Stress Analysis for Helical Gear and Development of New Gear Routing Algorithm

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Abstract— It is an important need for future to identify key problems in gear operations and develop new solutions as an algorithm software extension for existing packages like CATIA. The core objective of the paper is to present the real-time helical gear stress analysis and identify problems which may cause major gear failure. Also, the newly developed algorithm is presented to provide the new way for automatic gear analysis. In gear drives during transmission of power, a set of teeth undergoing two categories of cyclic stresses as bending stress which may lead to fatigue and contact stress leading to the possibilities of failure and fatigue. Gear factors such as pressure angle, helix angle have an impact on the load holding ability of gear teeth. Adequacy in bending load holding potential of a gear unit is a key condition. To look for the realistic bending stresses at tooth origin is extremely important part of a legitimate design for the gears. Also, there is a need of enhancement in gear design and testing technologies to provide more easy and reliable way. As CATIA software delivers the unique ability to model any product, but there is no facility for damage or deformation level testing. The present research provides new application programming interface (API) algorithm named "Gear Routing Algorithm" which provides very precise analysis of every gear tooth with even small deformation detection. As a theoretical method contribution, this research also suggests correction factor.

Index Terms— Stress Analysis, Helical Gear, Catia, Mechanical Algorithm

1 INTRODUCTION

As a consequence of the superior degree of integrity and compactness, gears might predominate because of so many effective methods for power transmission in the forthcoming era. Gear modeling is mostly a remarkably difficult art. The continual need to enhance inexpensive, quick functioning; lesser weight and much more robust equipment have led to a reliable shift in gear pattern. There are many categories of gears from those spur gears and additionally, helical gears are being used for transmitting power or mobility involving a couple of parallel shafts. Helical gears have more advantages than other gears especially spur gears like it has the smoother engagement of teeth, silent in operation, can handle a heavy load, high efficient etc.

Due to these advantages, it has the wide range of applications in high-speed high-power mechanical systems [1]. Gears predominantly fail in contact fatigue mode (pitting/spall) due to combined rolling and sliding motion [2]. Adequacy in bending load carrying potential of a gear unit is an issue. Within the industries, better potency, better integrity together with lesser weight gears are essential as lighter weight machines are usually in demand.

In the past, gears used to be analyzed by certain analytical methods that were based on a number of assumptions. This means that the theoretical methods do not provide the accurate stress value. The critical section of a gear tooth experiences bending stresses that cause most of the failures. The critical area is a section of a gear at which the fillet of a tooth commences. During the meshing of the tooth, internal dynamic forces are induced because of the elastic tooth deformation and manufacturing errors.

For stress analysis, photoelasticity [3] is a full-field technique which directly provides the information of principal stress difference and the orientation of principal stress direction by the fringe analysis of components made of birefringent materials. In particular, when experimental analyses concerning 3D photoelasticity are carried out, one of the most challenging issues relies on the determination of the most suitable load to be used for the stress freezing process.

This paper presents new gear routing algorithm to provide facility for stress analysis for helical gear.

2 LITERATURE REVIEW

The challenges of explaining the actual form of the contacting areas of gears are presented by several authors. As per a study by, reference [4], the real geometry is still a problem of great interest, especially when complex gear profiles are to be manufactured by means of face milling. Recently, a few solutions concerning an enhanced grid near to the contact are offered. These techniques allow getting adequate options either in the case of fillet stress together with of contact stress; nevertheless, they maintained an organized mesh in the enhanced case, to make sure that certain elements were over-stretched.

Furthermore, the procedure has not been suited in case of helical gears and/or misalignments, due to the fact in such cases the contact section is not a far more coincident along with the refined grid.

Reference [5] brought out investigation of pressure where a finite element pattern for stress evaluation of gear forces is suggested with the supreme goal of finding appropriate outcomes concerning contact and as well , bending stresses with reduced computational expense than those finite element designs where mesh improvement is not utilized. The applied procedure to finite element version permits the complete cycle of meshing reviewed and is structured on the usage of multi-point system for mesh advancement and besides that the application of elements by way of a lowered quantity of the usage points. Node synchronizations are computationally and immediately decided by request of the gear theory.

Additional as per reference point [6] the utilization of industrial universal numerical finite element software program has become an more and more well-known substitute for equipment tension analysis and this research compares the basic twisting stresses in exterior encourage gears established using ISO 6336:2006, AGMA 2101-G04 and statistical limited component evaluation (ANSYS) with fresh stress gauge validation.

Reference [7] provided information about latest advances in fatigue test monitoring techniques using signal processing stress monitoring of elements. These modern techniques are less time-consuming consist of simply applied quick cure coatings and record the fringe order using fully automated polar scope system.

As per reference [8] have studied that complex spur gear geometry with variable length of tooth contact lines during meshing period results in complex load distribution in gear mesh and the author used conjugated geometry with the line of contact of gear geometry for analysis.

3 Gear Analysis Algorithm (GAA)

Any gear steps by additional gear in order to transfer forces among diverse units in a system. Gears are produced by a number of ways. For any model assignment, it is usually essential to attention about teeth geometry, in order to achieve the best possible stresses with the layer or possibly in the major of helical pinion. A great suitable angles is needed to accomplish circular find. On the other hand, producers frequently assess, just abrasive estimated, ensuing in rubbing and wear results.

More precisely, the goal is to describe the point to point movement to be used within the design of helical gear. Three parameters are the required algorithm input data: the torque, the number of teeth and the pressure angle. The formula is established upon the equations of the spherical field and underlying width. The involute of the basic eliptical is utilized to pull the tooth information. The algorithm can be converted into any kind of system terminology. Even so, GAA-algorithm is recommended in order to evaluate it with a genetic protocol strategy providing Matlab code (which in turn can certainly employ as a plug-in with CATIA).

Following figure-1 shows GAA output for helical gear analysis. The plot for vertical and horizontal direction gives exact tooth stress position. From these graphs, the system records the positions for each tooth for desired pressure angle and variable torque etc. Further, loading condition can be analyzed and recorded to maintain historical data sheets.

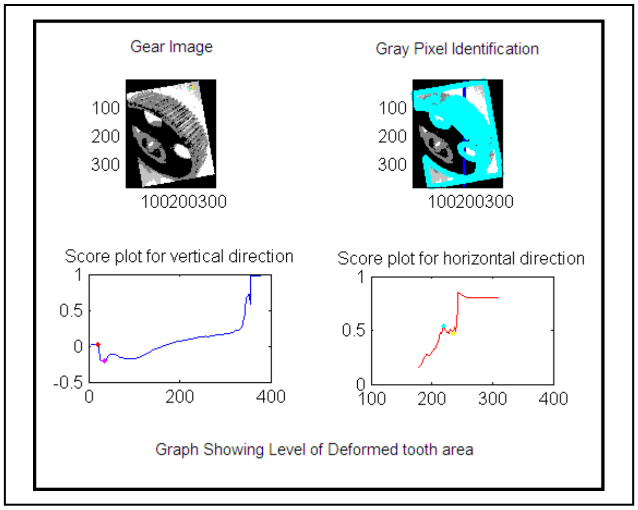

Figure1: GAA output for helical gear stress analysis

There is a fairly good agreement between bending stresses at the critical section under static condition by both experimental methods i.e. strain gauge analysis and 3-D photoelastic analysis, maximum error recorded is 3.86%. In a static state, the bending stresses at critical section by the theoretical method and finite element analysis are very close to each other, recorded error within 5.39%. The maximum error recorded between experimental and finite element analysis results is 16.75%, whereas between experimental and theoretical results is 10.49%. This lager variation in bending stress is due to theoretical and finite element methods based on certain assumptions. These assumptions give the surplus values of the bending stress as compared to the values obtained by photo elastic and strain gauge methods.

4 Conclusion

Although Gear Analyzer Algorithm (GAA) is developed for helical gear performance evaluation and gear failure due to stress, it can be also used for spur and worm gear design evaluation. GAA may use as a standalone or bundled API for other mechanical design software.

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