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3D MODELLING OF THE HARMONIC DRIVE USING "CATIA"

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Abstract:

This paper refers to the 3D modelling of the flexible gear wheel of HD, using the "Catia" environment, as well as to projecting the solid model and in analyzing the resulted model.

The flexible gear wheel and also the wave generator of the HD are modelled in "Catia" as solids. The wave generator is considered with two deforming waves which deform the flexible gear wheel of the HD.

The data resulted from the analysis with finite element reveal the deformations and strains which appear in the deformed flexible gear wheel.

1. INTRODUCTION

The harmonic drive, invented by C.W. Musser in USA in 1955 and patented in 1957, respond to the most advanced requirements of higher industry such as the space industry, the naval industry, the petroleum industry etc., regarding the operating safety, high accuracy and low jig.

There are plenty of constructive forms of the harmonic drives especially in radial construction, because of the component elements which can be in different shapes. Thereby, there are flexible gear wheels in ring shape, cup shape, cylindrical shape, conic shape etc. The wave generator could be with balls, rolls, cogs, electromagnetic wave generators, hydraulic wave generators etc. The gear wheel, flexible or rigid gear wheel, has rectilinear or involute tooth gear.

The most frequent is the radial harmonic drive but, recently discovered, the frontal harmonic drive comes with new advantages. The flexible gear wheel of the frontal harmonic drive is in plate shape and the wave generator pushes on its border.

The flexible gear wheels could be deformed by one, two, three or four arms wave generators.

A harmonic drive construction is shown in figure 1, where 1 represents the rigid gear wheel, 2 represents the flexible gear wheel and 3 represents the wave generator.

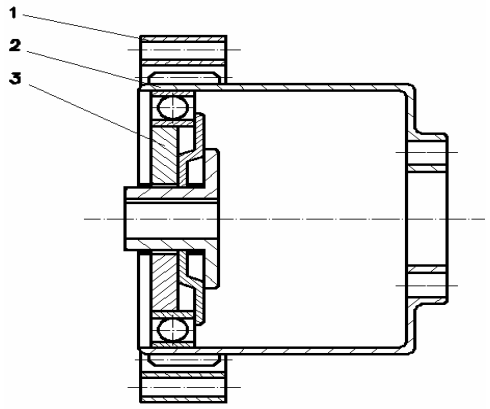

Fig. 1 Schematic representation of the harmonic drive

2. 3D MODEL OF FLEXIBLE GEAR WHEEL

The studies concerning the harmonic drive reveal that flexible gear wheel is the most stressed element of the transmission. This element is under an alternant stress which reduces its lifetime and requires certain interventions in fixing this deficiency.

In the past, the flexible gear wheel had a short lifetime, but now, because of the studies in materials science, different types of steel have features of flexibility and, in the same time, stiffness. It's about the austenitic steels like stainless steel, bearings alloy steels or springs alloy steels etc.

This paper presents the strains which appear on the 3D modelling of the flexible gear wheel of the harmonic drive, especially at the teeth area, studies and observations based on the finite element analysis.

The 3D modelling achievement was possible after a cup shape flexible gear wheel with the diameter Φ60 and length L=D (L=60 mm) was designed. For this gear wheel an external toothing formed by 120 teeth at 0,5 mm module was designed.

The materials used for the flexible gear wheel model were steels which exist on "Catia" library.

Figure 2 shows the flexible gear wheel design as it was used for 3D simulations.

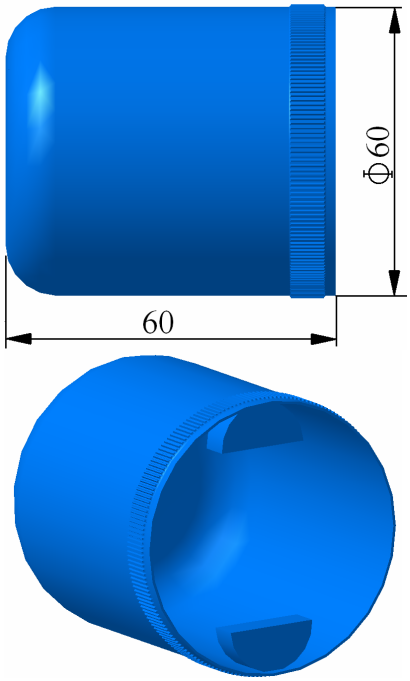

Fig. 2 Cup shape flexible gear wheel

The 3D model prepared for the finite element analysis also presents a simplified wave generator, because its role is more important than the representation and is easier to model in order to work with it in this form. The wave generator used for determinations had two deforming arms (two waves). It is represented like two parts: first part, a superior part on which mobile deforming forces were applied the and the other part, an inferior part on which the static forces were applied.

The forces applied were between 50 daN and 1000 daN, the results obtained with finite element analysis being observed.

A 16000 nods net was used in this phase, sufficient for the analysis and studies.

In figure 3 it could be observed the 3D model of the flexible gear wheel like it appears on the display of the “Catia” soft, at finite element analysis module.

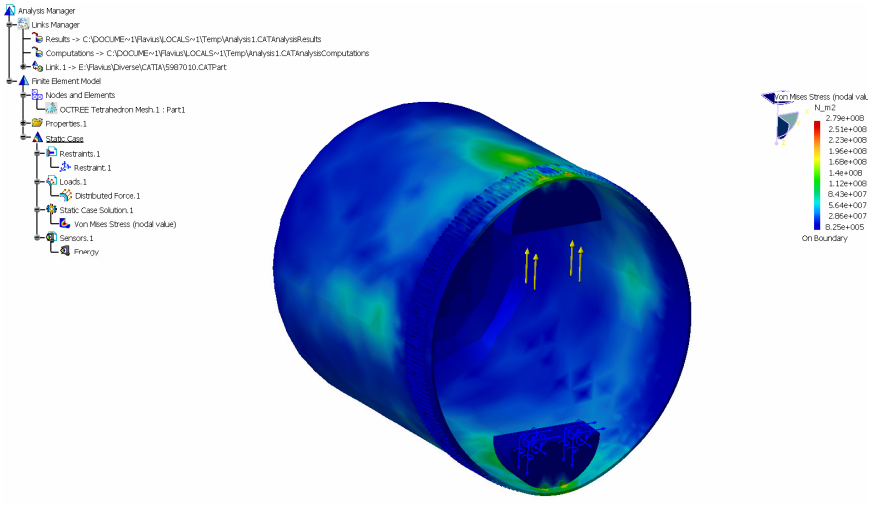

Fig. 3 3D modelling of the flexible gear wheel prepared for the finite element analysis

3. THE FINITE ELEMENT ANALYSIS RESULTS

Some characteristics were observed after the simulations, characteristics that the “Catia” soft had incorporated.

The stresses at the teeth area, marked with red, could be observed in figure 4, stresses which lead to short lifetime of the flexible gear wheel of the harmonic drive.

Some microstructure deficiencies of the gear wheels materials could raise the chances for the flexible gear wheel to be quickly destroyed.

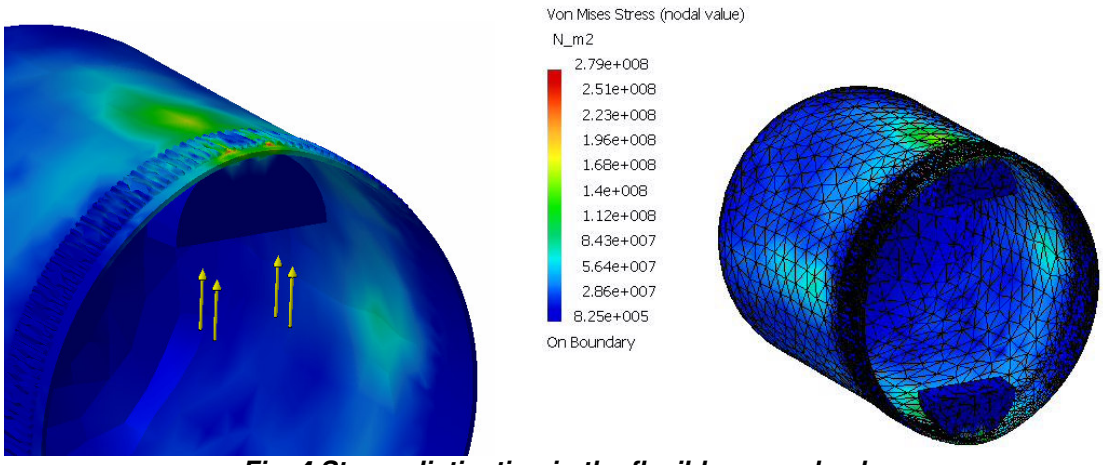

Fig. 4 Stress distinction in the flexible gear wheel of the harmonic drive

Those stresses could be measured and certain endurance, dimensioning and loading determinations could be performed.

4. CONCLUSIONS

Using finite element analysis for a model reduces the problems which can appear at the real model when it is produced.

In this case, even if it is known the fact that the flexible gear wheel of a harmonic drive is under deformations in functioning, resulting stresses in that element, the finite element analysis allowed us to find the most efficient variety which considerably reduces the fabrication costs.

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