A Review on Optimization of Helical Gear Pair using Genetic Algorithm to Analyze the Performance Characteristics

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Abstract— Gears are most critical elements in mechanical systems. Gears are typically used for short distance power transmission and the effectiveness of transmission is very high as related to other types of transmissions. Today's competitive market has brought increasing awareness to optimize the gear design. design optimization of gear pairs is difficult to solve because it includes various objectives and high number of variables. Therefore, to solve such difficulty robust optimization technique will be useful to develop optimal solution. The optimization of helical gear pair to gives results that can be applied in practice. Also results can benefit the creators to employ for a least material and cost by fulling design accuracy and other performance requirements.

Key words: Helical Gear Design, Optimization Tools, MATLAB Optimization Toolbox, Genetic Algorithm Optimization

I. INTRODUCTION

Helical gears are presently being used highly in earth moving industries, plastic industries, power and port industries, textile industries, Printing industries, fertilizer industries, food industries, oil industries & cutters, rolling mills, section rolling mills, conveyors, elevators, blowers, compressors etc.[2] Helical gear is preferable as compare to spur gear due to their relatively smooth and noiseless operation, huge load carrying capacity and greater operational speed.[1] Today's the performance of gears is very important in all above applications. When we are going to optimize the gear design which includes number of variables then it's necessary to check whether there is any change in the performance or not. Aim of this effort is to improve the design of helical gear pair to inspect the performance Characteristics. Formulation of helical gear pair model are shown below.

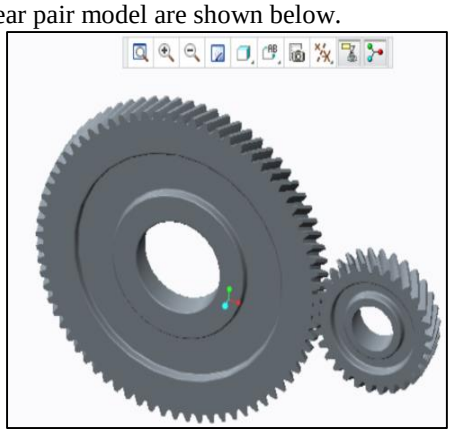

Fig. 1: Helical gear pair model

Using the specifications tooth shape were first created using Creo Parametric 2.0. In the beginning, gear modelling was carried out in Creo Parametric 2.0. The model was prepared by drawing the base circle using relations and parameters and afterward the extrude portion is formed the curve is created and the sweep option is performed to generate the tooth shape. Later on whole gear is created by means of pattern feature. In the similar approach pinion model was also accomplished. Finally, helical gear pair is obtained by assembling of the gear and pinion.

II. LITERATURE REVIEW

Jian Wang et al. [3] In this research the mathematical model of cycloid speed reducer is created. multi-objective optimization is consider including the important criteria and objective functions is established. Reasonable increase in efficiency (3.79%) and decrease in volume (32.51%) are achieved. Also suggested that multi-objective optimization design gives healthier design solutions.

Peng Yan et al. [4] In this paper 2-stage helical gear reducer design is considered and The relationship between teeth and the tooth shape coefficient is plotted by using neural network. GA is used to optimize the Output layer and Hidden layer weights. Finally, genetic algorithm is used for gear reducer optimization design. Also conclude that GA algorithm has extensive used in mechanical optimization design due to its high accuracy.

B. Venkatesh et al. [5] The effort is to examining the combined effect of gear design parameter on bending and compressive stress of high speed helical gear. Keeping constant remaining parameters, when increase gear ratio, then bending stress remained same and compressive stress decreases. Same way when face width is varied, the bending and compressive stress decreases linearly. the bending and compressive stress decreased when increasing helix angle. when module is varied, the corresponding the bending and compressive stress decreased.

S. Jyothirmai et al. [6] In this study different types of helical gear model are created with the support of Pro-e and The work is to compare different helical gear systems performance through FEA method and analytical approach through AGMA standards. By inspecting results of this two approach crossed helical gear performance in terms of stress and strength was found better and herringbone model and single helical gear model are engaged for best values of speeds and loads. In single helical gear pair, the low stresses were noticed.

Sunny Patel et al. [7] A helical gear pair reducer is taken in this research. Aim of this research is to minimize the volume of helical gear reducer. For minimum volume, variables and constraints are considered. With the help of Particle Swarm Optimization Technique (PSO). The results achieved for minimum material and cost by fulfilling the strength.

Javad Jafari et al. [8] In this effort 1, 2 and 3-stage gear trains has been taken and with the help of Matlab program and objective of this work is to reduced volume/weight of gearbox. By selecting different values for the power, gear hardness, gear ratio etc. the useful charts are

created from the results. all the essential parameters like no. of stages, modules, face width of gears, and shaft diameter can be derived. The chart results are compared with earlier works and an illustration is taken to display how the practical chart can be used.

Lucian Tudose et al. [9] In this research a 2-stage coaxial speed reducer is taken. Objective is to reduce the mass of the whole speed reducer which was defined by a set of mixed design variables and also was subjected to large number of constraints. By using Genetic Algorithms and traditional design method for mass reduction it can be observed that genetic algorithm is very effective as compare to traditional design method.

Long He, et al. [10] In this paper using MATLAB Toolbox researcher is going to make the size of the reducer smallest and minimize the requirement of materials. Here model of 2-grade of Helical Gear Reducer is created and then objective function, design variables and constraint condition was described. By comparing the results with the design data it can be observed that 35.28% saving in materials and center distance reduced by 33mm. so it can be observed that with the help of matlab toolbox result obtain was highly accurate and more useful.

Zhang Xiao, et al. [11] Using VB and MATLAB as development tool the paper established optimization design software for spur gear reducer to obtain optimal solution, greatly developed the design accuracy and design quality of gear reducer. By using Visual Basic programming with MATLAB, selecting the genetic algorithm to perform optimization on spur gear reducer. By showing the results it can be observed that greatly improved in design accuracy and design quality.

Faruk Mendi, et al. [12] Researcher is going to achieve the optimal dimensions for gear box components by using genetic algorithm tool. Firstly, model formulation is done then design variables and design constraints was described. Optimization of gearbox components is performed by genetic algorithm and also analytical method is used. By comparing results of this two method it was found that GA is more effective as compare to analytical. Also it can be observed that the design with smallest volume which can carry the system load is obtained.

R.V. Rao, et al. [13] Objective of this paper is to reduce the weight of spur gear train with the help of two optimization algorithms well-known as simulated annealing (SA) and particle swarm optimization (PSO). The design variables and design constraints are considered based on objective function. The results obtain from this two algorithm The results of the offered algorithms are matched with the earlier published results. It is detected that the offered algorithms give improved gear design solutions.

Cevdet Gologlu, et al. [14] The aim of this research is to reducing the volume of two stage helical gear trains. Penalty functions is used to make an Objective function for hold the design constraints. By using genetic algorithm to reduce the volume of gear train. By taking different values of gear ratio volume of gear train is measured and Then results comparison of design procedure and GA is carried out. It can be observed that the GA based approach produced better results and minimize the volume.

Giorgio Bonori, et al. [15] Aim of this paper is to improve gear dynamic performances by an optimization methodology using Genetic Algorithms. Objective is to reduced noise and gear vibration by profile modification of in linear and parabolic form and compared by several optimization approaches based on FEM analysis. Genetic algorithms optimization tool is very effective for design shape modifications for dropping the gears vibration, i.e. they permit a tough reduction of the vibration amplitude over a wide frequency range, as confirmed by dynamic investigates.

Santosh S. Patil et al. [16] In this research effort has been made to study contact pressure in gear pair. Gear Dynamic Stress Test Rig (GDSTR) are taken for the experimental testing and analysis of the helical gear pair. GDSTR is apply to figure out the contact stresses on the gear pair contact under real gear situations. The experimental examination showed favorable results which have been proved by the FEA approach. Helical gear system with the same specifications and for different frictional coefficient situations were also created by means of FE modelling. Study of contact stress by FEM has been taken to compare results of the GDSTR.

III. Conclusion

The important design criterion for gear pair is bending stress and compressive stress. If optimization of various parameter like helix angle, normal module, face width, gear ratio is done considering their combined effects then it will certainly enhance the effectiveness and performance of gears. Evolutionary optimization is used for gear pair optimization to obtained best result that can be applied in practice. Since genetic algorithm method of optimization is more accurate, effective and time-saving, it must be used by the researchers to optimize various engineering designs. Also we can conclude that by means of the MATLAB Toolbox and its algorithm, to achieved the gear smallest and save more materials.

References

[1] Handbook of Gear Design by *Gitin M. Maitra*, Tata McGraw-Hill Education, 1994
[2] www.hkdivedi.com
http://www.hkdivedi.com/2015/12/advantages-disadvantages-and.html
[3] Jian Wang, Shanming Luo, et. al, "Multi-objective optimal design of cycloid speed reducer based on genetic algorithm." [J], Mechanism and Machine Theory 102 (2016) 135–8
[4] Peng Yan, "Gear Transmission Optimization Design based on Intelligent Algorithm" [J], 7th International Conference on Intelligent Computation Technology and Automation, 2014
[5] S.V. Prabhakar, et. al, "Investigate the Combined Effect of Gear ratio, Helix angle, Face width and Module on Bending and Compressive stress of Steel Alloy Helical Gear" [J], Procedia Materials Science 6 (2014) 1865 – 1870
[6] S. Jyothirmai, et. al, "A Finite Element Approach to Bending, Contact and Fatigue Stress Distribution in Helical Gear Systems" [J], Procedia Materials Science 6 (2014) 907 – 918
[7] K. Tamboli, S. Patel, P.M. George, et al., "Optimal design of a heavy duty helical gear pair using particle

swarm optimization technique" [J], Procedia Technology 14 (2014) 513 – 519
[8] Javad Jafari et. al, "Gear train optimization based on minimum volume/weight design" [J], Mechanism and Machine Theory 73 (2014) 197–217
[9] Lucian Tudose et. al, "Optimal mass minimization design of a two-stage coaxial helical speed reducer with Genetic Algorithms" [J], Advances in Engineering Software 68 (2014) 25–32
[10] Long He, et. al, "Optimal design of Two-stage Helical Gear Reducer based on Matlab" [J], IEEE 2nd International Conference on Computing, Control and Industrial Engineering 2011
[11] Zhang Xiao, et. al, "Optimization design of spur gear reducer based on genetic algorithm" [J], International Conference on E-Product E-Service and E-Entertainment 2010
[12] Faruk Mendi, et. al, "Optimization of module, shaft diameter and rolling bearing for spur gear through genetic algorithm." [J], Expert Systems with Applications 37 (2010) 8058–8064
[13] R.V. Rao, et. al, "Optimal weight design of a gear train using particle swarm optimization and simulated annealing algorithms." [J], Mechanism and Machine Theory 45 (2010) 531–541
[14] Cevdet Gologlu, et. al, "A genetic approach to automate preliminary design of gear drives." [J], Computers & Industrial Engineering 57 (2009) 1043–1051
[15] Giorgio Bonori, et. al, "Optimum profile modifications of spur gears by means of genetic algorithms." [J], Journal of Sound and Vibration 313 (2008) 603–616
[16] A. P. Arjun, et. al, "Gear Test Rig - A Review." [J] International Journal of Mechanical & Mechatronics Engineering (2014) 140205-9696

