Manufacturing a bicycle delivering power equivalent to an automobile with the help of gear trains and chain drives: A Review

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***Abstract*:** After the study of various research papers on gears velocity ratio is taken as our process parameters. Then calculated the number of teeth, wear rate, power required for experimentation using theoretical approach. Further study of chassis design used to find the appropriate design of chassis according to the load sharing capacity and resistance to air. The study of chain drives were considered to decide the appropriate selection of chain weather single, duplex or triplex for effective transmission. Ball bearings were studied to confirm the fluency in transmission and load bearing capacity in it. The survey on brakes discusses the life of brake and the effect due to impact braking on them. And the review of tyres was done to understand the friction between tyre and road and the effect of temperature on tyre due to friction and their wear rate. The review of e-bike enlightened on the use of electricity to run the bicycle without paddling with the help of batteries.

Keywords: Gear, Chassis design, Chain drive, Brake, Tyre, Bearing, E-bike

1. Introduction

Ever since bicycles came with more than one sprocket on the front and back, they were usually referred to as the number of gear combinations that were offered. It wasn't that long ago that frames were made out of cast iron or even wood. Today bicycles are made out of exotic materials such as titanium, aluminum, and carbon fiber. Bicycles are made up of multiple sprocket and free wheel combinations; but as the input speed is itself low hence the output speed also is not that effective. Hence giving very high speed initially will automatically increase the output speed and attain a speed of an automobile. In our project the main part of this bicycle is the gear box where a combination of spur gears may lead to increase in output speed. The bicycle is having disc brakes for proper braking system and a compact design for better aesthetics. Although having more benefits of this bicycle applied torque may be one of its drawback as speed and torque are inversely proportion hence to attain high speed less torque is required and as higher speed can never been achieved directly from start. So we have to start from higher torque.

2.1 Literature Survey of machining processes:

The modern machining processes considered in this work are categorized in the following subsections separately as machining of granite using various techniques, water jet cutting, optimization techniques used.

2.1 Literature Survey on Gears:

Aleksey Suslin and Clovis Pilla [1] presented a study of point involute gear where they conducted test where two gears to be tested were mounted on test rim. The point involute gear had three pairs of teeth in contact which make it more hard than simple spur gear. They conducted the test up to gears fail where the spur gear point involute gear tooth. But the endurance limit to bending of point-involute gear does not significantly differ from that of involute spur gear. Hence point-involute gears can be implemented in gas turbine. But the manufacturing of point involute gear was difficult. Huaiju Liu et al. [2] studies the tribological performance of a coated spur gear pair buy developing a numerical coated thermal elastohydrodynamic lubrication model of coated gear tooth meshing. The generalized Reynolds equation is applied to incorporate the effect of thermal environment and the non-Newtonian lubricant. Energy equations of the oil film as well as the tooth solids are proposed to solve the temperature distribution within the contact region. The DC-FFT method is used to solve the surface elastic deformation where the influence coefficient is expressed in the frequency domain. Effect of working conditions and the coating properties on pressure, film thickness, surface traction, as well as the temperature are studied within the whole process of gear meshing. Atul surface et al. [3] experimented with AISI 4140 steel, particulate composite material AA 2014/A1203/10% and glass fiber reinforced polymer spur gear pairs. The damping properties of all the three materials were compared through experimental set up. The noise level was measured for the pair of spur gear of these three different materials at various speed of rotation. The present work includes the investigation into the effect of the damping properties of gear material and noise level in spur gears for light load application in automotive vehicles. The results indicated that glass fiber reinforced polymer spur gears are better than metal gears in light load power transmission applications due to their lesser noise and damping factor. X. Liu et al [4] explains dynamic wear prediction methodology is proposed by combining a translational-

rotational-coupled nonlinear dynamic model with a quasistatic wear model to investigate the coupling effects between surface wear and dynamic behaviors in a spur gear system. Based on the analyzes varied out in this study, the following conclusions can be drawn that the accumulated surface wear alters the mesh stiffness and the transmission error of the gear pair, thus affects the dynamic characteristic of the gear system significantly. The initial surface wear contributes to reduce the amplitudes of dynamic response and eliminate tooth separations of the gear pair operated at a resonance peek. However, additional wear amounts may aggravate the system vibration characteristics and cause tooth separations. The effects of surface wear on period of steady dynamic response are negligible except for the primary resonance peak. To improve the wear prediction accuracy, the translational deflections in the gear system must be included. During the mild wear stages, the effect of operational condition on surface wear is very weak. However, the wear depths are affected by the operating speed noticeably after some wear cycles. The wear depth values are the largest when the gear system operates near the second spur-harmonic resonance peak while achieve the smallest when operates near the primary resonance peak. A Diez-Ibarbia et al [5] experimented the load sharing impact on the efficiency of spur gears with modified profile was assessed in this work. The aim was to analyse the influence of the profile modifications on the load sharing, which also considers the effect of the torque level on the system deflections, and how these load sharing variations affected the system efficiency. Due to the frictional effect importance on power losses, in the operating conditions considered, sliding friction between teeth in presence of lubricant was studied in this proposal. The results established that tip relief improves the efficiency of the system due to the reduction of effective contact ratio. Moreover, there is a tip relief which makes optimal the efficiency in specific operating conditions, corresponding to the unit value of the effective contact ratio. Thus, the main conclusion of this work is that the tip relief which makes optimal the efficiency coincides with the theoretical dynamic optimum of the transmission. Huimin Dong et al [6] summarized the gear box configurations used in wind turbines first, and concluded that (Planetary Gear Train) PGT is the best transmission device as wind turbine gear box. For demonstrating the dynamic characteristics of PGT, the paper presented a dynamic model developed by lumped-parameter method incorporating time-varying

mesh stiffness. Then, taking a PGT as an example, its dynamic characteristics are discussed. The results show that support stiffness has a significant influence on load sharing, not obvious on gear vibration. Floating sun gear can improve the dynamic properties weakened by error and elasticity. Hence, this design can offer greater torque density by increasing the number of planets. Jun Qui et al. [7] presented a study on the development of wind power from 2000 to 2015. The main current type of gear box of wind turbine under different rated power are summarized, and the feature types of gear box with power split transmission are presented and will be predicted in the future wind turbines with more than 5 MW. In order to obtain the new types of gear box for 6W wind turbines, a new types synthesis approach is proposed by means of the state space methods. Through the operation of the duel vectors of the internal and external meshing transmission unit according to the connection rules of series, parallel and hybrid, the state equation of different gear transmission system are derived. Laxmikant S. Dhamande and Mangesh B. Chaudhari [8] aims to address the effect of bearing defect on gear vibration signature and effect gear defect on bearing vibration signature. Also it purpose is to make vibration monitoring set up is designed for analyzing the defect in outer rave of bearing and damaged tooth of gear. MATLAB is used for feature extraction and neural network is used for diagnosis. In the literature, many authors have analyzed defects in bearings and gears separately. But it is found that the real situation may be more complex. The work presents a laboratory investigation carried out through an experimental set up for the study of combined gear-bearing fault. This paper proposes a novel approach of damage detection in which defects in multiple components are analyzed using vibration signal. H. Xiao et al. [9] in this work, the lumped masses and springs dynamic model of the gear-shaft-bearing-housing system has been established to study the vibration transmission and energy dissipation characteristics through the multiple transmitting interfaces under the impulse excitation due to gear fault. The acceleration responses for different transmitting components, under the half-sine impulse force with different time duration, different amplitudes and different shaft rotating speeds were calculated. The vibration transmission and energy dissipation through the multiple interfaces were characteri8zed by the defined vibration transmission ratio and energy dissipation ratio. Obvious attenuation in acceleration magnitude has been observed between the transmitting components from

gear to housing. The maximum attenuation occurs at the transmission from inner rave to outer race and the minimum is between the outer race and the housing. The time duration of the impulse force determines the resonance and also the vibration transmission characteristics of the system. The energy dissipation increases nonlinearly with the amplitude of the applied impulse force and can be approximated using a power-law relation. It has also been shown that the interface between inner rave and outer rave, and the interface between gear and shaft are the main sources of energy dissipation in the system, which dissipated about 60% and 40% of the total energy. However, the vibration amplitude, vibration transmission and energy dissipation shows slight dependence on the shaft rotating speed. Experiments have been performed to validate the characteristics derived from the numerical results. N. Saravanan et al. [10] shows the fault diagnosis of Gear box is one of the core research areas in the field of condition monitoring of rotating machines. The work conducted, proposing the method of the gearbox fault identification based on fuzzy logic technique, shows the great potentiality and the strong ability to classify and identify machinery faults. This work has investigated the use of basic fuzzy logic principle as a fault diagnostic technique for spur bevel gearbox. The work conducted has demonstrated the potential of fuzzy logic to classify the likely fault conditions which are represent in rotating machinery. From the study carried out and presented in this paper, the diagnosis technique based on the fuzzy logic principle is found to be practical is found to be practical for the condition recognition of the gearbox. Also this work brings out the potential of decision trees to generate the rules automatically from the feature set which proves to be a great asset in generating fuzzy rules. This work has outlined the procedure of fuzzy diagnosis technique by using the characteristic variable which represent a particular running condition of the gearbox to determine the fuzzy membership function.

2.2 Literature Survey on Chain Drives:

NielsFuglede and Jon Juel Thomsen [11] presented an exact and approximate kinematic analysis of a roller chain drive modeled as a four-bar mechanism is presented. The span connects the sprockets such that they rotate in the same direction, and the sprocket size, number of teeth, and shaft center distance can be arbitrary. The driven sprocket angular position, velocity and acceleration, as well as span length, are calculated and their (discontinuous) variation

with driver angular position and main design parameters is illustrated. Kinematic prediction for the chain span motion are compared to results of multibody simulation, and there is seen to be very good agreement. All together this gives new insights into the characteristics of chain drive kinematics and the influence of main design parameters. Y. Wang et al. [12] experimented a new sprocket tooth profile which can effectively reduce the dynamic effect and meshing impact of chain drives. The tooth profile is obtained by modifying the traditional involute tooth profile. It can guarantee that the moving distance of the chain at any moment is equal to the arc length of the pitch circle to be turned, and that the roller center line of the tight side is always targent to the pitch circle of the sprocket. The new tooth profile enables rollers to mesh with the sprocket gradually so that the impact force between rollers and sprocket is reduced.

2.3 Literature Survey on Tyres :

A. Le Bot et al [13] the vibration in tyres submitted to random forces in the contact zone is investigated with the model of prestressed orthotropic plate on visco-elastic foundation. It is shown that beyond a cut-on frequency a single wave propagates whose speed is directional-dependent. A systematic numerical exploration of the governing equation solutions shows that three regimes may exist in such plates. These are modal field, diffuse field and free field. For actual tyres which present a high level of damping, the passage from low to high frequencies generally explores the modal and free field regimes but not the diffuse field regime. A. Kunnappillil Madhusudhanan et al. [14] a load Sensing Bearing based road-tyre friction estimator is proposed in this work. The use of the combined tyre slips and tyre forces enables an effective estimation in the presence of longitudinal dynamics, lateral dynamics and both. The estimator is studied in a simulator environment and validated with test data from a BMW 5 series E60 model test vehicle equipped with LSB technology. The main benefits of proposed estimator are: it is effective during combined tyres slip situations; it is robust as no parameterized tyre model is used, it can be employed to individual tyres and it is computationally inexpensive. Jan Krmela and Vladimira Krmelova [15] explains that the paper deals with method for dynamic experiment of parts of car radial tyres. The aim of research work of authors is also propose and evaluate the experimental procedures for cyclic loading of selected parts of tyres with textile reinforcement and rubber matrix. The universal testing device

Autograph AG-X plus 5 kN – Schimadzu with video-extensometer with test mode Control of software Trapenzium X was used for experiments. The five cycle loop were used. Every cycle loop consisted of five cycles, every cycle ios defined as loading to certain precent of elongation and unloading to certain present of elongation. The fifth cycle can be used as steady state for comparison of behaviour between specimens with different cord angle. Knowledge about characteristics of dynamic experiment such as cyclic tensile loading is necessary for the verification analysis between experiments and computational modeling of tyres by FEA. Also the determination of material parameters from experimental data will be used as input data to computational modeling of tyres. H>R>B> Bosch et al. [16] this paper focuses on the parameterization, validation and implementation of an Ftire model of a Michelin LTX A/T2 235/85R16 tyre. This tyre is designed for both on- and off-road use and is commonly used on all wheel drive SUVs. Quasi-static laboratory and dynamic field tests were con ducted to acquire parameterization and validation test data for the Ftire model. Quasi-static parameterization tests include acquiring vertical tyre stiffness over a flat plate and cleats, tyre footprint sizes and shapes, longitudinal, lateral and torsional tyre stiffness for various tyre normal load, as well as vibrational tyre responses. Dynamic parameterization tests include dynamic cheat test data. An Adams model of the tyre testing equipment is implemented to simulate the Ftire model and validate it against dynamic validation test results. Finally, the model is implemented on the fully nonlinear multi-body dynamics model of a Land Rover Defender. It is found that the Ftire model is able to predict the lateral tyre behaviour well on a smooth road surface. The vertical and longitudinal tyre behaviour on a smooth road surface and on a rough surface are predicted accurately. Julien Cesbron and Philippe Klein [17] the paper deals with the relationships between tyre/road noise levels measured by the Coast-By (CB) and the Close-ProXimity (CPX) methods. For that purpose, tyre/road noise was measured for a passenger car fitted with four identical patterned tyres rolling on a set of 15 imprevious road surfaces. The CPX and CB measurement methods have been used simultaneously on each road surface at vehicle speeds ranging between 50 km/h and 110 km/h

2.4 Literature Survey on Chassis Design:

R. M. Makharoblidze et al. [18] offered the theory of turn of adaptive bodies of mountain self-propelled chassis designated as power

unit in small farming enterprises. Is derived the design formula of radius of turn for two variants: drive on all six drive steering wheels, and without drive of forward steering wheels. The design formula reflects the impact of slip of forward steering wheels, redistribution of loading an wheels hook resistance, coefficient of blocking of differential, distance between centers of in pairs connected tandem wheels with center point suspension and other geometrical, kinematical and dynamical parameters. Akash Chaudhary Raghuvanshi et al. [19] this paper is about the design and development a GO KART named as "ASHVA" which can be folded by its mid with the help of a joint that connected between its two chassis front chassis-rear chassis. The strength analysis of the joint has been done with the help of ANSYS software. Further the development had been done after the designing and analyzing the joint of chassis. Pratiksh Boliaet al [20] a non-linear vehicle dynamic control system is described for an over-actuated vehicle equipped with in-wheel hub motors and sbw system. Full vehicle model simulation results shows that the proposed vehicle control structure enhances the vehicle stability and handling limit. A robust analysis framework is introduced to analyse theoretically the stability of the proposed vehicle control structure with respect to the vehicle parameter uncertainty. The most attractive feature of the proposed robustness analysis framework for the multi parametric uncertainty is that the whole analysis can be performed in the complex domain 2-dimensional rather than in the multi dimensional parameter space. Mohd Azizi Muhammad Nor et al [21] this paper aims to model, simulate and perform the stress analysis of an actual low loader structure consisting of I-beams design application of 35 tonne trailer designed in-house by Sumai Engineering Stn. Bhd, (SESB). The material of structure is Low Alloy Steel A 710 C (Class 3) with 552 MPa of yield strength and 620 MPa of tensile strength. The scope of this study concern on structural design of the I-beams for info and data gathering, which will be used for further design improvement. Finite element modeling (FEM), simulations and analysis are performed using a modeling software i.e. CATIA V5R18. Firstly, a 3-D model of low loader based on design from SESB is created by using CATIA. Stress and displacement contour are later constructed and the maximum deflection and stress are determined by performing stress analysis.

2.5 Literature Survey on Brakes:

Y. Zhang et al [22] explains the local Nusselt number on the surface of brake disc decreases along the radius direction. ON the surface of the brake disc the ratio of the local Nusselt number to the average Nusselt number is related to the diameter ratio of the brake disc to the rolling wheel, and is less sensitive to Reynolds number. A diameter ratio of the brake disc to the rolling wheel, and Reynolds number is obtained. Because of the influence of the ground, the average Nusselt number on the surface of the brake disc is largely dependent on the diameter ratio of the brake disc to the rolling wheel and Reynolds number. A correlation among the average Nusselt number ratio, the diameter ratio of the brake disc to the rolling wheel, and Reynolds number is obtained. E. M. Attia et al [23] the fluid is inserted between the rotating and fixed discs and a magnetic field is imposed on the fluid. In this paper, a complete test rig for an MR fluid disc brake is introduced. Experiments are conducted to measure the braking torque and speed of shaft during braking process and the result are presented at different voltage input to the brake. David Lie and Cheng-Kuo Sung [24] presents an investigation on the braking performance and safety for a bicycle riding on a straight and an inclined paths. The equations of motion for a wheel model as well as the model for ideal synchronous braking are derived to acquire the shortest braking distance and improve the riding stability. The optimal design of the bicycle braking is obtained based on the simulation results with various bicycle geometries, ratios of brake force, and road friction. Thomas J. Mackin et al [25] determined that the thermal cracking in disc brake rotors is a low cycle thermo-mechanical fatique problem. The frictional work of braking rapidly heats the rotors while having no effect on the hat region. This difference in temperatures sets up compressive thermal stress in the rotor during braking that reverse sign upon cooling. Thermo-mechanical stresses were calculated using a simple shrink-fit analysis wherein the hat was modeled as constraining the free thermal expansion of the rotor. These stresses were found to exceed the yield strength in the rotor over considerable distances from the hub and were very near the yield strength over most of the rotor. O. Maier et al. [26] presented the physical simulation model with its topology, modeling and parameterization. Especially, the quality of the parameters is crucial for the validity of the simulation results. For this reason all necessary parameters are collected systematically. Although the simulation model generates accurate results, some improvements can be made to extend examination possibilities. For example, the

precise internal geometry of both brake caliper and sensor adapters were disregarded in this study. Furthermore, both hydraulic fluid properties and friction coefficient between brake pads and disc are assumed to be constant during a simulation run. A multidimensional characteristic diagram would allow taking into account a temperature and pressure dependence of the fluid.

2.6 Literature Survey on Bearings:

I. S. Barmanov and M. N. Ortikov [27] significantly influence the interference on the ball on the dynamic characteristics and durability of the radial-thrust bearing was established in the work. The result permits to quantify the change in dynamic characteri8stics and durability of the bearing when you change the amount of interference on the balls. V. M. Nistane and S. P. Harsha [28] defined the quality of feature is extracted from vibrations signals for effective prognostics of bearing. These features explore information of forecasting the time of failure before it occurs. Scalar parameters illustrate damage of ball bearing but they do not provide information about the location of defect. The spectrum analyses are investigated at running test durations in order to envisage defect locations. The defect size can be depends upon vibration magnitude and its severity. Guangwei Yu et al. [29] the 4-DOF bearing dynamic mathematical model and the vibrating characteristics of deep groove ball bearing such as displacement, velocity and acceleration are solved by four order Runge-Kutta Method and Matlab. And the period of the model is consist with the theoretical value. By using the dynamic mathematical model, the influence of load on vibration acceleration of bearing is analyzed. It is concluded that the vibration response of the bearing is different under the same rotating speed and different load, and the effect of load on vibration acceleration is non-monotonic. Based on the mentioned model, the influence of rotating speed on vibration acceleration of bearing is analyzed. The results show that the vibration response of the bearing is different under the same load and different rotating speed.

2.7 Literature Survey on E-Bike:

C. Abagnale et al [30] the present paper deals with a wide activity carried out on a prototype of an innovative power-assisted bicycle. After the design and the modeling of the vehicle characterized by some innovative solution, the control has been implemented and testing on a suitable test rig has been

carried out. The feedback for the control is constituted by a new measurement system of the driving torque that characterizes the proposed bicycle. The results highlight that the proposed approach provides reduced tracking errors and good robustness; moreover, it performs better than classical pedelec assistance systems.

Conclusion:

The optimization of this bicycle done with the help of gears and chain drives to attain the speed equivalent to an automobile is possible.

Future Scope:

As there is a useless use of fuel and energy crises is any bottleneck of energy resources to economy. They gasoline shortage of World War II brought about the resurgence of horse-and-wagon delivery. Large fluctuations and manipulations in future derivatives can have a substantial impact on price. Hence in such cases having a convenient transport facility becomes almost a fatigue. Therefore having such a bicycle that would reduce your time of ferry would be best option to rely on.

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