THE STUDY OF THE REACTIONS VARIATION ON THE CYCLOID REDUCER SATELLITE GEAR DEPENDING ON THE NUMBER OF THE ROLLER TEETH IN GEARING

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Abstract: The paper presents the study of the variation of the reactions who act on the satellite gear depending on the number of the roller teeth and thumbs in gearing and on the position angle of the first gearing roller tooth related to the centroid centers line, φ.

Key words: Cycloid reducer, reactions, satellite gear roller teeth, gearing line.

1. INTRODUCTION

The determination of the distribution coefficients $\boldsymbol{v_i}$ and $\boldsymbol{l_j}$ of the pressure loads between the sun gear roller teeth and the profiled satellite gear teeth, respectively between the thumbs of the transversally coupling and the satellite gear holes is an extreme complex problem involving the utilization of the elasticity theory equations. The solving of the problem imposes the calculation of the static undetermined systems where, besides contact deformations, the final result it is very much influenced also by the deformations and the local stress.

2. THEORETICAL CONSIDERATIONS

We can express a number of hypothesis about the probability of the pressures distribution taking into consideration the manufacturing errors and the deformations of the cycloid satellite gear body determinate by the manufacturing of the r_d radius holes used for coupling the transversally mechanism (fig.1).

The hypothesis that approaches conditions close to the real functioning

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conditions is the simultaneously gearing of n_b roller teeth and n_d thumbs. In that real situation, we have the difficulty to establish the repartition of the stress on the roller teeth and thumbs in gearing, repartition expressed by the reactions distribution coefficients, $\boldsymbol{v}_i$ and $\boldsymbol{l}_j$.

In this hypothesis, we point up the spectres of the reactions variations during the gearing of a roller tooth, meaning we highlight the leaps of the reactions values at the entry in the gearing of a roller tooth and, also, at the exit of the another roller tooth from the gearing.

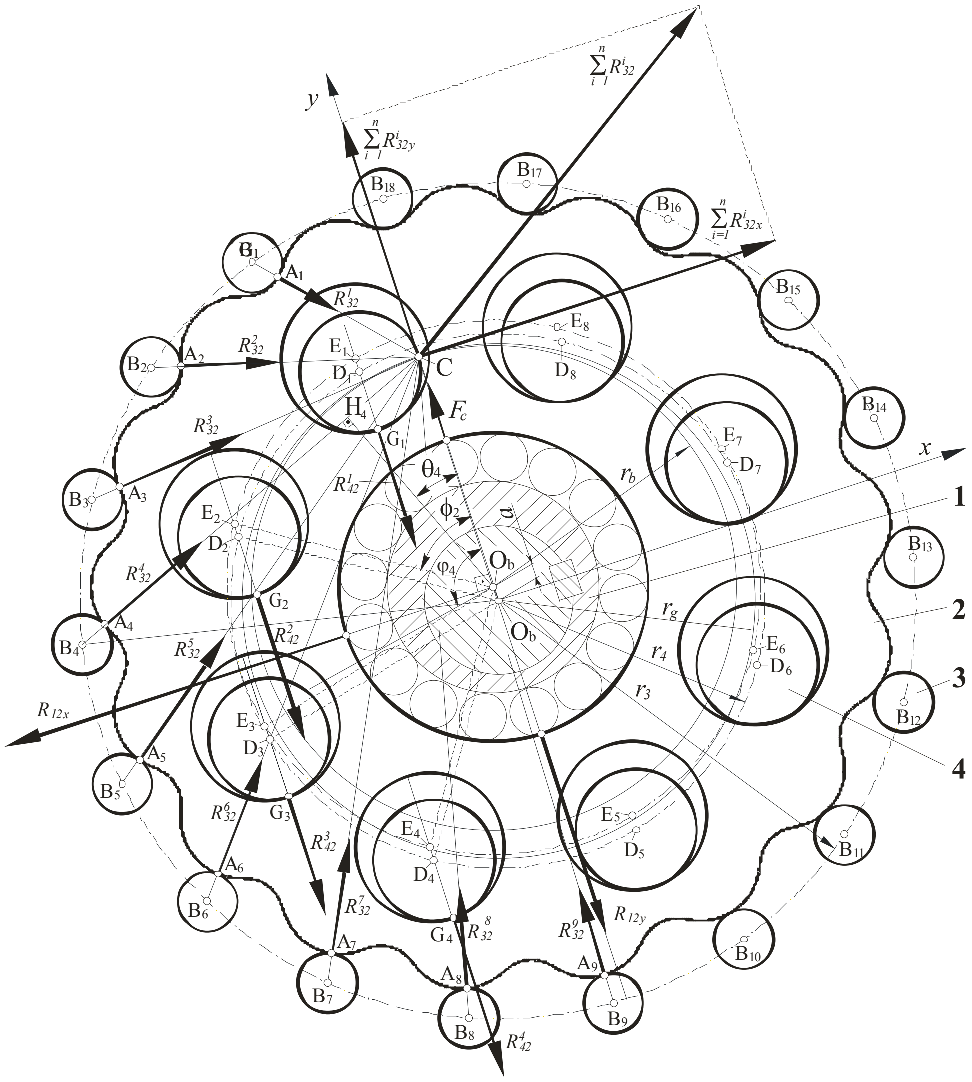

Fig. 1. The reactions who operate on the satellite gear in the case of gearing with n_b roller teeth

Analysing the way that the cycloid profile satellite gear gears with the sun gear roller teeth, we notice that, during the gearing of a reference roller tooth (going through the gearing line), n_b roller teeth exit the gearing (roller teeth situated downstream from the reference roller tooth) and other n_b or n_b-1 roller teeth (situate upstream from the reference one) enter into the gearing.

At the enters, respectively at the exits of a roller tooth in/from the gearing, there are produced modification of the stress distribution on the roller teeth causing leaps of the reactions values. The leaps of the reactions values constitute an important source of mechanical transmission vibrations production.

To point out the roller teeth moments of entering / exiting in gearing, we consider the roller tooth nr.1, fig. 1, in the moment of entrance in the gearing. For that moment, we determine the number of the roller teeth n_b who is in the gearing with the following formula:

$$n_b = \left[\frac{\varphi_a}{2\pi} z_2 \right] + 1 \tag{1}$$

where: [*] – represents the fraction whole part; φ_a – represents the described angle by a roller tooth in gearing with a tooth of the cycloidal profile.

In this position, knowing the number of the gearing roller teeth and the corresponding angle to the active gearing line arc, we determine the $\Delta\varphi_a$ angle corresponding to the gearing line arc contents between the last gearing roller tooth (roller tooth nr.1) and the extremity of the gearing line. This angle is towards the end part of the gearing line, at the exit of the roller teeth from the gearing and can be determinate with the formula:

$$\Delta\varphi_a = \varphi_e - n_b \frac{2\pi}{z_2} \tag{2}$$

At the rotation of the centres line with $\Delta\varphi_a$ angle, the number of the gearing roller teeth remains the same, n_b+1, then a roller tooth exit the gearing remaining n_b gearing roller teeth.

n_b roller teeth remain in gearing during the rotation of the centre line with $\Delta\varphi_i$ angle:

$$\Delta\varphi_i = \frac{2\pi}{z_2} - \varphi_a \tag{3}$$

Through the modification of the cycloid profile of the satellite gear, the number of the roller teeth who gear simultaneously is reduced proportionally with the reducing of the length of the gearing line.

In this paper, we study the variation of the reactions who act on the modified profile of the cycloid satellite gear, meaning that the gearing of a roller tooth with the cycloid profile is limited on the profile corresponding to the angle ω =13° ÷ 120°.

During the gearing of a roller tooth appears several cycles. One cycle of $\boldsymbol{R_{32}}$ reaction variation *corresponds to a rotation of the port-satellite bar with an angle equal with the angular spacing of the roller teeth.* The beginning of a cycle coincides with the moment of the entrance of a new roller tooth in gearing, and the end of a cycle coincides with the entrance of the next roller tooth in gearing.

If a roller tooth exit from gearing coincides with another roller tooth entrance in gearing, the gearing arc is multiple of the angular step.

$$\Delta\varphi_a = (n_b + 1)\frac{2\pi}{z_2} \tag{4}$$

We draw the next conclusion:

- *If the gearing arc it is a multiple of the angular step, than, during a cycle gears the same number of roller teeth,* $\boldsymbol{n_b+1}$*;*
- *If the gearing arc is not a multiple of the angular step than, during an interval of the cycle gears* $\boldsymbol{n_b+1}$ *roller teeth, and on the remaining cycle gears* $\boldsymbol{n_b}$ *roller teeth.*

Example about the study of the variation of the reactions who act on the satellite gear depending on the number of the roller tooth and thumbs in gearing and on the position angle of the first gearing roller tooth related to the centroids' centers line, φ. Using the utilitarian program MathCAD we point out the R_{32} reaction variations in the first approximation case, when we consider being uniform the repartition of the reactions on the roller teeth and on the thumbs, $\boldsymbol{v_i}$ *=1* and $\boldsymbol{l_j}$*.=1*. The graphs of the reactions variation are traced during the gearing of a roller tooth.

The gearing line is considered contained between the limits: 15° and 120°. The number of the roller teeth who gear on the different intervals of the gearing line results from the graph, fig. 2.

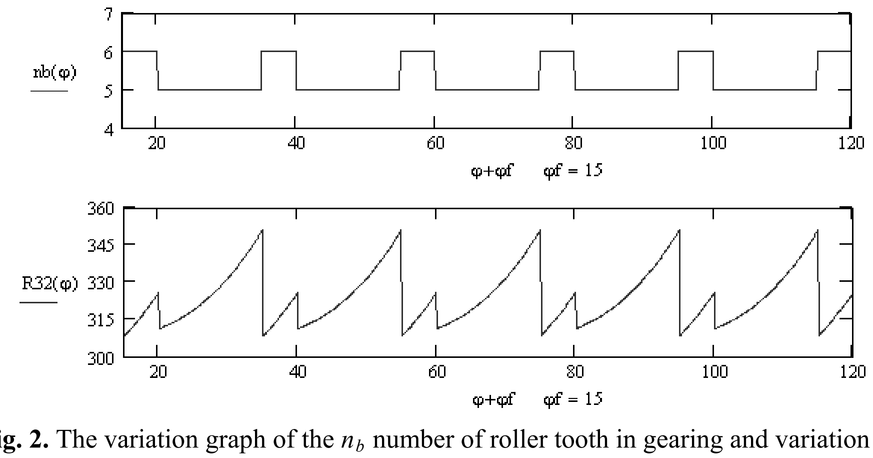

Fig. 2. The variation graph of the n_b number of roller tooth in gearing and variation graph of the reaction R_{32} in the case of the some arc of the gearing line

The R_{32} reaction variation is the same on each gearing roller tooth and presents leaps on each entry in gearing of a roller tooth and on each exit from the gearing of a roller tooth.

Considering de position of the gearing line with central angle φ_a =108^o (indivisible with the angular step of the sun gear roller teeth) who begin at the different values of the angle corresponding to the dedendum circle, respectively to the addendum circle of the active profile, we obtain different modes of reaction variations R_{32}, Fig. 3.

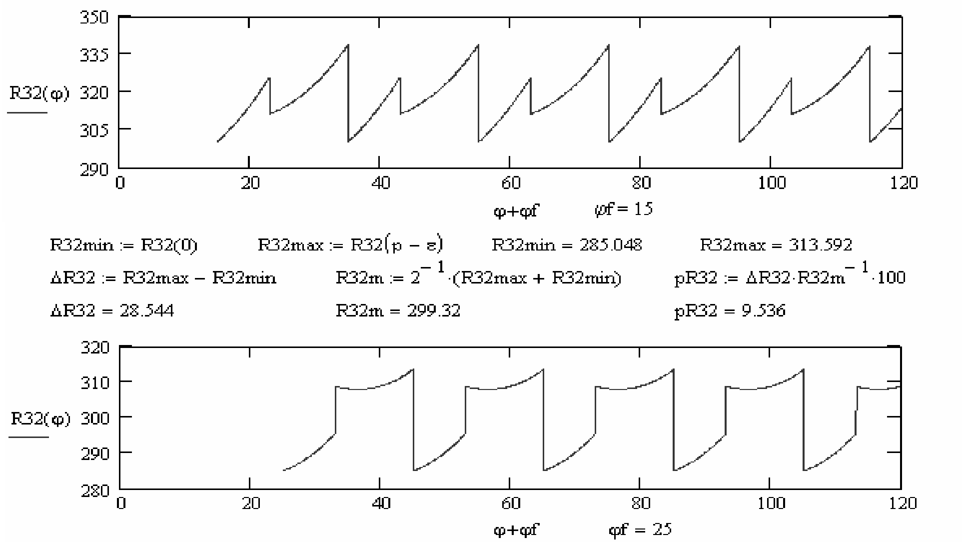

Fig. 3. The graphs of the R_{32} reaction variation in the case of the gearing line arc angle φ_a =108^0 beginning the gearing with the angle φ_f = 15^0, respectively beginning of the gearing with the angle φ_f = 25^0

In bout cases, the gearing line arc angle is indivisible with the roller tooth angular step, p=20^o.

In fig. 4 we present the graphs of the R_{32} reaction variation in the case of gearing line angular arc multiple of the roller teeth angular step in two different situation of the roller teeth entrance angle φ_f in gearing.

The reactions' variation R_{32} is the same for each roller tooth in gearing and the number of the leaps is reduced to half because each roller tooth who exits the gearing corresponds to a next roller tooth that enters in the gearing.

3. CONCLUSIONS

When the gearing line is moving to the bigger values of the addendum circle, the values of the reactions are decreasing until a certain value of the displacement than they have a pronounced increasing.

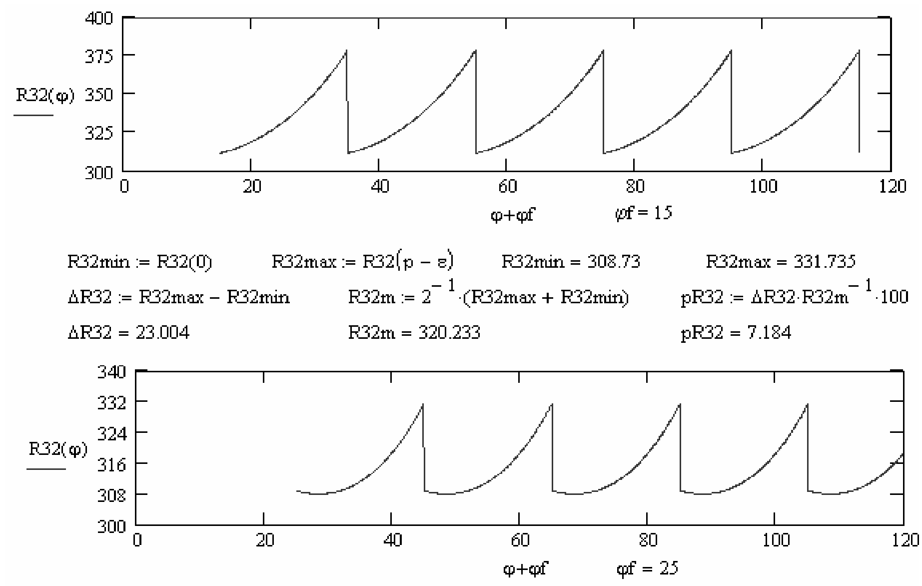

Fig. 4. The graphs of the R_{32} reaction variation in the case of the gearing line arc angle multiple of the roller teeth step

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