A REVIEW ON GEAR PARAMETERS OPTIMIZATION USING COMPOSITE MATERIALS

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Abstract

Gearing is one of the most effective methods for transmitting power and rotary motion from the source to its application with or without change of speed or direction. Gears are mostly used to transmit torque and angular velocity from one shaft to another shaft. The failure of gears occurs when the working stress exceeds the maximum permissible stress. Contact stress analysis between two spur gear teeth was considered in different contact positions representing a pair of mating gears during rotation. The less efficiency of gear box of a machine tool is a serious problem as it increases maintenance cost and also affects the reputation of a firm. Hence its life has to be increased and should be made more reliable. The present investigation is devoted to explore the static stresses developed on gear tooth material at low speed and high torque for different materials such as high strength steels, forged stainless steels, copper based alloys aluminium alloys and magnesium alloys etc. for their high strength values. Optimization plays an important role in gear design as reducing the weight or volume of a gear set will increase its service life and improve the bearing capacity. The method of optimum design is effective in the field of gear research to determine the optimum gear parameters for satisfactory design. In gear design, number of parameters is involved. The gear design also requires an iterative approach to optimize the gear parameters. The philosophy for driving this work is the lightness of the gear for a given purpose while keeping intact its functionality. The process constraints for manufacturing the gear also needs to be considered while recommending alternative/s. This study will focus on the weight optimization of the gear set, keeping the torque transmitting capacity intact, thus reducing the material cost of the gear.

Keywords: Gears, Helical gear, Composite Material, Weight reduction, Parameters, Stress;

INTRODUCTION

Gears are compact, positive-engagement, power transmission elements that determine the speed, torque, and direction of rotation of driven machine elements. Gear types may be grouped into five main categories - Spur, Helical, Bevel, Hypoid, and Worm. Typically, shaft orientation, efficiency, and speed determine which of these types should be used for a particular application. Gears have wide variety of applications. They form the most important component in a power transmission system. Advances in engineering technology in recent years have brought demands for gear teeth, which can operate at ever increasing load capacities and speeds. The gears generally fail when tooth stress exceeds the safe limit. Therefore, it is essential to explore the alternate Gear material. The important considerations while selecting a Gears material are the ability of the Gear material to withstand high frictional temperature and less abrasive wear. Weight, manufacturability and cost are also important factors those are need to be considered during the design phase. Moreover, the Gear must have enough thermal storage capacity to prevent distortion or cracking from thermal stress until the heat can be dissipated. It must have well anti fade characteristics i.e. their effectiveness should not decrease with constant, prolonged application and should have well anti wear properties. The design of gears is a highly complicated task, and the need to develop light weight, quiet and more reliable designs has resulted in a variety of changes in the design process. Identifying the best design using graphical methods becomes tedious once the number of design variables exceeds two. Therefore, a more general and systematic approach to gear design is desirable. Eliminating lubricant in geared systems is both cost saving and environmentally sound, but does pose some technical challenges. Metal-to-metal contact of tooth surfaces sliding and rolling against each other under contact pressure causes high tooth temperature that may result in material microstructure changes. Tooth surfaces can severely wear away and even deform plastically. Tooth-sliding velocity and contact pressure can be reduced by changing the gear design

LITERATURE SURVEY ON COMPARISON OF COMPOSITE MATERIALS

R, Yakut [1] 2009 and K. Mao [2] (2007) proposed a new design method for polymer composite gear based on the correlation between polymer gear rate and its surface temperature.

M. Brahma Kumar [3] 2005 proposed that Natural Fibres are replacing synthetic fibers as reinforcement in various matrices. Incorporation of sisal-jute fiber with GFRP can improve the properties and be used as an alternate material for glass fiber reinforced polymer composites.

S.V Prasad et al [4] 2003 contributed to the study of Aluminium Metal Matrix composites for their tribological behaviour in automotive applications. Blaza Stojanovic et al., 2013 [5] studied the application of aluminium hybrid composites in Automotive Industry. Varuzan Kevorkijan et al. [6] 2002 studied the development of Aluminum metal matrix composites for automotive industry.

Huang et al [7] 2005 formulated an interactive physical programming and thereby optimized the three stage spur gear unit used for speed reduction. Vijayakumar K. et al. [8] 2003 modified the traditional ant colony algorithm by introducing a bi-level search procedure, for optimizing multi-pass turning operations.

Wang et al. [9] 2004 introduced an improved heuristic algorithm named bi-directional convergence ant colony optimization for job-shop problem and proved that the ACO can solve the multi-constrained problem in less computational time. Savsani et al., [10] 2010 attempted to reduce the weight of the spur gear unit using particle swarm optimization.

Raj Gandhi [11] in April 2018 gave a review paper on how composite polymer gears perform under various Load applications. Different reinforcements with composite polymer improved fibre interface bonding and increased strength of the composites. The negative impacts of fibre's physical treatments on tensile and impact properties of polymer gears were also reviewed.

Nair Ajit [12] in July 2018 in his paper designed, analyzed and fabricated helical gear. This helical is made up of composite material. Used a metal matrix composite consisting of Aluminum and Nickel boride. This metal matrix composite will provide the better performance and will increase the life time of the gear compared to the traditional helical gears. Design of gear is done with Creo, analysis is done using ANSYS and fabrication will be based on stir casting.

S. Mahendran [13] in 2014 to design the spur gear to study the weight reduction and stress distribution for cast steel and composite materials. To study the impact analysis for cast steel and composite materials. To study the torque loading for cast steel and composite materials. Finally, comparing and analyzing of the composite gear with existing cast steel gear is to be done.

J. Venkatesh [14] in 2014 introduced in this paper bending and contact stresses are calculated by using analytical method as well as Finite element analysis. To estimate bending stress modified Lewis beam strength method is used. Pro-e solid modeling software is used to generate the 3-D solid model of helical gear. Ansys software package is used to analyze the bending stress. Contact stresses are calculated by using modified AGMA contact stress method. In this also Pro-e solid modelling software is used to generate contact gear tooth model. Ansys software package is used to analyze the contact stress. Finally these two methods bending and contact stress results are compared with each other.

K. Krishnakanth [15] in December 2015 introduced new design method for polymer composite gear. This design method is based on the link between polymer gear wear rate and its surface temperature. It has been found from the tests that the polymer (acetyl) gear wear rate will be increased dramatically when the load reaches a critical value for a specific geometry. The method has been related to test results under different operating ambient temperature and gear geometries. Good agreement has been achieved between the proposed method predictions and experimental test results. Experimental investigation on polymer composite (glass fibre reinforced nylon with PTFE as internal lubricant) gears have also been carried out and two forms of failure have been found, root and pitch fractures.

Mrs. S. Kausalya Devi S [16] in Jan 2017 attempted to design, model and finite element analysis of spur gear using composite material. Conventional spur gears are made up of cast iron or mild steel. Composite material could be an alternative for conventional materials considering the advantage of less weight, rust formation and less maintenance. Modeling of spur gear is done using solid works and finite element analysis is done in Ansys. Based on the analysis results it is suggested that short carbon reinforced (SCF) nylon to be used in place of cast iron or mild steel for limited load applications under 1500 watts.

Mr. Sharad. J .Chauhan [17] in 2017 gave a review paper on bending and contact stress analysis of helical gear. It mainly focused on ANSYS, finite element methods and AGMA standards for computation of bending and contact stress on a root of helical gear. It discussed the bending and contact stress of the gear tooth are examined and are one of the contributors for the failure of the gear. This paper contains the theoretical, numerical and analytical methods for the gear pair analysis.

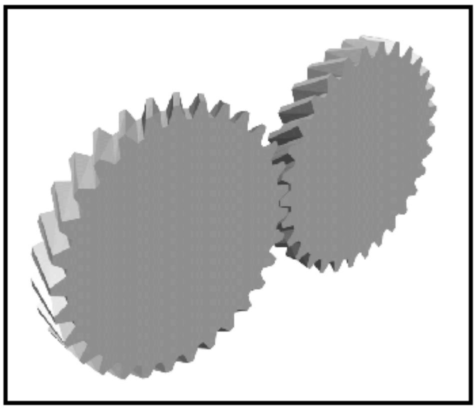

Fig 1: Gear-Helical Gear

VARIOUS PARAMETERS ANALYSIS OF GEAR

Module (mm)

Pressure angle (degrees)

Contact Ratio

Number of teeth

Mass moment of inertia (kg.m2)

Mass (kg)

Bearing radial stiffness (n/mm)

Bearing damping coefficient (Ns/m)

Gear mesh stiffness (N/m)

Damping of gear teeth (N.s/m)

Damping of gear-shaft interface (N.M.s/rad)

Back lash (micro meter)

Coefficient of Friction

SELECTION OF COMPOSITE MATERIAL

Tempered steel is one of the most common materials for different types of gears, and aluminium is also common. Other materials used are:

- High strength steels
- Forged stainless steels
- Copper-based alloys
- Cast or forged aluminium alloys
- Cast iron or grey cast iron
- Magnesium alloys

APPLICATIONS

Gears are used in various industries in numerous machines. The list below shows the main application fields (industry category).

- Factory automation
- Packaging machine
- Industrial robots
- Food processing machine
- Car production machine
- Machine tool industry
- Material handling
- Printing machine
- Automatic cutting / welding machine
- Machine for medical/cosmetic field
- Construction machine
- Wood / Glass processing machine
- Agricultural machinery

ADVANTAGES

- It is positive drive hence velocity remains constant
- Provisions for changing velocity ratios can be made with the help of gear box
- Its efficiency is very high
- It can be used even for low speeds
- It can transmit high torque values
- It is compact in construction

DISADVANTAGES

- They are not suitable when shafts are distant
- At high speeds noise and vibration happens
- It requires lubrication
- It has no flexibility

REASONS OF GEAR FAILURE

There are following reasons of Gear failure.

- Abrasive wear
- Corrosive wear
- Initial pitting
- Destructive pitting
- Scoring

Depending on the requirement and place of use there are several types of Gears.

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