International Journal of Advanced Technology & Engineering Research (IJATER)
www.ijater.com

Performance Enhancement of Spur Gears Through Weight Reduction via Static Structural Analysis- A Review Study

Rajkapoor Jaiswal[1], Mahendra Prajapati[2], B.S. Choudhary[3]
[1]M.Tech Student, Department of Mechanical Engineering, Millennium Institute of Technology, Bhopal (M.P.)
[2 & 3]Department of Mechanical Engineering, Millennium Institute of Technology, Bhopal (M.P.)

Abstract:

Gearing application is an important feature in the mechanical industry which is required for transmission of power between to shafts. Taking this aspect as the base, current research study focuses on reviewing the enhancement of performance of spur gears using different new kind of materials specially composite materials, through static structural analysis. Several results which ere obtained through this study, include- Spur gears have been in continuous focus of the researchers for their process optimization. Spur gears have been mostly analyzed for their material using ANSYS software through Static Structural Analysis module. During analysis of the spur gears, weight, volume & power have been mostly studied output parameters. Face width has mostly been studied for its effect on contact stress & face width if found to be inversely proportional to contact stress. As far as material optimization of spur gears is concerned, composite materials have been found out to be possible alternatives to the conventional material.

Keywords- Gearing, Transmission of Power, Spur Gears, Composite Materials, ANSYS, Weight, Face Width Contact Stress

Introduction

Gearing is one of the most critical components in a mechanical power transmission system, and in most industrial rotating machinery. It is possible that gears will predominate as the most effective means of transmitting power in future machines due to their high degree of reliability and compactness. In addition, the rapid shift in the industry from heavy industries such as shipbuilding to industries such as automobile manufacture and office automation tools will necessitate a refined application of gear technology.

A gearbox as usually used in the transmission system is also called a speed reducer, gear head, gear reducer etc., which consists of a set of gears, shafts and bearings that are factory mounted in an enclosed lubricated housing. Speed reducers are available in a broad range of sizes, capacities and speed ratios. Their job is to convert the input provided by a prime mover (usually an electric motor) into an output with lower speed and correspondingly higher torque. In this thesis, analysis of the characteristics of spur gears in a gearbox is studied using FEM.

Fig. 01 Simple form of Spur Gears

The spur gears are placed on straight and parallel to axis of the wheel. That gears are called as spur gear. Spur gear are used to transmit the rotary motion between parallel shafts. The gear is may be as internal or external gears. When the external gear is rotated in opposite direction and the internal gear are rotated in same direction.

Over the last thirty years' composite materials, plastics and ceramics have been the dominant emerging materials. The volume and number of applications of composite materials have grown steadily, penetrating and conquering new markets relentlessly. Modern composite materials constitute a significant proportion of the engineered materials market ranging from everyday products to sophisticated niche applications.

While composites have an already proven their worth as weight-saving materials, the current challenge is to make them cost effective. The efforts to produce economically attractive composite components have resulted several innovative manufacturing techniques currently being used the composites industry. It is obvious, especially for composites, that the improvements in manufacturing technology alone is not enough to overcome the cost hurdle. It is essential that there be an integrated effort in design, material, process, tooling quality assurance, manufacturing, and even program management for composites to become competitive with metals.

Literature Review

Yatika Gori et al. [2022] Most mechanical devices contain gears as one of their basic components. Spur gears are a type of gear that is often used to transfer power between two parallel shafts. Spur gears have a parallel gear cut to the shaft axis. The design of gear has a direct impact on the efficiency of the transmission. As a result, the significance of proper gear design and testing is of the highest importance in modern machines. Simulation has recently gained

popularity as a cost-effective alternative to laboratory testing. Explicit Dynamic, Static Structural and Modal Analysis performed on Spur Gear in this project to illustrate the gear's reaction to different boundary conditions. As a simulation tool, ANSYS workbench is utilized.

Amit Kumar Shah et al. [2022] Present research work focuses on static analysis of spur gear under different materials. For the purpose of research, first of all a spur gear of standard dimensions, provided by a customized machine manufacturing firm, was designed, and four properties, namely, Von misses stresses, total deformation and total equivalent strain were investigated, with four materials, namely, PLA, Ceramic ZrO2, Epoxy and ABS. Results of static analysis, with an applied load of 1000 N showed the suitability of PLA material for the gear. The software used were Creo 3.0 and SimScale. Following were the results of the research

C. Sivakumar et al. [2022] To get better stuff tooth potency, much work has been accomplished, yet all generally utilized positive profile moving. This commitment shows lower surface failure and scoring resistance and minimize contact proportion bringing about much more commotion and pulsation throughout the force transmission. To reduce transmission blunder for a given prod gear at the ostensible force through the profile change boundaries. The uniqueness of the work is gear profile alteration is being made on the spike stuff to such an extent that the stuff tooth including a typical involute functioning profile from the tip circle distance across of the stuff to the base circle breadth of the stuff. Regular standard root filet supplanting by round about root filet from the base circle to expand the tooth potency and to limit the disappointment of the tooth in the prod gear. An endeavor has been made to discover the twisting pressure and disfigurement of cog wheels utilizing ANSYS 12.0 programming for anticipating the exhibition.

Roshni Khanna et al. [2021] In the modern industry today, gear is the most crucial component in power transmission system for various applications. Nowadays, varying load and speed is required to operate machines. Teeth of gear generally fails when the applied load increases above definite limit. Hence, it is needed to examine possible materials for the production of gear. With deep study, it was found that composite materials are the best alternative that provides adequate strength with weight reduction for the replacement of metallic gears. An attempt has been made for the replacement of the gear of conventional material with the best possible composites material. Carbon fiber-reinforced composite and carbon epoxy composite are composites considered. Efforts have also been carried for modeling of the gear on solid works, and then, structural behavioural analysis of all different material gears was studied. In this work, main focus is being carried out to determine the deformation and stress. Composite gears proved to give improved and better properties and can be used as better alternative for replacing metallic gears.

Husaini et al. [2020] studied about Damage or failure frequently occurs on gearbox gears. If this occurs in the gearbox of tractors, this can be severe. This study aimed to determine the cause of the spur gear fracture through empirical and simulation studies. The hardness test was undertaken employing the Rockwell method where the fracture surface was observed using a scanning electron microscope (SEM) in order to identify crack initiation and the type of fracture. The stress intensity factor was next analysed using the finite element method (FEM). The results of the chemical composition testing indicated that the material used was according to the AISI 8620 standard containing an element of Carbon (C) of about 0.142 %. The hardness value of the gear was 109 HRB. The observation of the fracture surface showed a brittle fracture surface, suggesting that an impact load had occurred. The simulation results using the FEM also showed that the maximum stress intensity factor and KI value ccurred at the centre of the tooth. The value of KI was shown to be larger than the fracture toughness and (KIC). Therefore, this result indicates that a crack will continue to propagate until final failure.

V.A. Gavali et al. [2018] studied about gears while transmitting the power generates high stresses. at the mating positions over the teeth as they amend the rate of rotation of machine shaft. The axis of rotation for high-speed machinery is the optimal medium for low energy loss and high accuracy. Toothed spur gears are used to transmit the power with high velocity ratio. Various methods are used to find out contact stresses such as Hertz contact stresses, Lewis bending Equation, AGMA Equation. Most of the research work attempted on mathematical contact stress analysis and compared with finite element analysis. In few papers the work was focused on the stress redistribution technique by introducing the stress relieving features in the stressed zone for minimization of stresses in spur gear. The purpose of this dissertation work is to identify the magnitude of the stresses for a spur gear used in lathe machine for operations such as boring, facing. Various case studies are going to perform. For simulation we are going to use FEA tools such as Hypermesh, Abaqus. For validation we can go for experimental stress analysis i.e., photo elasticity method. Before going for FEA and Experimental we will go for analytical analysis. The contact stresses and deformations obtained by experimentally and compared with the results of FEA.

Fatmir Azemi et al. [2016] studied about Gears are one of the most important components in mechanical power transmission systems. The bending and surface strength of the gear tooth are

considered to be one of the main contributors for the failure of the gear in gear set. The three-dimensional solid model can be generated in CAD software, in this case we have created model in Autodesk Inventor 2015. This model of the spur gears is imported in ANSYS software and then contact stress and bending stress can be calculated in ANSYS. The paper presents the results of calculation of pair spur-gears that it used in the gear-box reduction of the working wheel of the Excavator located in open-cast coal mines, and after that will be optimized the shape of the spur gear with usage of ANSYS software. To be more specific, how much material can be removed from the gear body without compromising the gear meshing properties? Consequently, the aim of this research is to reduce weigh of the gears.

G.C. Mohan Kumar et al. [2020] studied about Gear is the most critical component widely used in the transmission of motion and power between shafts. During motion, the gears are loaded, which develops critical bending stress at the root of the gear and also at the point of contact. The loading point "Highest Point Single Tooth Contact" (HPSTC) is the most critical in any gear. The present research work involves a reduction in the weight of gear by optimizing material inside the tooth. This work involves removing material by making holes inside the tooth at different locations with different sizes. The FEM analysis leads to optimizing the material utilization and is carried out using ANSYS APDL tool.

Putti Srinivasa Rao et al. [2015] studied about contact stress in the mating gears is the key parameter in gear design. Deformation of the gear is also another key parameter which is to be considered. Gears generally fail when the working stress exceeds the maximum stress. The study in this paper shows that the complex design problem of spur gear which requires fine software skill for modelling and also for analysing. The project aims at the minimization of both contact stress as well as deformation to arrive at the best possible combination of driver and driven gear. In this process of spur gears mating, 3 different materials were selected and the software programme was performed for 9 different combinations to get the best result possible. The results of the two-dimensional FEM analysis from ANSYS are presented. These stresses were compared with the theoretical Hertz's equation values. Both results agree very well. This indicates that the FEM model is accurate.

El-Sayed Aziz et al. [2001] studied about A methodology for the analysis of load distribution and contact stress on gear teeth. which utilizes a combination of closed form solutions and two-dimensional finite element methods, within a constraint-based knowledge-based environment, is presented. Once the design parameters are specified, the complete process of generating the analysis model, starting from the determination of the coordinates of the tooth profile, the creation of a sector of the mating gear teeth, automatic mesh generation, boundary conditions and loading, is totally automated and transparent to the designer. The effects of non-standard geometry, load sharing on the contact zone, friction and root stresses are easily included in the model. The Finite Element Method (FEM) based results compare favourably with those obtained from closed form solutions (AGMA equations and classical Hertzian contact solution). The advantage of the approach rests in the ability to modify any of the gear design parameters such as diametral pitch, tooth profile modification etc., in an automated manner along with obtaining a better estimation of the risks of failure of the gear design on hand. The procedure may be easily extended to other types of gearing systems.

Deepika Potghan et al. [2015] studied about This paper deals with the reduction of contact stresses of the spur gear and pinion used in headstock of a lathe machine. its introducing stress relieving feature of different shapes i.e., circular hole, elliptical hole and aero fin hole. In this paper the stress analysis of mating gears of the spur gear with three different materials is done to determine the contact stresses generated in the gear teeth. In the previous paper the results obtained from Finite Element Analysis (FEA) using Ansys are compared with the values obtained from theoretical Hertzian equation. The materials of spur gear used for analysis are grey cast iron, high carbon steel and medium carbon steel. In this paper the stresses which were calculated has been reduced by introducing stress relieving feature of different shapes. It was found that Stress relieving feature having the shape of aero- fin yielded better results when compared to elliptical and circular holes.

Vrushali Wable et al. [2016] studied about Gear is most effective part of transmission system due to efficiency and reliability. Gear is used for high load in machine tools. These gears are continuously operated under specified conditions. If gear failure occurs, it is due to pitting failure and scoring failure. In this paper, pitting failure has been studied for a gear. Modelling of gears in CATIA V5 is done by parametric formulation. The gear is analysed in ANSYS for deformation and max contact stress which causes pitting. Experimental Analysis is done using photo elastic method on photo elastic apparatus.

Prafulla M. Chor et al. [2015] studied about the gears are used for a wide range of industrial applications. They have varied application starting from textile looms to aviation industries, automobile gear box and machine tool application to transmitting the power. Their function is to convert input provided by prime mover into an output with lower speed and corresponding higher torque. Spur gears are used to transmit the power up to velocity ratio is ten. This

phase they induce high stress at the point of contact. A pair of teeth in action is generally subjected to contact stresses causing fatigue failure of gear tooth. The main purpose of this study is to reduce the contact stress of gear by increasing the module of gear. One Spur gear train is selected for analysis. The Contact stress of existing gear train is calculated and compared with fatigue strengths of gear material. If this stress on gears is higher than fatigue strengths mean gears are failed due to fatigue. To reduce the contact stress by increasing the module of gear. The contact stress is calculated by Hertz's Equation and Strain gauge is used for the experimental investigation of the stress field.

Xiaohe Deng et al. [2015] studied about A design method for the geometric shape and modification of asymmetric spur gear. this geometric shape and modification of the gear can be obtained directly according to the rack-cutter profile. In the geometric design process of the gear, a rack-cutter with different pressure angles and fillet radius in the driving side and coast side was selected, and the generated asymmetric spur gear profiles also had different pressure angles and fillets accordingly. In the modification design of the gear, the pressure angle modification of rack-cutter was conducted firstly and then the corresponding modified involute gear profile was obtained. The geometric model of spur gears was developed using computer-aided design, and the meshing process was analysed using finite element simulation method. Furthermore, the transmission error and load sharing ratio of unmodified and modified asymmetric spur gears were investigated. Research results showed that the proposed gear design method was feasible and desired spur gear can be obtained through one-time rapid machining by the method. Asymmetric spur gear with better transmission characteristic can be obtained via involute modification.

Miss. Kachare Savita et al. [2015] studied about the spur gear design. A designer of modern gear drive system must have to remember that the main objective of gear drive is to transmit higher power with comparatively smaller overall dimensions of the driving system which can be constructed with minimum possible manufacturing cost, runs reasonably free of noise and vibration and which requires little maintenance. In this paper single stage spur gear train and helical gear train with an idler gear are designed by American Gear Manufacturing Association (AGMA) standard. An idler gear is placed between two gearwheels to obtained the same direction of rotation. AGMA stress equation is used to determine the tooth bending strength and surface contact strength. As a result, dimensions of gears are finding out and comparative study is carried out to select the optimum design of gear train for a given input parameter.

Ms. Nilesha U. Patil et al. [2017] studied about Gears are machine elements used to transmit motion and power between rotating shafts it means progressive engagements of projections. Gears have wide variety of applications. Their application varies from watches to very large mechanical units like the lifting devices and automotive. Engineering components made of composite materials find increasing applications ranging from space craft to small instruments. It is possible that gears will predominate as the most effective means of transmitting power in future machines due to their high degree of reliability and compactness. 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 Von-mises stresses. Analysis is done by considering different materials for gears like Structural Steel, Gray Cast Iron, Aluminium Alloy and Epoxy E Glass UD, and results are compared.

Fatih Karpat et al. [2017] studied about Gears are one of the most crucial parts of power transmission systems in various industrial applications. Recently, there emerged a need to design gear drivers due to the rising performance requirements of various power transmission applications, such as higher load-carrying capacity, higher strength, longer working life, lower cost, and higher velocity. Due to their excellent properties, gears with asymmetric teeth have been designed to obtain better performance in applications. As the rotation speed of the gear transmission increases, the dynamic Behaviour of the gears has become a subject of growing interest. The most important contributing factor of dynamic Behaviour is the stiffness of the teeth, which changes constantly throughout the operation. The calculation of gear stiffness is important for determining the load distribution between the gear teeth when two sets of teeth are in contact. The primary objective of this article is to develop a new approach to calculate gear mesh stiffness for asymmetric gears. With this aim in mind, single tooth stiffness was calculated in the first stage of the study using a finite element method. This study presents crucial results to gear researchers for understanding spur gears with involute asymmetric teeth, and the results will provide researchers with input data for dynamic analysis.

Sameer Chakravarthy N C et al. [2014] studied about the gear fitted in the gearbox Armoured tracked vehicle. It is vulnerable to considerable fatigue damage over its life period due to the dynamic excitations caused by the terrain undulations, the rotating wheel and track assemblies. For this purpose, initially static analysis of the model was carried out to validate the model and the

boundary conditions correctness. Further Modal analysis is carried out to determine the dynamic characteristics of the gear model. The random load time history is transformed in to frequency domain using Fast Fourier transform to obtain load Power Spectral Density (PSD). Then the stress PSD response is obtained at critical node from the random vibration analysis. Once the spectrum of stress variation is obtained given input to the fatigue analysis and fatigue life is determined by FE package ANSYS 11.0.

P. B. Pawar et al. [2015] studied about The Spur gears are simplest and widely used in power transmission. In recent years it is required to operate machines at varying load and speed. Gear teeth normally fail when load is increased above certain limit. Therefore, it is required to explore alternate materials for gear manufacturing. Composite materials provide adequate strength with weight reduction and they have emerged as a better alternative for replacing metallic gears. In this work metallic gears of steel alloy and Aluminium Silicon carbide composite have been manufactured. Composites provide much improved mechanical properties such as better strength to weight ratio, more hardness, and hence less chances of failure. So, this work is concerned with replacing metallic gear with composite material so as to improve performance of machine and to have longer working life. Efforts have also been carried out for modelling and finite element analysis of gears using ANSYS 14.0. Composite gears have been manufactured by stir casting, which is economical method. Composite gears offer improved properties over steel alloys and these can be used as better alternative for replacing metallic gears.

Ram Krishna Rathore et al. [2014] studied about Gear teeth failure due to fatigue is a general incident observed. a minor drop in the root bending stress results in enormous enhancement in the bending fatigue life of a spur gear. If gear fails in tensile fatigue condition the results are cataclysmic and arise with modest or no notification. So, in spite of the reasons stated above, this paper is of more practical significance. Up till now the gear design has been enhanced by using better material, surface hardening and carburization, and shot penning for surface finish etc. Some extra efforts have been completed to enhance the durability and strength by changing the various parameters i.e., pressure angle, by asymmetric teeth, by root fillet curve alteration and so on. The majority of these techniques do not provide assurance for the interchangeability of the existing gear design. This work shows the potential by means of the stress concentration methods by inserting the stress relieving features at the most stressed area for the reduction of root fillet or bending stress in spur gear. In this work, circular and elliptical stress relieving holes are employed and better results are obtained than using circular stress relieving holes, which were employed in previous researches. A finite element model of spur gear is considered for analysis and compared with the analytical method and stress relieving features of various sizes are inserted on gear teeth at root area. In this work the optimum size and location of the stress relief features for Spur gear are proposed, which help in reducing the fatigue failure in gears.

Geramitcioski T et al. [2003] studied about the design and calculation of a spur gear transmission. One of the often-performed mechanical engineering tasks, requires a lot of long and complicated tedious computations. With today's modern technology that process that could be easily simplified by the use of the computer. However, the result for successful work of the computer programmer will be only as good as the accuracy of data of the input information as well as the procedure of calculation, provided by mechanical engineering science. In this paper, is developed the algorithm for design of the gear includes typical steps of analysis and stress calculation of the main components, such as gears, shafts and bearings. Same different calculations, resulting from the special requirements and conditions of the application's exploitations can be also included in mechanical modelling procedure, as a choice. computer program writing in a Visual C++ was also made. The computer program simplifying standard procedure of tedious mechanical computations is also provided. The advantage of the time shortening for complicate reiterations and decreasing of the routine mistakes due to use of computer program is evaluated.

Ashu Jangid et al. [2018] studied about a pair of spur gear teeth in action is generally subjected to bending stresses and contact stress. Thus, creating an explanatory methodology what's more modelling technique should assess stress dissemination might gatherings give a functional device will enhance spur gear configuration for with high effectiveness and low cosset. The reason for this work of effort may be to examine furthermore accept those bending stress appropriations over involute spur gears utilizing contemporary business FEM project ANSYS coupled for the Solid Works. Gear profiles would made over Solid Works utilizing parametric mathematical statement of involute bend something like that likewise on make it an all model, dependant on specific magic characteristics in number for teeth, diametric pitch, and weight point. These models need analysed after that broke down for 3-D and 2-D bending stresses utilizing simulation for ANSYS. Ascertained results obtained, at contrasted with standard AGMA stresses hint at beneficial concurred upon.

Rahi Jain et al. [2016] studied about a gear which is a rotating machine part having a cut tooth. which meshes with another toothed part in order to transmit torque. Gears are mainly typed like spur gears, helical gears, double helical gears, bevel gears, crown gears, hypoid gears, worm gears, rack and

pinion, epi cyclic gears etc. This paper presents the stress analysis of mating teeth of spur gear to find maximum contact stress in the gear teeth. The results obtained from Finite Element Analysis (FEA). For the analysis, 15NiCr1Mo15 and SCM415 are used as the materials of the spur gear. The spur gears are designed in the Creo Parametric and the .its file is exported to ANSYS. As Finite Element Method (FEM) is the easy and accurate technique for stress analysis, FEA is done in finite element software ANSYS 14.0. Also, deformation for 15NiCr1Mo15 and SCM415 is obtained as the efficiency of the gear depends on its deformation. The results show that the maximum contact stresses and induced bending stresses obtained from Finite Element Analysis are very less and well under the safe limit. The deformation patterns of 15NiCr1Mo15 and SCM415 gears depict that the difference in their deformation is negligible.

B. Sivakumar et al. [2018] studied about a gear or "gear wheel" is a rotating machine part having cut teeth or cogs. which mesh with another toothed part in order to transmit power. Two or more gears working in tandem are called a transmission and produce a mechanical advantage through a gear ratio and thus may be considered a simple machine. gears are mostly used in the mechanical field for power transmission, this project report on stress analysis of spur gears. Spur gear made of cast iron is considered as the conventional model in this project. The conventional model is optimized with carbon fibre high modulus material and the analysis is carried out. Boundary constraints are defined and the total deformations for model are calculated and the results are tabulated.

Krishanu Gupta et al. [2018] studied about the principal intentions of this paper are geometrical modelling and computational study. It is different static stresses on spur gears of different materials for an indigenous mechanical solar tracker. The analysed static stress results of the symmetric type involute profiled gear pair are compared on the basis of the material and the best result is selected for the application in the tracker mechanism. Providing importance on the non- renewable energy sources, solar energy is the major primary source of energy which can satisfy the human needs for the future. Gear operated mechanical Solar Tracking System is cheaper, require less skilled worker, easy to maintain and can be placed at hilly areas, remote or dusty or rainy place to help electrical power deficiency in rural areas and also can be installed easily in educational institutions, big offices, etc., which can save non-renewable sources of electrical energy for future use. The gears are one of the most imperative and crucial components in a mechanical power transmission unit, and its robustness led to the choice as mechanical component in the tracking mechanism. Since, the system is open to environment; therefore, the material selection of the gears becomes an important issue.

Dario Croccolo et al. [2020] studied about the modern design of mechanical parts. such as gears, which goes through the continuous demand for a high level of efficiency and reliability, as well as an increased load carrying capacity and endurance life. The aim of the present paper was to perform a review and to collect practical examples in order to provide interesting tips and guidelines for gear design, including both its dimensioning and its lubrication. From this point of view, this paper is particularly novel, as it is a full-comprehensive collection of all the tools supporting gear design. Several practical aspects have been taken into account, including the definition of the right profile shifting, the selection of a proper lubricant, and the definition of the quality grade and of the tolerances needed to obtain the correct backlash. Finally, a numerical example is provided, addressing the research of the best solution to fit a given space, while maximizing the transmittable torque over weight ratio for two mating spur gears.

Edmund S. Maputi et al. [2019] studied about the optimization of gears is crucial to the development of energy efficient mechanical systems. Weight, volume and power output are major objectives dependent on reduced inertia of rotary, mobile systems and losses in power transmission. In the present work, an extended version of an optimal weight design problem available in literature is investigated using multi-objective teaching and learning-based optimization (MOTLBO). Four design cases differentiated by variable ranges and sets were formulated based on an optimal weight design problem in literature. Power input and contact ratio variables were added to the design problem formulation which was investigated by previous authors as a single objective minimum weight problem. The generated Pareto frontiers were also investigated using decision-making methods viz. Linear Programming for Multidimensional Analysis of Preference (LINMAP), Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS). Results obtained reflect the trade-off effects of multiple objectives by increase in optimal weight value as compared to previous studies. The results also highlight the importance of design preference articulation by reflecting on minimum possible results which were better than some obtained in literature.

S Rajeshkumar et al. [2017] studied about parametric design and contact analysis of composite spur gears are investigated numerically. Composite gear provides an adequate strength to weight ratio, more hardness, durability and low maintenance cost. It is emerging better alternatives for replacing metallic gears. The finite element model of spur gear is developed with the assistance of the Ansys software. In this study each design factor such has stress distributions, strain and deformation are considered to compare composite gear with steel and polymer gears. An APDL gear model has been

developed for the design evaluation and comparison study.

Ali Jammal et al. [2015] studied about Gear meshing is a complicated process, and is subjected to the simulation process in the following paper. A flexible quasi-static and dynamic finite element analysis (FEA) model were built, to calculate contact principal and shear stresses. Full sized 3D spur gears are simulated under different boundary conditions. The first model, was a quasi-static analysis, where torque was used as input; and the second model, which was transient dynamic analysis, where rotational speed was used as input. The static analysis showed high stress concentration at the tooth contact point and under the contacting surface. The dynamic analysis provided the highest stress value at the different stages of gear engagement points along the line of action. Analytical and simulation result were in agreement in general, and the use of the new simulation model was discussed.

Mohammed Abdul Wafi et al. [2018] studied about auxiliary power unit (APU) is a device on a vehicle that provides energy for functions other than propulsion. They are commonly found on large aircraft and naval ships as well as some large land vehicles. The primary purpose of an aircraft APU is to provide power to start the main engines. Turbine engines must be accelerated to a high rotational speed to provide sufficient air compression for self-sustaining operation. This work provides a good understanding of spur gear design and analysis from basics, considering bending, pitting and scoring criteria. Detailed discussion of various correction factors and overview of material selection for gears is covered. It also focuses on optimization and reliability. A solved example is provided for better understanding of the concepts. In this paper, we dealt with the whole procedure for design and analysis of spur gears into a nut shell. We assumed fundamental parameters and arrived at whole geometry. Based on the given data, assumed fundamental parameters like diametrical pitch, pressure angle, etc. and using tooth proportions we arrived at the geometry of tooth. Calculating loads and stresses for force analysis of individual gears in gear train and for calculating the loads and the stresses. We used stress equations suggested by AGMA. We Estimated strength or life of gears and for that, we need to assume a standard material for gears and estimate the strength of gears using strength equations suggested by AGMA. Later we evaluated Scoring resistance. Finally, we optimized and arrived at final design by performing several iterations for optimum design. In this way the different tasks were carried out and we arrived at a conclusion.

Muhammad Farhan et al. [2015] studied about Spur gear is used to transfer rotary motion between parallel shafts. The simplicity in its design is one of the advantages of the spur gear. However higher frictional force that is accumulated on the gear teeth will influence the spur gear performance. Many previous papers elaborated extensively on the contact stress in the spur gear but few of them gave the details on how friction affects the gear teeth. There are insufficient frictional effect data in the gear and thus should be regarded as an important research parameter. In this paper, the contact stress of spur gear has been evaluated with and without friction by employing the Hertz theory, AGMA standard and finite element method (FEM). The frictionless contact stress result has been validated with both the theoretical methods with minimum deviation. Frictional coefficient range of 0.0 to 0.3 was selected and the corresponding contact stress is directly proportional to the friction coefficient. The work also involves the variation of face width of the gear set under the influence of friction. The contact stress of spur gear was found to be inversely proportional to the face width.

Deviprajwal. S. Shetty et al. [2016] studied about gears are machine members, which are perhaps the most common elements used in power transmission. Compared to the other power transmission systems such as belts, chains, or pulleys the efficiency of the gears are very high and are thus used in wide variety of application ranging from small domestic items such as watches and toys to large scale industrial applications such as turbines and propellers. Thus, the stresses in the gears must be analysed under operating conditions in order to prevent its failure. Finite element software's such as ANSYS provide a much more detailed stress distribution compared to traditional stress analysis.

Sushovan Ghosh et al. [2016] studied about Gear is basically a toothed wheel. But it is one of the most important machine elements in mechanical power transmission system. It has a wide range of applications starting from wrist watch to heavy industries due to its high degree of reliability and compactness. Reckoning the bending stress and total deformation of gear tooth is considered to be the paramount objective for modern gear design industry. The present work is an attempt to estimate the root-bending stress and total deformation of a spur gear tooth. Dimensions of the gear tooth are taken from practical understanding and is analysed for different torque specifications of the three existing vehicle models of Maruti Suzuki using ANSYS (Workbench R14.5) software considering structural steel as tooth material. The present study also concentrates on the manufacturing of gear based on composite materials at the critically stressed section with the help of software-based analysis. We suggest that, generative manufacturing or any other forms of layer-by-layer manufacturing methods could be employed for the generation of precision gears in this regard. Validation of the cantilever beam concept and Castigliano's theorem associated with the analytical calculation of gear

design, has also been contemplated in the present work.

Conclusions

Spur gear has always been a prominent topic of research among the researchers. Hence a lot of previous researches were found when searching about the literature related to spur gears. Some of the conclusions from the literature review are presented below-

- Spur gears have been in continuous focus of the researchers for their process optimization.
- Spur gears have been mostly analyzed for their material using ANSYS software through Static Structural Analysis module.
- During analysis of the spur gears, weight, volume & power have been mostly studied output parameters.
- Face width has mostly been studied for its effect on contact stress & face width if found to be inversely proportional to contact stress.
- As far as material optimization of spur gears is concerned, composite materials have been found out to be possible alternatives to the conventional material.

References

[1] Husaini, Dzikra M. Dawud, Teuku Edisah Putra, and Nurdin Ali. Failure Analysis of Spur Gears Used in Transmission System Applied on a Hand Tractor Key. *Engineering Materials Submitted: 2019-08-07 ISSN: 1662-9795, Vol. 841, pp 144-149*

[2] V. A. Gavali, C. P. Satav. Review Paper on Analysis of Spur Gear**.** *IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)**,** e-ISSN: 2278-1684, p-ISSN: 2320-334X PP. 04-07*

[3] Fatmir Azemi, Bekim Maloku, Musaj Terbunja. A Review on Design, Analysis and Shape Optimization of Spur Gears of The Gear-Box Reduction of The Working Wheel of The Excavator Schrs 1300 24/5.0 Using CAD/CAE Software. *International Journal of Mechanical and Production Engineering, ISSN: 2320-2092, Volume-4, Issue-7, Jul.-2016.*

[4] G. C. Mohan Kumar, Bilal Basheer, Sanjay Sutar, and Mrityunjay Doddamani. Material optimization of spur gear tooth**.** *Cite as: AIP Conference Proceedings 2247, 020020 (2020) Published Online: 16 July 2020*

[5] Putti Srinivasa Rao, Nadipalli Sriraj, Mohammad Farookh. Contact Stress Analysis of Spur Gear for Different Materials using ANSYS and Hertz Equation**.** *International Journal of Modern Studies in Mechanical Engineering (IJMSME) Volume 1, Issue 1, June 2015, PP 45-52*

[6] Elsayed S. Aziz, C. Chassapis. An Intelligent System for Spur Gear Design and Analysis. *Conference Paper · September 2001 DOI: 10.1115/DETC2001/DAC-21037*

[7] Deepika Potghan, Prof. Suman Sharma. Stress Reduction by Introducing Stress Relieving Features of Spur Gear Used in Lathe Headstock. *ISSN: 2277-9655 (I2OR), Publication Impact Factor: 3.785, August 2015*

[8] Dr. D. M. Mate, Guide, D.Y.P.C.O.E & T (2016). Ambi**.** An Investigative Study of Spur Gear Failure by FEA and Photoelastic method**.** *International Engineering Research Journal Page No 746-751*

[9] Prafulla M. Chor, Dr. Priam Pillai, M. E. Machine Design, PHCET. Spur Gear Contact Stress Analysis and Stress Reduction by Experiment Method**.** *International Journal of Engineering Research and General Science Volume 3, Issue 3, May-June, 2015 ISSN 2091-2730*

[10] Xiaohe Deng, Lin Hua, and Xinghui Han**.** Research on the Design and Modification of Asymmetric Spur Gear**.** *Hindawi Publishing Corporation Mathematical Problems in Engineering Volume 2015, Article ID 897257, 13 pages.*

[11] Miss. Kachare Savita**.** A Comparative Study of Design of Simple Spur Gear Train and Helical Gear Train with An Idler Gear by Agma Method**.** *International Journal of Innovation in Engineering, Research and Technology [IJIERT] ICITDCEME'15 Conference Proceedings ISSN No - 2394-3696*

[12] Ms. Nilesha U. Patil, Mr. Sunil P. Chaphalkar, Mr. Gajanan L. Chaudhari. Stress Analysis of Spur Gear by using Different Materials: A Review. *International Conference on Ideas, Impact and Innovation in Mechanical Engineering (ICIIIME 2017) ISSN: 2321-8169 Volume: 5 Issue: 6 355 – 363*

[13] Fatih Karpat, Oguz Dogan, Celalettin Yuce and Stephen Ekwaro-Osire. An improved numerical method for the mesh stiffness calculation of spur gears with asymmetric teeth on dynamic load analysis.
Advances in Mechanical Engineering 2017, Vol. 9(8) 1–12 The Author(s) 2017 DOI: 10.1177/1687814017721856

[14] Sameer Chakravarthy N C and B Subbaratnam. Finite Element Analysis and Fatigue Analysis of Spur Gear Under Random Loading. *ISSN 2278 – 0149 www.ijmerr.com Vol. 3, No. 4, October 2014 © 2014 IJMERR.*

[15] P.B. Pawar, Abhay A Utpat. "Analysis of Composite Material Spur Gear under Static Loading". *Condition Materials Today: Science direct, Proceedings 2 (2015) 2968 – 2974*

[16] Ram Krishna Rathore, Abhishek Tiwari. Bending Stress Analysis & Optimization of Spur Gear. *International Journal of Engineering Research & Technology ISSN: 2278-0181 Vol. 3 Issue 5, May – 2014*

[17] Tale Geramitcioski, Ljupco Trajcevski. Design Analysis of Spur Gear with The Usage of The Advanced Computer. *Conference Paper · January 2003*

[18] Ashu Jangid, Sandeep Kumar. Modelling and Simulation Analyses for Bending Stresses in Involute Spur Gears by Finite Element Method. *International Journal of Applied Engineering Research ISSN 0973-4562 Volume 13, Number 12 (2018) pp. 10914-10923*

[19] Rahi Jain and Pratik Goyal. Design and Analysis of Gear-Box Using Spur Gear and Eliminating the Differential Unit. *International Journal of Mechanical Engineering and Technology (IJMET) Volume 7, Issue 6, November–December 2016, pp.510–517, Article ID: IJMET_07_06_050, ISSN Print: 0976-6340 and ISSN Online: 0976-6359*

[20] B. Sivakumar, I. Joe Michael. Design and Stress Analysis of Spur Gear. *International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056 Volume: 05 Issue: 05 | May-2018 www.irjet.net p-ISSN: 2395-0072*

[21] Krishanu Gupta, Sushovan Chatterjee. Analysis of Design and Material Selection of a Spur gear pair for Solar Tracking Application, *ScienceDirect Materials Today: Proceedings 5 (2018) 789–795 PMME 2016*

[22] Dario Croccolo, Massimiliano De Agostini, Giorgio Olmi and Nicolò Vincenzi. A Practical Approach to Gear Design and Lubrication: A REVIEW. *Received: 9 June 2020; Accepted: 14 August 2020; Published: 20 August 2020*

[23] Edmund S. Maputi & Rajesh Arora. Multi-objective spur gear design using teaching learning-based optimization and decision- making techniques, *ISSN: (Print) 2331-1916 (Online) Journal PUBLISH -17 DEC. 2019*

[24] S Rajeshkumar and R Manoharan. Design and analysis of composite spur gears using finite element method. *14th ICSET-2017 IOP Publishing IOP Conf. Series: Materials Science and Engineering 263 (2017) 062048 doi:10.1088/1757-899X/263/6/062048*

[25] Ali Jammal, Hui Wang, Yiming Rong. Spur Gears Static and Dynamic Meshing Simulation and Tooth Stress Calculation. *DOI: 10.1051/ C Owned by the authors, published by EDP Sciences, 2015 / 00 (2015) conf 201 Web of Conference*

[26] Mohammed Abdul Wafi, Sufyan Mohiuddin, Mohammed Noman Ahmed, Syed Yousuf Imtiaz. Design and Analysis of Spur Gear Train for APU Gear Box in a Manned Aircraft Vehicle. *International Journal of Advance Research and Development. Volume-3, issue 1*

[27] Muhammad Farhan, Saravanan Karuppanan and Santosh S. Patil. Frictional Contact Stress Analysis of Spur Gear by using Finite Element Method. *Applied Mechanics and Materials Online: 2015-07-08 ISSN: 1662-7482, Vol. 772, pp 159-163*

[28] Deviprajwal. S. Shetty, K. G. Gurukiran, Manish, Manish. R. Jagtap, Prashantha. B. Y. Design and Evaluation of Bending Stress of a Spur Gear Using ANSYS. *International Journal of Emerging Research in Management &Technology ISSN: 2278-9359 (Volume-5, Issue-5), MAY -2016*

[29] Sushovan Ghosh, Rohit Ghosh, Bhuwaneshwar Patel, Tanuj Srivastava, Dr. Rabindra Nath. Structural Analysis of Spur Gear Using Ansys Workbench 14.5. *International Journal of Mechanical Engineering and Technology (IJMET) Volume 7, Issue 6, November–December 2016, pp.132–141, Article ID: IJMET_07_06_015, ISSN Print: 0976-6340 and ISSN Online: 0976-6359*

[30] Yatika Gori, Chandan Swaroop Meena, Nitesh Dutt, Shivansh Gour. "FEA-based Design and Analysis of Spur Gear", International Journal of Materials, Manufacturing and Sustainable Technologies (IJMMST) Vol. 1, Issue 1, page 21-27, 2022 https://doi.org/10.56896/IJMMST.2022.1.1.004

[31] Khanna, R., Sinha, P.K. (2021). Structural Analysis of Spur Gear with Composite Material Under Different Loading Conditions. In: Muzammil, M., Chandra, A., Kankar, P.K., Kumar, H. (eds) Recent Advances in Mechanical Engineering. Lecture Notes in Mechanical Engineering. Springer, Singapore. https://doi.org/10.1007/978-981-15-8704-7_73

[32] Amit Kumar Shah, Mrs. Priyanka Jhavar. "A Review Paper on Static Structural Analysis of Spur Gear with Different Materials", IJARIIE, Vol-8 Issue-4 2022

[33] C. Sivakumar, A. Geethaselvarani (2022). Comparative Stress Analysis of Spur Gear with Various Speed. AIP Conference Proceedings **2426**, 020039 (2022); https://doi.org/10.1063/5.0127213