DETERMINE THE PRECISION OF AVIATION BEVEL GEAR, MADE BY THE SELECTED INCREMENTAL TECHNIQUES AND USING AN OPTICAL SCANNER ATOS II TRIPLE SCAN

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Summary

Designing and manufacturing of aeronautic bevel gearbox is a complicated and time-consuming process due to complex kinematics of the machining process and numbers of manufacturing methods. Algorithms used in manufacture process are usually provided by machine manufacturers. Using other and commonly available calculation algorithms requires a lot of studies to verify whether the proposed gearbox works correctly. In order to reduce the manufacturing costs of prototypes, it is possible to use Rapid Prototyping methods.

Using coordinate optical measurements enables to determine the accuracy of prototypes manufactured by selected methods using and introduce such changes in the model to get the best accuracy of mapping models. Increasing the accuracy of the models enables to verify the correctness of assumptions made in the initial stage of product designing. This approach reduces significantly both prototyping time and manufacturing costs.

The article presents the model ling and manufacturing process of aeronautic bevel gear taking into consideration the accuracy of selected Rapid Prototyping methods. The gear modeling is based on machining simulation method conducted in Autodesk Inventor software. The measurement results are shown in displacement maps obtained with an optical scanner Atos II Triple Scan and universal GOM Inspect Professional software, which determines the prototype accuracy in relation to 3D-CAD models.

Keywords: CAD model, simulation cutting, rapid prototyping optical measuring,

OKREŚLENIE DOKŁADNOŚCI KÓŁ ZĘBATYCH LOTNICZEJ PRZEKŁADNI STOŻKOWEJ WYKONANYCH WYBRANYMI METODAMI PRZYROSTOWYMI Z ZASTOSOWANIEM OPTYCZNEGO SKANER ATOS II TRIPLE SCAN

Streszczenie

Projektowanie oraz wytwarzanie lotniczych przekładni stożkowych jest skomplikowanym i czasochłonnym procesem ze względu na złożoną kinematykę procesu obróbki oraz ze względu na liczne metody wytwarzania. W procesie produkcji stosowane są zazwyczaj algorytmy dostarczane przez producentów obrabiarek. Wymaga to znacznych nakładów finansowych, a w efekcie podnosi koszty wykonania wyrobu. Zastosowanie innego ogólnie dostępnego algorytmu obliczeniowego wymaga przeprowadzenia szeregu badani mających na celu weryfikacje poprawności pracy projektowanej przekładni. W celu ograniczenia kosztów związanych z wytwarzaniem prototypów metodami ubytkowymi możliwe jest wykonanie prototypów metodami przyrostowymi.

Dzięki zastosowaniu współrzędnościowych pomiarów optycznych możliwe jest określenie dokładności otrzymywanych wybranymi metodami prototypów i wprowadzenie takich zmian w modelu aby uzyskać jak najlepsza dokładność odwzorowania modeli. Podniesienie dokładność modeli umożliwia ich wykorzystanie do weryfikacji poprawności poczynionych założeń konstrukcyjnych w początkowym etapie powstawania wyrobu. Podejście takie skutkuje znacznym skróceniem czasu prototypowania oraz obniżeniem kosztów produkcji.

Artykuł przedstawiał będzie proces modelowania i wytwarzania stożkowych kół zębatych stożkowej przekładni lotniczej, z uwzględnieniem dokładności wybranych metod RP. W modelowaniu kół zębatych wykorzystana zostanie metoda symulacji obróbki prowadzona w środowisku oprogramowania Autodesk Inventor. Przedstawione zostaną wyniki pomiarów w postaci map odchyłek uzyskane z zastosowaniem optycznego skanera Atos II Triple Scan oraz uniwersalnego oprogramowania GOM Inspect Professional, określające dokładność prototypów w odniesieniu do wzorców 3D-CAD.

Słowa kluczowe: model CAD, symulacja obróbki, szybkie prototypowanie, pomiary optyczne.

1. INTRODUCTION

Despite of the continual progress, bevel gearboxes are still indispensable elements of power transmission systems. They are widely used in many industries, therefore, have to meet a number of requirements. The most specific requirements are associated with using bevel gearboxes in the aviation industry. Manufactured gear boxes are required to transmit high load while maintaining high reliability and with minimum weight and noise level reduced. For this reasons, in the aviation industry are used bevel gearboxes with the circular-arc tooth line. Bevel gears design process for the aviation industry is a difficult and complicated issue due to the complex gear boxes geometry and kinematics of machining process as well as the numerous methods of bevel gears manufacturing. Therefore, at the gear design stageis necessary to verify it's correctness of work. Determinants of the bevel gear quality is the location, shape and size of the cooperation trace as well as evenness of the power transmission. To determine the correctness of cooperation of the bevel gearbox gears is necessary to carry out research in laboratory which entails the necessity of gears manufacturing. This is time and costs consuming.

Process which has been made in the field of computer-aided design systems makes running simulations of bevel gears cooperation possible. Nevertheless, it is still necessary to produce a gear prototype to be examined. The increasing use in manufacturing process are gaining additive manufacturing technologies, that is why it was decided to examine the suitability of rapid prototyping methods to produce bevel gears prototypes. The study aimed to determine the geometrical accuracy of prototypes produced using different rapid prototyping methods. The paper present the results obtained for the pinion.

2. PROTOTYPING

The first stage of the research was creating bevel gears solid models in a CAD environment. The bevel gearbox's gear solid models have been created using the solid machining simulation method. The bevel gears machining simulation due to the complex machining kinematics belongs to the most complicated cases of creating gears solid models in the CAD environment [2,4]. The gearbox model has been created using the SGT method of the Gleason company. Machining simulation is based on an iterative execution of subtract operations of the machined bevel gear and tool in the subsequent positions resulting from the machining kinematics. Simulations. Method of creating solid model using machining simulation method is presented on the example of the concave side of the pinion tooth.

In the first stage, the tool solids and the work piece envelopeare created and placed on the basis of setup parameters. Then, the machining simulation process is carried out involving iterative execution of subtract operation of the tool solid from the work piece solid in the positions resulting from the kinematic of the actual machining process (fig. 1)

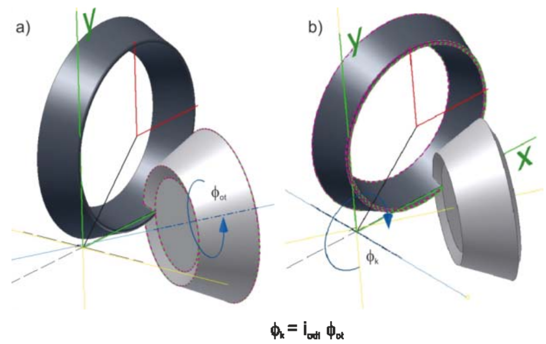

Fig. 1. Carrying out the machining simulation: a) discreet rotation of the envelope, b) discreet rotation of the tool

After completing machining simulation obtained a concave surface of a tooth pinion. (fig. 2)

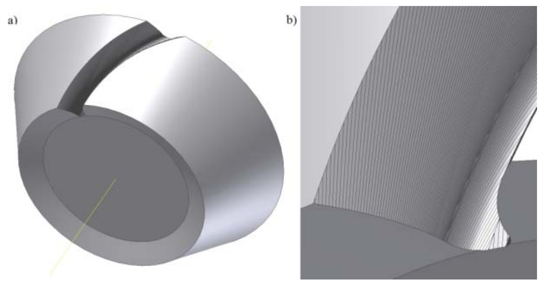

Fig. 2. Simulation results: a) obtained concave surface of tooth side, b) detailed view

Then, in the same way have been conducted a machining simulation of the convex side of tooth pinion. As a result of the assembly obtained one notch. In the next stage, in order to simplify the complete bevel gear modeling procedure, a notch surface obtained in simulation process has been replaced by a smoothed surface. This surface has been used to generate a solid model of the pinion (Fig. 3).

Fig. 3. Obtained gears solid models of bevel gearbox

In subsequent stage, on the basis of a solid model, after export to a format appropriate for the RP devices, the prototypes have been produced using two methods of Rapid Prototyping: FDM and PolyJet.

3. DETERMINATION OF THE PROTOTYPES ACCURACY

Determine the geometric accuracy of the obtained prototypes were carried out using modern measurement methods. To do so, has been used an optical scanner of blue light – ATOS II Triple Scan. Using this tool allowed to gather information on the entire geometry of the analyzed models. It allowed for more precise determination of the accuracy and usefulness of rapid prototyping methods used in the study. After the measurement was performed an analysis of measured model's displacements in relation to the 3D-CAD model using GOM Inspection program. The results obtained in the color global displacements maps form on the basis of which were determined displacements of the tooth profile in selected sections [1,3]. The results obtained for the prototypes made by FDM method are shown in Fig 4 and 5.

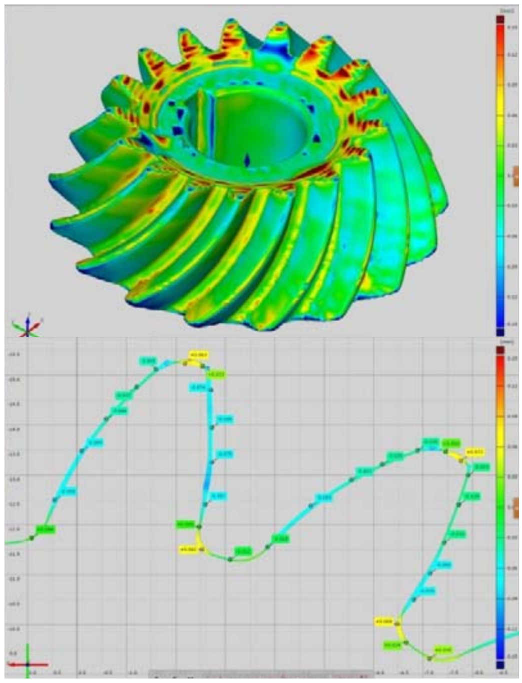

Fig 4. Displacements map obtained for the pinion model made by FDM method

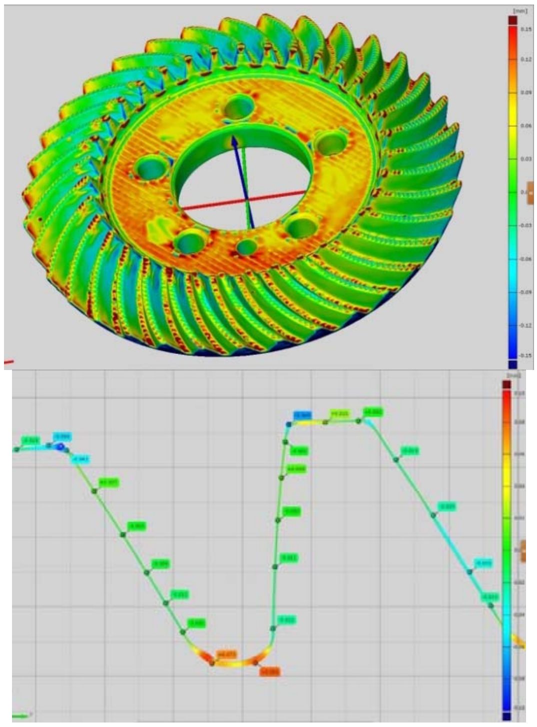

Fig. 5. Displacements map obtained for the bevel gear made by FDM method

Analysis of the obtained measurement results showed that the tooth profile displacements are smaller than 0,1 mm, and the maximum values come to 0,15 mm. Analogous measurements and analyzes were performed for the prototype made by PolyJet method. Results are shown in Fig. 6 and 7.

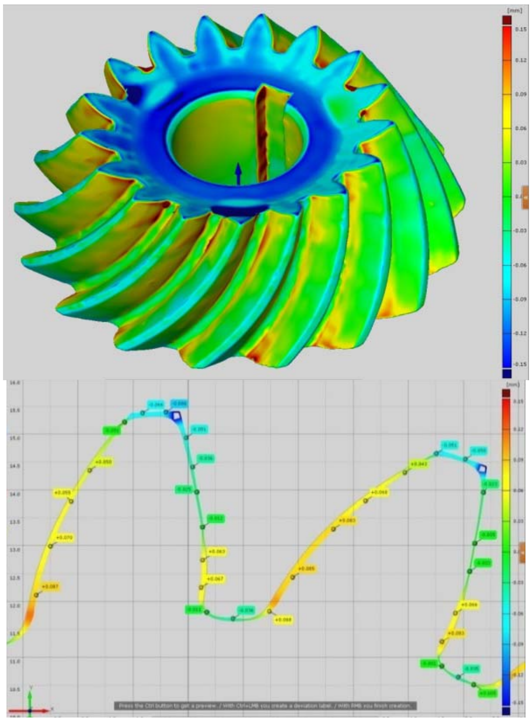

Fig.6. Displacements map obtained for the pinion model made by PolyJet method

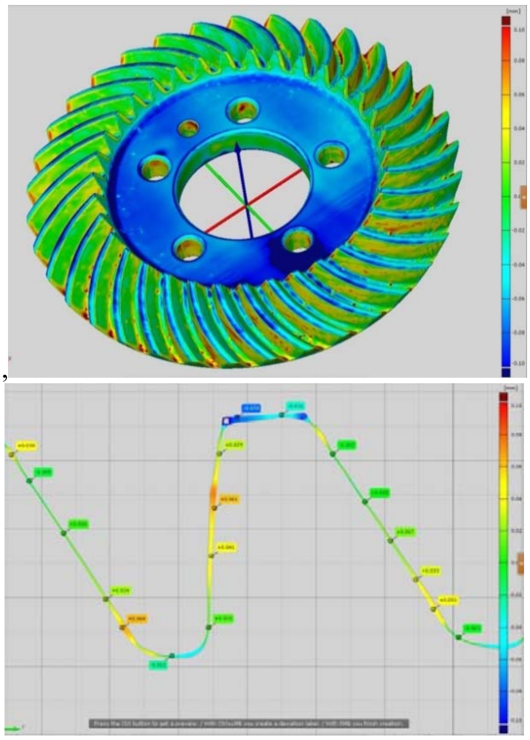

Fig. 7. Displacements map obtained for the bevel gear made by PolyJet method

In the case of the model made in PolyJet technology were observed similar values of displacements as in the case of FDM technology using. Moreover, it should be noted that displacements measured on the concave (active) side of the pinion tooth are smaller.

4. CONCLUSIONS

The study shows that using modern prototyping methods, based on computer-aided design systems and rapid prototyping methods, is possible to create actual models with correctness about 0,1 mm. On the basis of optical measurements and results of analysis it is possible to determine the size of geometry modifications of the produced prototype aimed at overcoming the errors generated in the rapid prototyping process. Their implementation willimprove the correctness of models thus allowing for production by Rapid Prototyping methods

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