a simplified six-DOF nonlinear lumped parameter model to simulate the vibration response of the gears. First, various time domain statistical parameters were extracted from the original, and the residual vibration signals, where the gear was kept healthy, and a single crack was supposed to appear on the pinion. The results of this model were verified in three stages. First, the contact ratios obtained from the Shock and Vibration.

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