MODELING AND SIMULATION OF BEVEL GEARBOXES IN CAD ENVIRONMENT

Adam MARCINIEC, Bartłomiej SOBOLEWSKI

Rzeszow University of Technology Faculty of Mechanical Engineering and Aeronautic Powstańców Warszawy Av.8, 35-959 Rzeszów, Poland email: b_sobolewski@prz.edu.pl; amarc@prz,edu.pl

Summary

Designing and manufacturing of aeronautic bevel gearboxes is a complicated and time-consuming process. This is due to the high quality requirements to the aviation industry products and the complex kinematic of the machining process. So far, in practice, this process has required a series of research and prototypes testing. The development, has been made in the field of Computer Aided Design systems, allows increasing use in design process and carry out the necessary research in the CAD environment. This approach simplifies and accelerates the aeronautic bevel gearboxes design process.

The study presents process of gears solid models generating and carrying out simulate of cooperation bevel gearbox in the CAD environment. Solid models has been prepared by the solid machining simulation, while the performed analyzes are used to determine temporary tooth bearings, summary tooth bearing and motion graphs.

Keywords: CAD model, simulation cutting, bevel gears,

MODELOWANIE I SYMULACJA WSPÓŁPRACY PRZEKŁADNI STOŻKOWYCH W ŚRODOWISKU CAD

Streszczenie

Proces projektowania i wdrażania do produkcji lotniczych przekładni stożkowych jest zagadnieniem złożonym i skomplikowanym Wynika to ze względu na wysokie wymagania jakościowe stawiane wyrobom przemysłu lotniczego oraz na złożoną kinematykę samego procesu obróbki. Dotychczas w praktyce proces ten wymaga przeprowadzenia serii badań i testów prototypów. Rozwój jaki dokonał się w dziedzinie komputerowych systemów wspomagania projektowania. Umożliwia coraz szersze wykorzystanie w procesie projektowania oraz przeprowadzenie części niezbędnych badań w środowisku CAD, upraszczając i przyśpieszając proces projektowanie lotniczych przekładni stożkowych.

Artykuł przedstawiał będzie generowanie modeli bryłowych kół zębatych oraz przeprowadzenie symulacji współpracy przekładni stożkowej w środowisku CAD. Modele bryłowe otrzymywane są na drodze bryłowej symulacji obróbki, natomiast wykonane analizy pozwalają na określenie chwilowych śladów styku, sumarycznego śladu współpracy i wykresów nierównomierności ruchu.

Słowa kluczowe: model CAD, symulacja obróbki, przekładnie stożkowe

1. INTRODUCTION

The use of CAD systems in bevel gearboxes design process enables to perform a preliminary analysis in order to verify them both in terms of manufacturing technology and accuracy of bevel gearbox cooperation. The analysis in the CAD environment allow to determine the temporary and summary tooth bearing as well as obtain motion graphs. This allows to simplify and accelerate the design and implementation to manufacturing by reduction the number of prototype bevel gearboxes necessary to perform. All analyzes presented in this paper was carried out in Autodesk Inventor environment.

2. ANALYSIS OF COOPERATION

Bevel gears solid models used to analysis of bevel gearboxes cooperation have been obtained by three-dimensional machining simulation [1]. Thus obtained pinion and gear solid models are assembled together in construction gearbox intended to analyzes of gearbox cooperation (Fig. 1).

Fig. 1. Construction bevel gearbox solid model

Conducted analyzes were designed to obtain temporary and summary tooth bearings, contact path on a gear and pinion tooth flank, line of action and motion graph.

Temporary and summary tooth bearings were obtained by performing geometric analysis of gearbox cooperation. In order to obtain temporary bearing, there were assembled tangentially cooperating gears surfaces. In next step, to obtain bearing, solid of pinion was moved into gear solid by a distance resulting from the resilient strain of cooperating gears [2]. As a result of Boolean intersection operation obtained temporary bearing. The summary bearing the sum of temporary bearings appearing during the gearbox work on the tooth surface. During the simulation gears are rotated with the assumed discreet rotation. Because of the accuracy of the obtained results important is the way of determining discreet rotation of cooperating solids. The most commonly used method for determining the discreet rotation based on the gearbox geometric ratio does not reflect the actual gear teeth flanks cooperation. The method which allows to eliminate the inaccuracies of this type is rests on the assumption a constant value of the discreet rotation angle for only one of the cooperating gears, rotation angle of the cooperating gear results from the tangency of cooperating surfaces. In each of the discreet positions generated temporary bearings as described above. As a result of summing them created a summary bearing shown in Fig. 2.

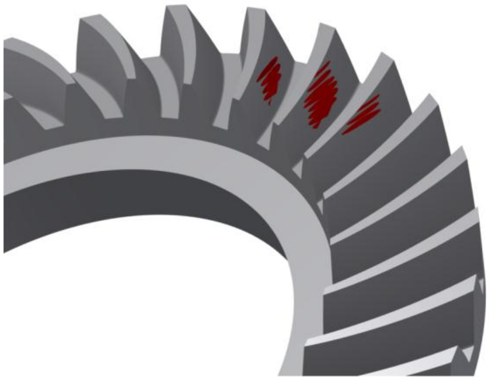

Fig 2. Summary bearing on the gear tooth flank

Generating a contact path and line of action requires the determination of geometric center points of temporary bearings. Determination of center points of bearings obtained on the bevel gearboxes gears surfaces is troublesome due to the geometric complexity of the surfaces. In order to eliminate such difficulties was prepared a new method of determining the contact line and line of action. Construction gearbox has been modified by adding an additional element in the sphere form with small, relative to the gears, radius. Between flank surfaces of the gearbox gears have been left constraints from previously described construction gearbox. An additional element is bonded with the inner flank of the gear tooth and the outer flank of the pinion tooth surface using the tangency constraint. Flank surfaces of the teeth and surface of the intermediate element, connected in this way, have only one common point (Fig. 3). This point is also a center point of the temporary bearing.

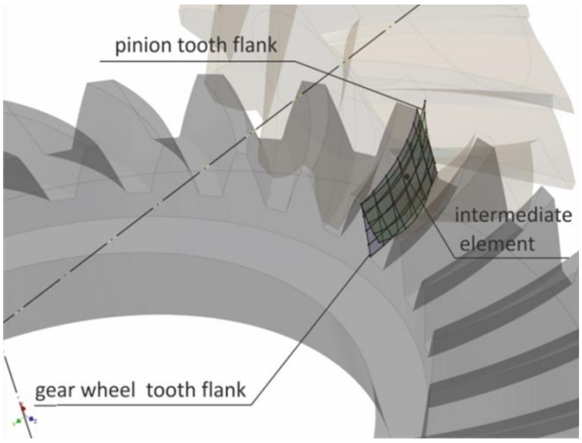

Fig. 3. Analysis of the bevel gearbox cooperation with the intermediate element using

Assembly of construction gearbox, connected in the manner described above, maintains mobility. Generating on its basis the contact line on the teeth surfaces and the line of action is based on recording the path of the temporary bearing center point in the suitable coordinate system. Contact lines (Fig. 4a and 4b) in the coordinate systems connected with the gears, and line of action (Fig. 4c) in the assembly of construction gearbox coordinate system.

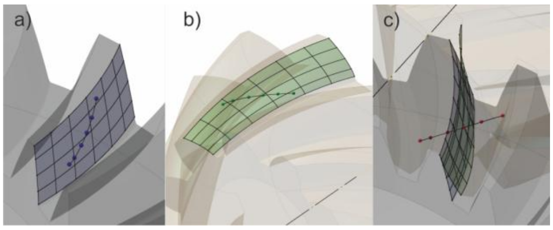

Fig. 4. Results of motion simulation of a gear drive: a) contact path on a gear tooth flank b) contact path on a pinion tooth flank, c) line of action.

The bevel gearbox solid model was also used to generating the motion graphs. In order to obtain the motion graphs is required to register the rotation angles of cooperating gears in each discreet positions of bevel gearbox. Due to the possibility of registering the changes of elements rotation angles, kinematic analysis was carried out in the dynamic simulation environment of the Inventor program. To the bevel gearbox solid model was added a mainstay to enable the analysis in dynamic simulation environment. Gears have been connected rotatably with the mainstay, and then on the cooperated flanks applied the contact constraint (Fig. 5). Moreover, added fixing in order to get an assembly moving. As a result of prepared analysis obtained, using output ghrapher, graphs showing changes of rotation angles during simulation.

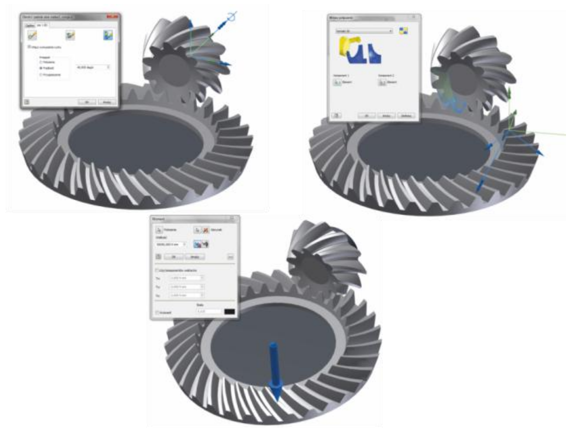

Fig. 5. Bevel gearbox solid model in the dynamic simulation environment

In the next stage, using the Excel program, created processing of data obtained in the kinematic analysis and getting motion graph for bevel gearbox (Fig. 6).

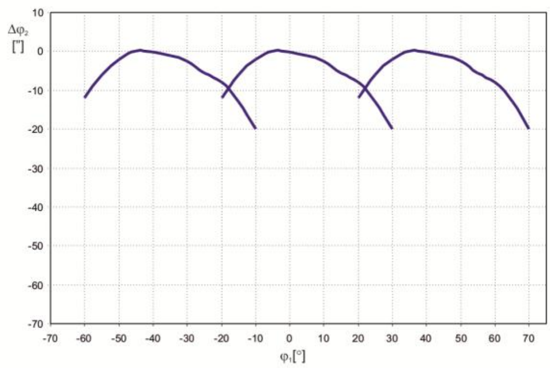

Fig. 6. Exemplary motion graph

To confirm the compliance of the obtained results, they were compared with the results obtained from the commercial KIMOS software (Fig. 7).

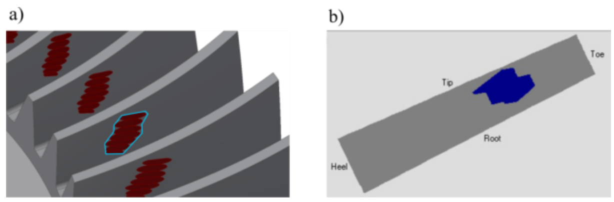

Fig. 7. Comparing the results obtained: a) in CAD system, b) in KIMOS software

3. CONCLUSIONS

Presented in this article examples of using CAD systems in modeling and analysis of bevel gearboxes of Gleason system show the usefulness of these methods in the process of design. Due to the possibility of making assumptions of assembly errors or displacements errors (resulting from the usage) in the gearbox model, presented method can be used in the machinery and equipment diagnosis.

Financial support of Structural Funds in the Operational Programme - Innovative Economy (IE OP) financed from the European Regional Development Fund - Project "Modern material technologies in aerospace industry", Nr POIG.01.01.02-00-015/08-00 is gratefully acknowledged.

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Adam Marciniec, DSc, PhD, Eng. is an Associate Professor in mechanical engineering since April 2003 at the Rzeszow University of Technology. He has been working as an academic for 28 years at the Department of Mechanical Engineering, Faculty of Mechanical Engineering and Aeronautics of the university. His research activity focuses on issues related to the use of numerical methods and computer technology (CAD, CAM, FEA, Rapid Prototyping) for the analysis and computer simulations aimed at improving the quality and operational parameters of machine parts and assemblies. In particular, he concerns on the problems of design and manufacturing of gears, especially bevel and hypoid gears. He has been involved in a number of nationally funded research projects on machine parts, assemblies and gear drives.

Bartłomiej Sobolewski, PhD, Eng. works in the Department of Machine Design at the Faculty of Mechanical Engineering and Aeronautics of the Rzeszów University of Technology.His scientific research interests include issues related to the use of CAD/RP methods in designing and analysis of the mechanical design, and gears in particular.