A Review on Carbon Fiber Sprocket Design Analysis and Experimental Validation

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Abstract- *Roller chain or bush roller chain is the type of chain drive most commonly used for transmission of mechanical power on many kinds of domestic, industrial and agricultural machinery, conveyor bicycles, cars and tube drawing machines, motorcycles, and printing presses. It consists of a series of short cylindrical rollers held together by side links. It is driven by a toothed wheel called a sprocket. We see there are some common problems that might occur when using a sprocket chain like broken bush, pins, sprockets etc. In our project, we are going to model a sprocket chain in 3D modeling software (CatiaV5), meshing will be done in Hypermesh and for post processing we will use Ansys. A sprocket chain will be manufactured with carbon fiber material. Testing will be carried to validate the results between numerical and analytical model.*

Keywords- chain drive, sprocket, modeling, meshing, post-processing, manufacturing, testing and validation.

I. INTRODUCTION

The roller chain design reduces friction compared to simpler designs, resulting in higher efficiency and less wear. The original power transmission chain varieties lacked rollers and bushings, with both the inner and outer plates held by pins which directly contacted the sprocket teeth; however this configuration exhibited extremely rapid wear of both the sprocket teeth, and the plates where they pivoted on the pins. This problem was partially solved by the development of bushed chains, with the pins holding the outer plates passing through bushings or sleeves connecting the inner plates. This distributed the wear over a greater area; however the teeth of the sprockets still wore more rapidly than is desirable, from the sliding friction against the bushings. The addition of rollers surrounding the bushing sleeves of the chain and provided rolling contact with the teeth of the sprockets resulting in excellent resistance to wear of both sprockets and chain as well. There is even very low friction, as long as the chain is sufficiently lubricated. Continuous, clean, lubrication of roller chains is of primary importance for efficient operation as well as correct tensioning.

II. LITERATURE REVIEW

Following is a list of researchers who has worked in this area of sprocket chain and optimization. The combination with the following literature research on the latest use of alternate materials is expected to make the investigation as complete as possible.

Ebhota Williams S, Ademola Emmanuel, OghenekaroPeter[1] "Fundamentals of Sprocket Design and Reverse Engineering of Rear Sprocket of a Yamaha CY80 Motorcycle", International Journal of Engineering and Technology Volume 4 No. 4, April, 2014

This study involves the fundamentals of sprocket design and manufacturing of a Yamaha CY80 motorcycle rear sprocket through reverse engineering approach. It discusses dimensioning, drafting, chemical composition, material selection, choice of manufacturing process, heat treatment, surface finish and packaging as the eight steps that need to be followed sequentially in this reverse engineering approach. In this work, universal milling machine was used to produce the sprocket from the blanked medium carbon steel (AISI 1045) with chemical composition of C=0.45%, Mn=0.75%, P=0.03% max, S=0.04%. Induction heat treatment was applied to move the material hardness from 13 HRC to 45 HRC as shown by hardness test.

R. V. Mulik, Prof. M. M. Joshi, Dr. S. Y. Gajjal, S. S. Ramdasi and N. V. Marathe[2] "Dynamic Analysis of Timing Chain System of a High Speed Three Cylinder Diesel Engine", International Journal of Engineering And Science Vol.4, Issue 5 (May 2014), PP 21-25 Issn (e): 2278-4721, Issn (p):2319-6483

The scope of the work includes developing a simulation model in suitable simulation software and its dynamic analysis. The results are expressed in terms of parameters such as contact forces and normal forces between different components and link tension forces etc. The results presented in this paper shows that the external forces and loads can be easily sustained by the timing chain components. The obtained values for the contact forces, tensions etc. were much below the maximum permissible values. The layout designed is compact, functionally and dynamically stable and

safe and can be implemented in actual engine. The current layout can be modified further to a single chain layout for more compact and reliable design. The current methodology thus proves to be a fair solution to analyze timing chain drives, a vital component of an engine.

Candida Pereira, Jorge Ambrosia, AmilcarRamalho[3] "Contact Mechanics In A Roller Chain Drive Using A Multibody Approach", 11th Pan-American Congress of Applied Mechanics Copyright © 2009 by ABCM January 04-08, 2010

In this work, a novel multibody methodology to address the kinematic and dynamic effects of roller chain drives is presented. The chain itself is modeled as a collection of rigid bodies, connected to each other by revolute clearance joints. Each clearance revolute joint, representing the connection between pair of links, is made up of the pin link/bushing link plus the bushing link/roller pairs, if the chain is a roller chain. The clearance joint approach is further extended to the roller/sprocket teeth surface contact pairs. The internal conformal contact and the external contact between these cylindrical geometries is described using a new analytical model that puts together the precision of the contact force evaluation with the numerical efficiency required. To start the dynamic simulation and to ensure the accuracy prediction outcomes of the dynamical behavior of these nonlinear mechanical systems, a proper set of initial conditions on the positions and velocities of the chain drive components is required. Furthermore, the problem of contact initialization and its coordination with the numerical integration procedures is taken into account by controlling the time step size of the numerical integration algorithm in the vicinity of the impact. The methodologies adopted results in a computer program general enough to analyze very different chain drive systems, e.g. chain drives in industrial machines, marine engines, car engines or motorbikes. This methodology is demonstrated through its application to the study of a bicycle roller-chain drive being the methodological assumptions discussed in the process.

Sine LeergaardPedersen[4] "Simulation and Analysis of Roller Chain Drive Systems", PHD Dissertation, technical university of Denmark

The research objective of the work presented in this thesis is to contribute with a novel theoretical basis for the analysis of chain drive systems, by posing and validating different mathematical models, and compare to the prior done research. Even though the model is developed at first for the use of analyzing chain drive systems in marine engines, the methods can with small changes be used in general, as for e.g. chain drives in industrial machines, car engines and motorbikes.

C Conwell[5] "An Examination of Transient Forces in Roller Chain Drives",. Ph.D. Dissertation: Vanderbilt University, Nashville, TN, 1989.

The work is related to roller chain so further discussion will be limited to chain of this type. Chain drives were poorly understood through the 1980's for a variety of reasons, including the polygonal action, nontrivial sprocket geometry, intentional clearances and 14 unintentional dimensional variations due to manufacturing tolerances, friction, and the large number of bodies that make up the typical chain and sprocket system. The manufacturer of roller chains has been standardized by the American National Standards Institute under standard B29.1 (ANSI,1972) since 1913. The first report in an ASME journal devoted to the study of roller chain drive based upon sprocket impact loads and experience. Bremer reported on marine applications and analyzed the various loads on chain drives.

SwapnilGhodake, PrashantDeshpande, ShrikantPhadatare[6], "Optimization of Excavator Sprocket and it's Validation by Test Rig Concept", Conf. on Advances In Engineering And Technology, ISBN: 978-1-63248-028-6

In an excavator, a sprocket is a toothed wheel that engages with a chain or track to transmit rotary motion. Sprocket, track and idler form an assembly to cause the motion of excavator. Optimization is a methodology of making something (as a design, system, or decision) as fully perfect, functional, or effective as possible to maximize productivity or minimize waste. In this paper, sprocket weight optimization is done with reducing material to get optimized design which can perform well under torque condition keeping same constraints. For this purpose, an FEM tool is used for analyzing existing and optimized sprocket with different types of FEA techniques. Strain Gauging is done for correlation with FEA virtual strain to confirm the loadings. Conceptual Test rig is proposed to validate the optimized sprocket.

V.V.R.Murthy, T.Seetharam, V.PrudhviRaj[7] "Fabrication and Analysis of Sprocket Side Stand Retrieval Systems", International Journal & Magazine of Engineering, Technology, Management and Research, ISSN No: 2348-4845

From the above research it was concluded that "Sprocket- side stand retrieve system" will definitely good retrieve system. since the setup is compact it does not affect the performance of the vehicle. because of the power is obtained from chain drive. Definitely this system could be

used in all type of two-wheelers (Tvs-XL, all front, back, hand geared)for retrieving the side stand ,it will be the major system to control accidents due side stand problem and protect the careless rider. These system can be implemented in all types of bikes by changing small variation in size and cost of this system also very low and so it will not affect the eco¬nomic level also while compare to other system this SPROCKET SIDE STAND RETRIEVE SYSTEM will be the life saver.

Tushar D. Bhoite, Prashant M. Pawar&Bhaskar D. Gaikwad[8] "Fea Based Study of Effect of Radial Variation of Outer Link in A Typical Roller Chain Link Assembly", International Journal of Mechanical and Industrial Engineering, ISSN No. 2231 –6477, Vol-1, Issue-4, 2012

The paper delves into various application aspects and manufacturing aspects to formulate an idea of the system. Finite Element Analysis (FEA) has been used to conduct shape optimization. Since lot of work has already been done in other components, in this paper the focus has been narrowed down to specific component of outer link. Within the outer link, most dimensions in the industry are parametrically defined, however one dimension, the radius that is in between the inter connecting holes is left to manufacturer convenience. In this paper we assess the impact of this radius on the stress in the system, and see if material saving and consequently efficiency increment is possible.

Karim H. Shalaby, SimonaLache, and Florin Corciova[9] "Contact Forces Analysis of an Analogous Huygens Pendulum Using Inverted Tooth Chain", International Journal of Materials, Mechanics and Manufacturing, Vol. 4, No. 3, August 2016

The paper analyses and brings to light the importance of contact forces of the Inverted Tooth Chain (I.T.C.) plates on the sprocket wheel at different locations on the Analogue Huygens Pendulum, knowing that the contacts between plates and sprocket always cause vibrations and noise. The MSC ADAMS SOLVER/VIEW software, which is based on multibody dynamics, is used for simulating the contact forces. The simulation results lead to the conclusion that the contact between the plates of the inverted tooth chain (I.T.C.) and the sprocket produces elastic-plastic impacts.

III. CONCLUSION

This literature review work includes study of design and analysis of sprocket chain. Also study the various optimization techniques. For the finite element based optimization purpose the study of suitable software for optimization of weight and selection of alternate material will carry out by referring different books and earlier research works published in reputed journals.

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