Topology Optimization of Spiral Bevel Gear-A Review

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***Abstract*—**Gears are an integral and necessary component in our day to day lives. Gears have been around for hundreds of years and their shapes, sizes, and uses are limitless. For the vast majority of our history gears have been understood only functionally. That is to say, the way they transmit power and the size they need to be to transmit that power have been well known for many years. It was not until recently that humans began to use mathematics and engineering to more accurately and safely design these gears.Bevel gears are widely used because of their suitability towards transferring power between nonparallel shafts at almost any angle or speed. The American Gear Manufacturing Association (AGMA) has developed standards for the design, analysis, and manufacture of bevel gears. The bending stress equation for bevel gear teeth is obtained from the Lewis bending stress equation for a beam and bending stress value derive for the spiral bevel gear. For above mentioned gear comparison between analytical value and value obtain by the ANSYS Workbench

***Index Terms*—Component, bending, Gear, AGMA, ANSYS**

I. INTRODUCTION

Indian history as per our mythological stories is more than 12,000 years old. Since then people living here have been striving to improve the living conditions. We also know that earlier people were living in the caves and the doors of the caves were made of granite. How were these heavy doors opened and closed? They were opened and closed by none other than a system with gear mechanism, wheel, lever and rope drives. However, the documented evidence has been lost due to destruction by the invaders and improper storing of palm leaf literature. The guru Kula method of teaching and passing of the information from mouth to ear procedure and keeping some of the advances as closely guarded secret have resulted in poor dissemination of the knowledge and documentation. But, the knowledge of gears has gone from India to east through some of the globe trotters from China as back as 2600 years BC. They have used the gears then ingeniously in chariots for measuring the speed and other mechanisms. Primitive gears shown in Fig. Were first used in door drive mechanism in temples and caves, and water lifting mechanisms 2600 B.C. in India and elsewhere.

Aristotle in the fourth century B.C. mentions in his writings that gears were being used very commonly in many applications. Classical origin of worm gearing was made by Archimedes 287-212 B.C. Vitruvius a military engineer in his writing in 28 B.C. has described a number of gear applications.

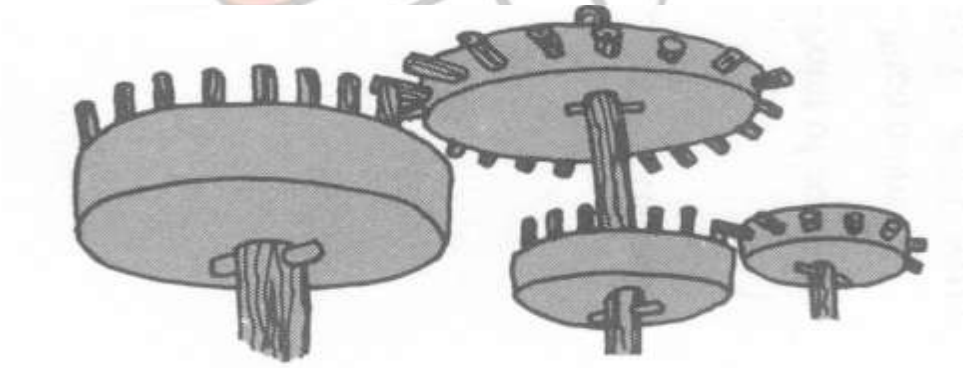

Figure 1.1 Primitive gears made of wood

II. DEFINITION OF GEARS

Gears are toothed members which transmit power / motion between two shafts by meshing without any slip. Hence, gear drives are also called positive drives. In any pair of gears, the smaller one is called pinion and the larger one is called gear immaterial of which is driving the other.

When pinion is the driver, it results in step down drive in which the output speed decreases and the torque increases. On the other hand, when the gear is the driver, it results in step up drive in which the output speed increases and the torque decreases.

III. LITERATURE REVIEW

TITLE:-BENDING STRESS ANALYSIS OF BEVEL GEARS

Author:-Ratnadeepsinh M. Jadeja, Dipeshkumar M. Chauhan, Jignesh D. Lakhani

Summury:-They are worked on Bending Stress Analysis of Bevel Gears. Gears are an integral and necessary component in our day to day lives. They are present in the satellites we communicate with, automobiles and bicycles we travel with. Gears have been around for hundreds of years and their shapes, sizes, and uses are limitless. For the vast majority of our history gears have been understood only functionally. That is to say, the way they transmit power and the size they need to be to transmit that power have been well known for many years. It was not until recently that humans began to use mathematics and engineering to more accurately and safely design these gears. Bevel gears are widely used because of their suitability towards transferring power between nonparallel shafts at almost any angle or speed. The American Gear Manufacturing Association (AGMA) has developed standards for the design, analysis, and manufacture of bevel gears. The bending stress equation for bevel gear teeth is obtained from the Lewis bending stress equation for a beam and bending stress value derive for the spiral bevel gear, straight teeth bevel gear and zerol bevel gear. For above mentioned gear comparison between analytical value and value obtain by the ANSYS Workbench 14.0

Title:- Analysis of bending strength of bevel gear by FEM

Author:-Abhijeet .V. Patil, V. R. Gambhire, P. J. Patil

Summury:-Studied on Analysis of bending strength of bevel gear by FEM In bevel gear will have a tangential load, radial load and axial load due to the speed and torque .This will be a transient phenomenon and will need careful stress analysis for determining life of the gear. In gear design, the Mechanism will be more Challenging as it should transmit high torque. All gears are not to be used for such high torque applications due to their low capacity and strength. Bevel gears are used in differential drives, which can transmit power to two axles spinning at different speeds, such as those on a cornering automobile, hand drill, to redirect the shaft from the horizontal gas turbine engine to the vertical rotor. In this paper a comparison between Lewis equation and Ansys workbench is done.

Title:-The Mathematical Model of Spiral Bevel Gears

Author:-Jixin Wang, Long Kong

Summury:-Worked on The Mathematical Model of Spiral Bevel Gears, The spiral bevel gear (SBG) is a key component of the power transmission of intersection axes. Since the mathematical model of the SBG is a basis for stress and thermal analysis, the optimization of machine-tool settings, frictional contact analysis in lubricated condition, and advanced manufacturing technology, research on designing and manufacturing of SBGs based on mathematical models of SBG has long been a topic of considerable interest in the field of mechanical transmission. The significance of research on the mathematical model lies not only in analyzing and building the tooth surface model, but also in investigating the design principles and manufacturing processes. This paper conducts a comprehensive literature review regarding the mathematical modelling of SBGs. The methods of building mathematical models, such as the matrix method, the vector method and the geometry method, are illustrated, compared and summarized in detail. Furthermore, the research history and applications of each method of building a mathematical model of SBGs are presented for better understanding. Based on applications of the mathematical model of SBGs, it is also indicated that more manufacturing methods could be updated or explored with the future development of universal milling machine technologies and computer aided manufacturing methods.

Title:- Stress Analysis of Bevel Gear Tooth using FEA

Author:-Sachin Gupta, Dr. P.S Chauhan, Prof.Juber Hussain

Summury:-worked Stress Analysis of Bevel Gear Tooth using FEA Finite element analysis of stress and deformation on the three-dimensional bevel gear has been conducted in the present paper. Structure steel has been taken as a material of bevel gear. First a CAD model has been generated than the stress, deflection, safety factor and strain analyses have been conducted. Modelled bevel gear has 20 teeth and a load has been applied at one of the teeth of the gear. Effect of different meshing methods like fine, medium and coarse meshing have been studied, with this effect of different element sizes like 10mm, 5mm and 1mm have been considered. At the end their effects on the number of nodes and elements have been studied. Remote displacement boundary condition has been applied at the center of the bevel gear. Maximum deflection of 32850mm, maximum von-misses stress 30.354MPa, maximum von-misses strain 15.835e-5 and minimum safety factor of 2.8398 have been found in the present study.

Title:- Parametric Design of Straight Bevel Gears Based on Solidworks

Author:- Shan Yuxia, Zhang Wei

Summury:-worked on Parametric Design of Straight Bevel Gears Based on Solidworks. The Visual Basic program of standard straight bevel gear's parametric design based on Solidworks software was completed. The geometric features of bevel gears were analyzed, parametric design variables were defined, each control point was determined in Cartesian coordinate system. In

development of the system, the API functions such as CreatLine, FeatureRevolve,FeatureCut, CreatePlaneAtAngle, InsertCutBlend and FeatureCircularPattern were used; the involute profiles of bevel gear at large end were fit by splines. The parametric design of bevel gears may provide a basis for further finite element stress analysis or assembly.

Title:-Design and Static Structural Analysis of Bevel Gear
Author:-Rohan R. Kurlapkar, M. M. Mirza, V. M. Naik
Summury:-studied on Design and Static Structural Analysis of Bevel Gear.Gears are fundamental asset for power transmission in automation industry. Bevel gears are used to transmit the power between two intersecting shafts at almost any angle or speed. In this present work an attempt is made to design the bevel gear for compact MIG welding robot and static structural analysis using ANSYS. A pair of bevel gear while transmitting the power generally subjected to two types of Failure. The bending failure due to bending stresses and pitting failure due to contact stresses. Various forces acting on the gear has been calculated. The bending stress equation by using Lewis bending stress equation and bending stress value determined for straight teeth bevel gear and carried out comparison between analytical value and value obtain by the ANSYS Workbench 15.0.

Title:-Design and Analysis of a Spiral bevel gear
Author:- A.Nagarajan
Summury:-Worked on Design and Analysis of a Spiral bevel gear. The spiral bevel gear used in BMW K75 motor bike of material SAE 9310 is selected. Bevel gear has applications such as these need spiral bevel gears to turn the corner from the internal combustion engine to the rear drive gear. These gears must typically operate at extremely high rotational speeds and carry high power levels. The material is changed with FLEXOR, with these difficult operating conditions; an improved analytical capability is paramount to increasing safety and reliability. Also, literature on the analysis and testing of spiral bevel gears has been very sparse in comparison to that for normal gears. The Spiral bevel gear is modeled and subjected to analysis and the variation in result is plotted.

Title:- Achieving mass reduction in the spur gear using topology optimization for design evaluation and analysis
Author:- Mr.Satyavan S. Mokashi, Mr.Milind S. Ramgir
Summury:- All manufacturing enterprises strive to develop the optimized product commonly by reducing the weight while ensuring they produce cost effective products that meet their design functionality and reliability. Structural optimization tools like topology optimization along with manufacturing simulation are becoming attractive tools in product design process. These tools also help to reduce product development time. As gears are important elements in a variety of industrial or commercial applications such as machine tool, vehicles, turbines, etc. Objective of this investigation is to reduce weight of gear. Reduction of weight has been one the critical aspects of any design. It has substantial impact on vehicle performance, fuel efficiency and in turn reduces the emissions. This work would focus on the Design space offered by the component functionality while determining the nature and extent of the mass reduction over the locations identified during topology optimization. Experimentation shall be conducted for ascertaining stiffness of the gear in the light of feasibility of the testing setup.

Title:- Design and optimization trough weight reduction of spiral bevel gear for wood working machinery
Author:- N.P.Deokar, Prof.N.D.Padwale
Summury:- Wood working machines are used to cut wood work-piece in furniture making, Casting pattern making, wooden seat design, wood prototyping etc. They use a set of spiral bevel gears for transmission of power from motor to tool in the application. The weight of the hand held tools and subsequent vibrations makes it difficult to operate the machine for longer time and so also power consumption per unit cut has been found to be very high , and vibrations lead to inaccuracy in cutting and error in profile shape. Thus methodology used in study is to carry out test on three sets of bevel gears namely plain(ie no weight reduction), secondly weight reduction done by providing recess on the face of the gear , an thirdly by providing even number , equispaced holes on the face. Comparative analysis of the performance of the gears by load so as to derive the optimal performance of the gear. By optimization of spiral bevel gear we can reduce weight of bevel gear and thereby cost of product or gear is depending on manufacturing process & material used for it.

IV. CONCLUSION

Finally, complete content and organizational editing before formatting. Please take note of the following items when proofreading spelling and grammar. The design of spiral bevel gear is very necessary to transmit power. The calculation of maximum stresses in a bevel gear at tooth root is three dimensional problems. The accurate evaluation of stress state and distribution of stress is complex task. The stresses produced at any discontinuity are different in magnitude from those calculated by elementary formulae.

In theory of bevel gear we are considering that load is acting at one point and the stress is calculated. But, in case of FEM a continuous load is considered. So a pressure will act along the teeth of bevel gear.

By following the design procedure we get the design force transmitted by spiral bevel gear and by FEM analysis we can calculate the stress and deflection in spiral bevel gears. There is fairly good agreement between experimental and finite element results

Total 9.09% weight reduced by using taguchi method for optimization

V. ACKNOWLEDGMENT

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[3] "Analysis of bending strength of bevel gear by FEM" Abhijeet .V. Patil, V. R. Gambhire, P. J. Patil

[4] "Stress Analysis of Bevel Gear Tooth using FEA" Sachin Gupta, Dr. P.S Chauhan, Prof.Juber Hussain

[5] "Achieving mass reduction in the spur gear using topology optimization for design evaluation and analysis" Mr.Satyavan S. Mokashi, Mr.Milind S. Ramgir

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