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COMPARATIVE ANALYSIS OF TENSIONS STATUS IN PLAIN SPIROID WORM-WHEEL TEETH WITH STRAIGHT LINE, RESPECTIVE COMPOSITE AXIAL TOOTH PROFILE

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ABSTRACT

The spiroid gears with composite axial tooth profile were imagined in order to increase the performances of this type of transmissions, by reducing the appearance frequency and the magnitude of interference phenomenon. However, it is important to observe the influence that the new type of tooth profile brings on the tensions and displacements status into the worm-wheel teeth, referred to the worm-wheel with straight-line axial tooth profile.

In this paper, a comparative analysis between the tensions and displacements in both types of teeth, by using the finite elements method is presented.

1. INTRODUCTION

It is already known that the spiroid worm-gears have certain advantages respect to the classical worm-gears, like the higher loading capacity and a silent gearing; in the same time, spiroid worm-gears have a geometry that allows better functioning conditions, which are leading to a higher endurance in comparison to other types of middle and high transmission ratio gears.

On the other side, we must mention the main problem that appears in the case of the spiroid worm-gears: the interference.

A new type of spiroid worm-gear tooth profile was imagined to replace the straight-line axial one (Fig.1), in order to eliminate or, at least, to reduce the magnitude of the interference phenomenon [2]; the new profile is a composed from different arcs of circles, Fig.2 and the studies made by using "the Trajectories Method" [4] are shown its superiority, from this point of view.

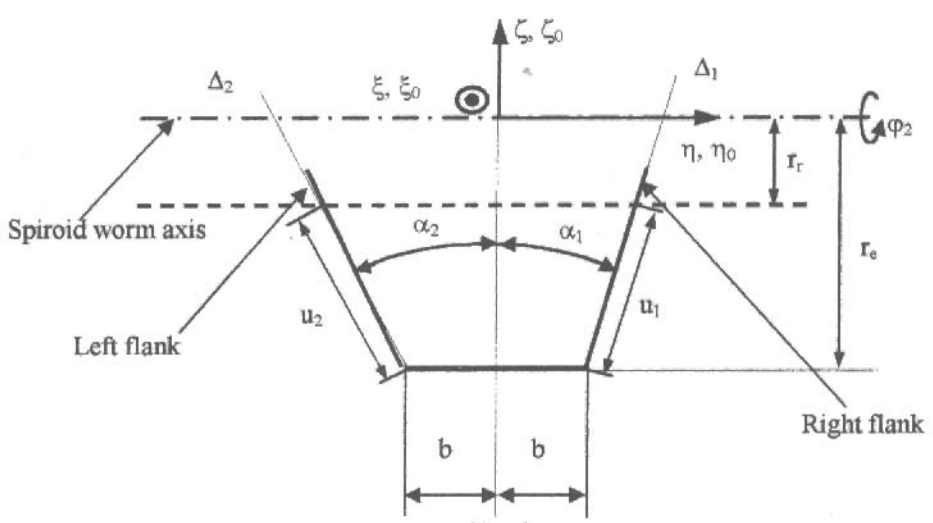

Fig. 1

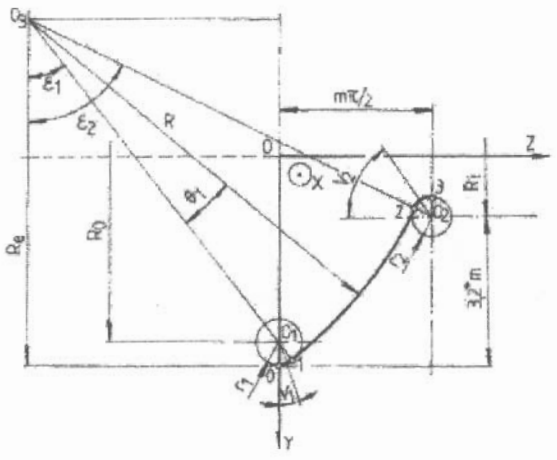

Fig.2

2. GENERAL CONDITIONS TO REALISE THE FINTE ELEMENTS GEOMETRICAL MODEL

The loading capacity study, in the case of the new type of spiroid worm-gear was realized by comparison to the cylindrical spiroid worm-gear having straight-line tooth flanks in axial section, by modeling the tensions and displacements status in the plain spiroid worm-wheel teeth.

Only three successive teeth were considered to study by using the finite elements method the solicitations of the spiroid worm-wheel; between these three teeth, only the central-one was loaded along the contact line. This hypothesis is good enough because the limit conditions haven't influence on the tensions status in the loaded tooth.

Continuity conditions (blocked nodes) were imposed in the sections which are making the delimitation of the modeled tooth; null displacements were, also, imposed in the region of the modeled tooth which corresponds to the tooth blocked face.

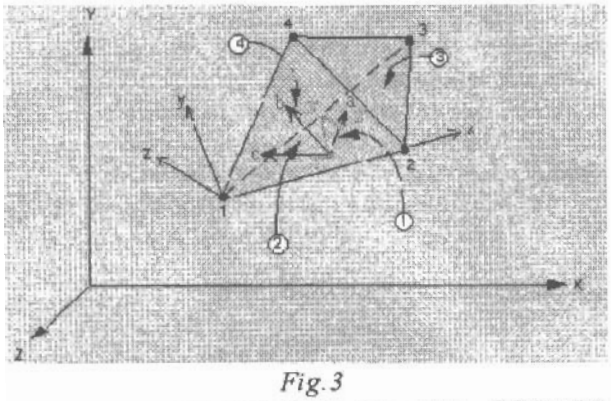

Fig.3

Modeling was done by using COSMOS 2.5 soft, implemented on a Pentium II PC with 132 Mb internal memory.

The finite element used to realize the teeth mesh is TETRA 4 type, currently used in tri-dimensional models to make linear calculus of the structures. Three translations were considered as liberty-degrees of each node, in the case of this element (Fig.3).

The elements were obtained by using an automatic mesh.

An uniform and very detailed mesh was realized, in order to obtain an acceptable solution, because of the asymmetric tooth profile and also because the concentration of the level curves at the tooth foot.

11568 nodes, 57567 elements and 33771 liberty degrees were used to realize the mesh for the three teeth.

The teeth were considered confectioned by steel, having the elasticity module, in longitudinal direction $E = 2.1 \cdot 10^5$ MPa and Poisson constant $\nu = 0.3$.

3. NUMERICAL RESULTS

The distribution of Von Mises equivalent tensions is shown in Fig.4 (in the case of spiroid worm gear with straight-line tooth axial profile) and in Fig.5 (in the case of spiroid worm gear with composite tooth axial profile).

The maximum tension in the case of the new worm gear results as 111.26 MPa, at the foot of the loaded tooth and it is smaller than both the steel admissible tension (150 MPa) and the maximum tension in the case of spiroid worm gear with straight-line tooth axial profile (179.63 MPa).

The displacements field, in the same two cases, results as in Fig.6 (in the case of spiroid worm gear with straight-line tooth axial profile) respective Fig.7 (in the case of spiroid worm gear with composite tooth axial profile).

The maximum displacement, having components along all three co-ordinates axis is around 0.01 mm, at the top of the loaded tooth, in both cases of spiroid worm-gears considered.

4. CONCLUSIONS

As results of the plain spiroid teeth tensions analysis by using the finite elements method, in the conditions initially mentioned, the following conclusions may be drawn:

- the soft that was used, COSMOS 2.5 has the capacity of describe, rigorously enough, the status of tensions and displacements in the spiroid worm-gear tooth;
- by considering a constant loading along the contact line between the peripheral active surfaces of the worm and the worm-wheel, the maximum tension appears at the tooth foot;

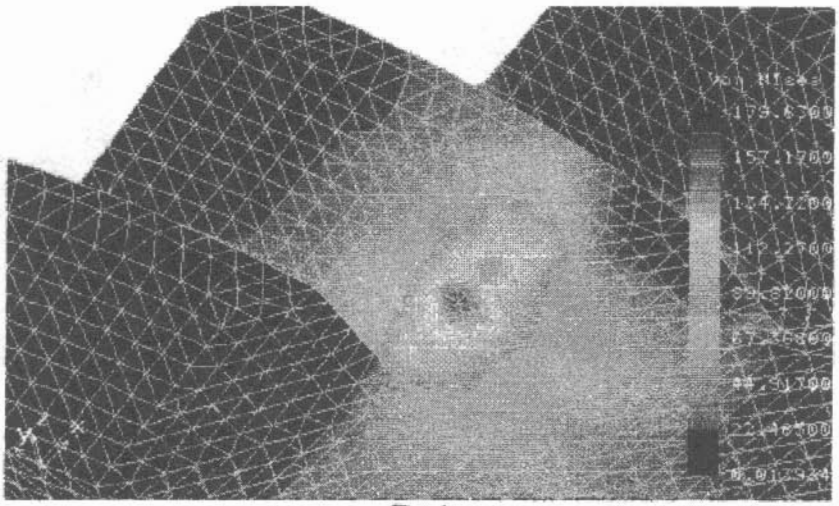

Fig.4

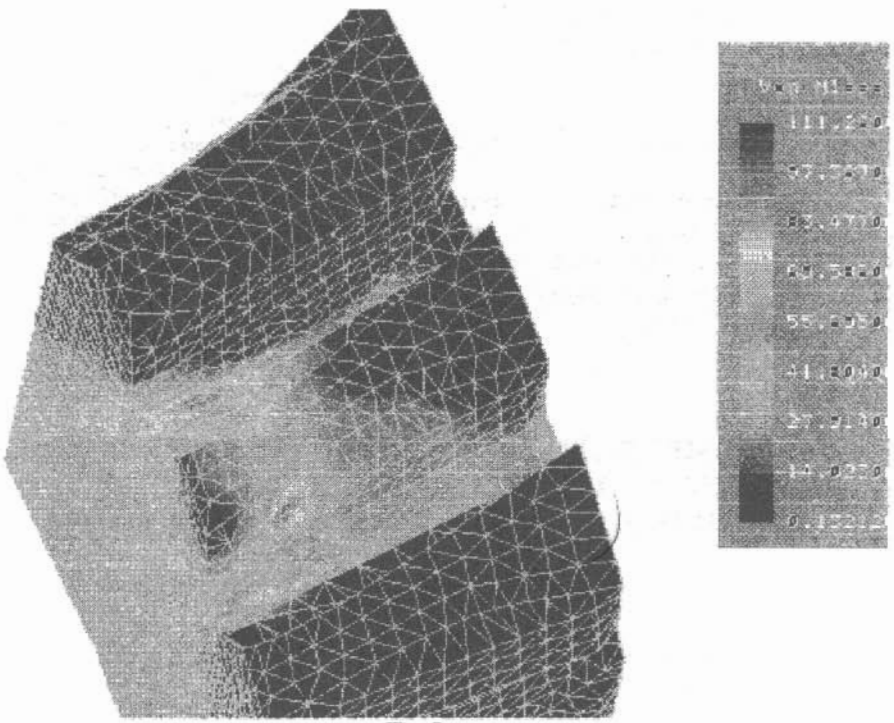

Fig.5

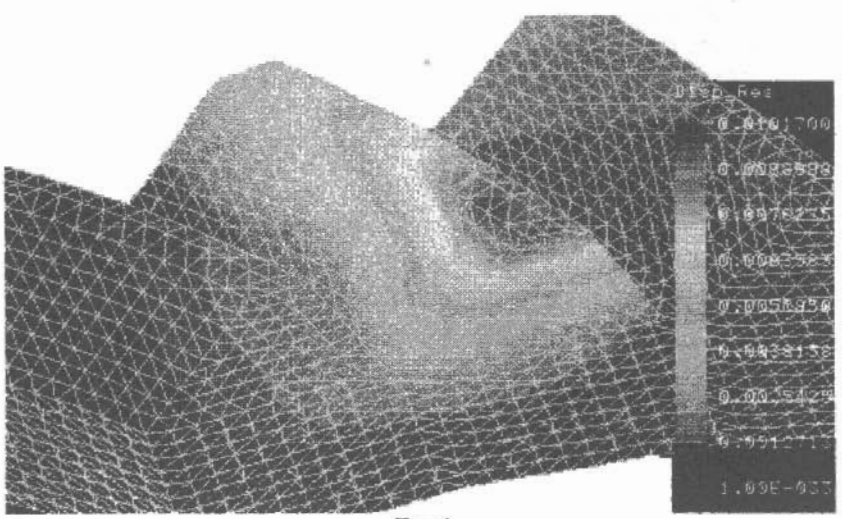

Fig.6

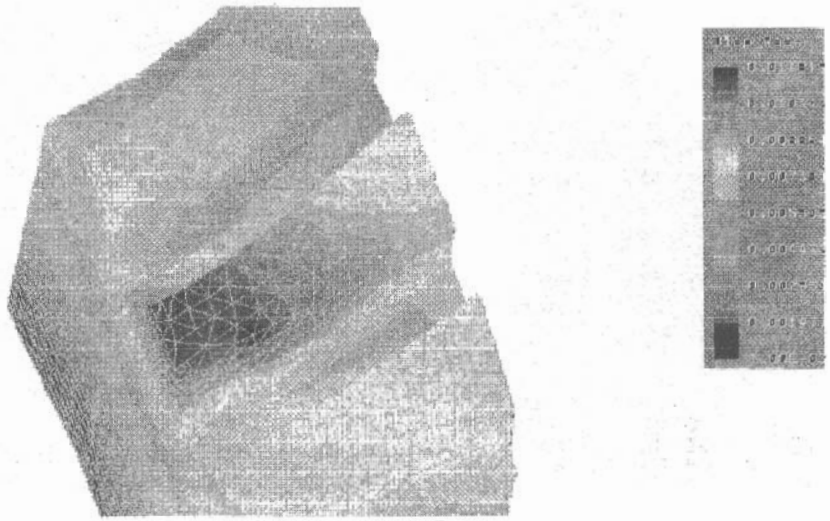

Fig.7

- the maximum value of the modeled tension is smaller (by 40%) in the case of the new type of gear, referred to the classic spiroid worm-gear;
- the maximum elastic deformation is reached at the tooth head;
- the new constructive solution of spiroid worm gear may be characterized as more convenient, referring to the load capacity, because of the specific tooth geometry (without zones of tensions concentration).

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ANALIZĂ COMPARATIVĂ A STĂRII DE TESIUNI ÎN ROATA PLANĂ A ANGRENAJULUI MELCAT SPIROID CU PROFIL AXIAL RECTILINIU, RESPECTIV COMPOZIT, AL DINTELUI

- Rezumat -

Angrenajele spiroide cu profil axial compozit al dintelui au fost concepute cu scopul de a îmbunătăţi performanţele acestui tip de angrenaje, prin reducerea frecvenţei de apariţie a fenomenului de interferenţă. În aceste condiţii, este important de observat efectul pe care îl are utilizarea noului profil al dinţilor asupra stării de tensiuni şi deformaţii din dintele roţii melcate, comparativ cu dintele având profil rectiliniu în secţiune axială.

În lucrarea de faţă este prezentată o analiză comparativă între stările de tensiuni şi deformaţii, în condiţiile aplicării aceleiaşi sarcini, în dinţii roţii melcate spiroide cu profil axial rectiliniu, respectiv compozit, realizată prin metoda elementelor finite.

ANALISE COMPARATIVE DE L'ETAT DES TENSIONS ET DEFORMATIONS DANS LES DENTS DE LA ROUE PLAINE DE L'ENGRENAGE SPIROID AVEC PROFILE AXIAL RECTILIGNE, RESPECTIVE COMPOSITE DU DENT

- Résumé –

Ce papier présente une analise comparative pour l'état des tensions et déformations parmi les dents de la roue plaine de l'engrenage spiroid avec profile axiale rectiligne, respective composite, en utilisant la métode des élements finis.