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The Use of Reverse Engineering to Create FEM Model of Spiroid Gears

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Abstract

This paper describes the process of creating a digital model of spiroid gears used in the defense industry. This is where the precise measurement of the parts with the highest requirements for accuracy is of great importance The construction of a computational model of a physical object was carried out using an optical three-dimensional scanner. Based on the cloud of points obtained in the process of scanning, a spatial digital model reflecting the geometry of an existing element was developed. Polygonization and mesh reconstruction allowed to create a finite element method model that enabled the precise reproduction of the scanned object. The created model was subsequently used to conduct appropriate analysis and simulation to verify the correctness and possible modification of the construction of both elements of spiroid gears: worm thread and face gear.

Keywords

reverse engineering, 3D scanning, point cloud, spiroid gear, FEM

1. Introduction

Reverse engineering is reconstruction of surface in three dimensions that uses the so-called point clouds. This technique converts a large number of measured data points into a concise and consistent computer representation [1]. A surface that was constructed from scanned points in the three-dimensional space was converted into a geometrical shape as shown in Figure 1.

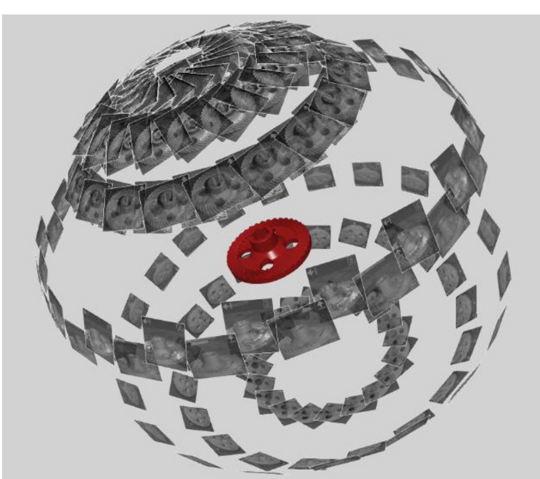

Figure 1. Assembly of the model from several dozen scans.

During the measurement, a fringe pattern that is captured by two cameras, in the ATOS three-dimensional (3D) scanner, is projected onto the surface of the measuring object (Figure 2).

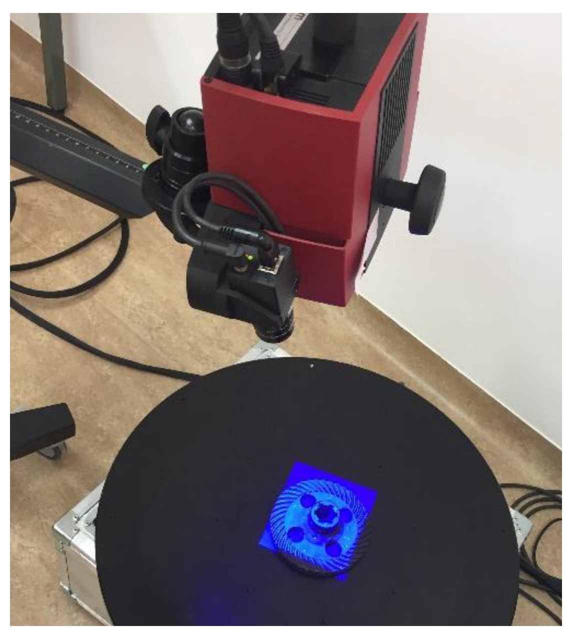

Figure 2. A view of the face gear measurement using an ATOS 3D scanner on a standard rotation table. 3D, three-dimensional.

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Both elements of spiroid gears, worm thread and face gear, in real are shown in Figure 3. Furthermore, there will be described the process of creating digital model of spiroid gears.

Figure 3. Both elements of spiroid gears: worm thread and face gear in real.

The construction of a computational model of a physical object was carried out using an optical 3D scanner [2]. Based on the obtained results, in the process of scanning point cloud, a spatial digital model reflecting an existing element was developed. Polygonization and mesh reconstruction [3] allowed to create a finite element method (FEM) model that enabled the precise reproduction of the scanned object. The created model was subsequently used to conduct appropriate analysis and simulation to verify the correctness and possible modification of the construction of both elements of spiroid gears: worm thread and face gear.

2. Methods

For completely capturing complex model geometry, different partial views need to be combined. Using reference points, the software transforms the single measurements into a global coordinate system. The number of such individual measurement is determined by how completely the measuring object is scanned.

When the captured object is complete, polygonization can be started. The single measurements are available as separate preview meshes. The preview mesh is edited automatically and converted into a single mesh of nonoverlapping triangles. With these curvatures of the measuring spiroid gears, the triangle mesh has a high density. Polygon meshes can be smoothed, thinned, and refined as shown in Figure 4.

Some corrections of surface discontinuities of the measuring object such as dust, scratches, shavings, dents, etc. were carried out using the ATOS Professional software. In addition, holes in the mesh were filled and curvatures were extracted. The mesh was processed using curvature-based algorithms [4] and tolerances. It was also refining mesh done what increase the polygon density in the selected surface, e.g. to refine the shapes of edges and radius of worm thread and face gear. One iteration increased the number of polygons in the selected area three times. However, there was a need to refine the resolution on the edges to be able to mil directly and to get a tooth outline, which is shown in Figure 5.

The mesh can be smoothed based on the adjustable surface tolerance. In case of a corner, the effects of the smoothing are only visible in the colored deviation view (Figure 6.)

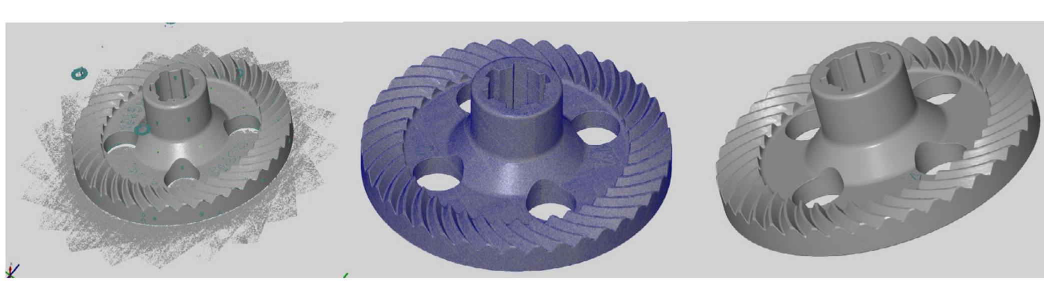

Figure 4. Raw data of point cloud (left), polygonized surface of the measurement object with the polygons displayed (middle), and the object after polygonization (right).

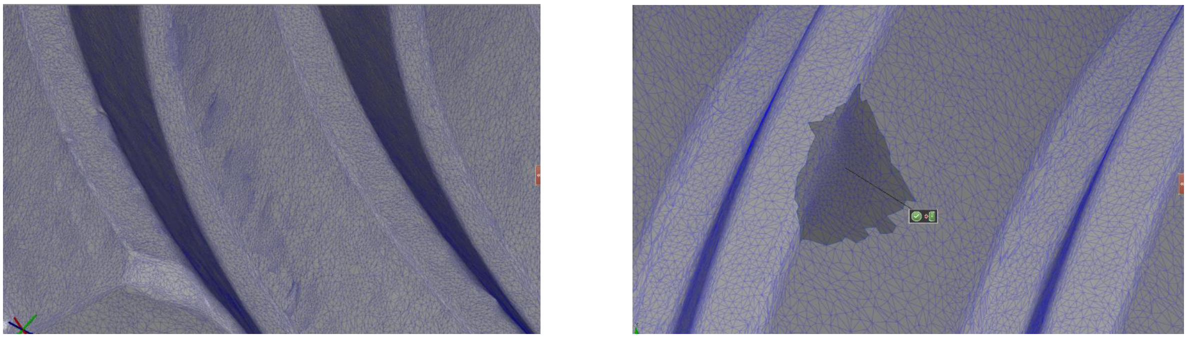

Figure 5. Refining mesh to increase the polygon density.

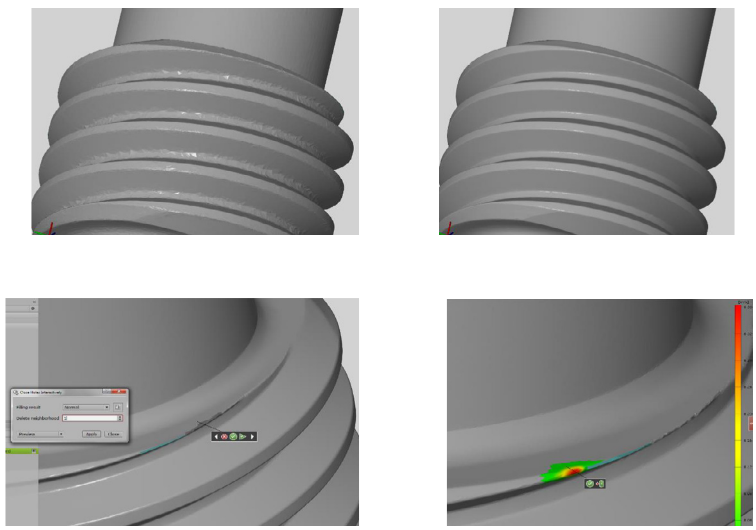

Figure 6. Polygonization of the worm thread of spiroid gear with a local, numerical visualization of the deviation in the selected surface.

3. Summary

Based on the obtained results in the process of scanning point cloud, a spatial digital model reflecting an existing element was developed. Polygonization and mesh reconstruction allowed to create an FEM model that enabled the precise reproduction of the scanned object. The created model was subsequently used to conduct appropriate analysis and simulation to verify the correctness and possible modification of the construction of both elements of spiroid gears: worm thread and face gear.

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