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AN INFLUENCE OF TOOL GEARINGS PARAMETERS ON THE PARAMETERS OF ACCURACY AT THE PROCESSING BY ROLLING METHODS

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Summary. On the basis of the carried out analytical and experimental researches on machine-tool gearings at sheaving by methods of „a short course" and tangential submission it has been established that the arising in the beginning and the end of an operation cycle of deformation of technological system result in a displacement of a stain of contact along a tooth of preparation, a change of a corner of crossing of axes of preparation and the tool. With an increase of a corner of crossing of axes sheaving and preparations, both the size of the combined skew and an error of a direction of a tooth are increased.

Key words: sheaving, angle of the crossing, a stain of contact.

INTRODUCTION

One of the central issues in mechanical engineering is the problem of quality and productivity at manufacturing details of machines with the minimal expenses. These requirements are especially significant in the manufacturing of machine details, including cogwheels. In the operations of final gear wreaths processing much popularity was gained by the methods of free rolling at crossed axes sheaving and HONINGS. Now in mechanical engineering five methods of cogwheels sheaving have been recognized: longitudinal, diagonal, tangential, „a short course" and cuttings [Kalashnikov and Kalashnikov 1985].

The method of tangential sheaving (Fig. 1) is characterized by the presence of a tangent of the submission 3 directed perpendicularly of an axis of a the processed wheel 1. For the realization of tangential sheavings sheaving 2 should be wider than the gear wreath of the wheel. At small allowances, tangential sheaving is carried out for one double course, and at significan ones – work for some courses of a table with radial submission is possible. At such method of processing, the centre of crossing moves concerning a surface teeth sheaving, therefore a deterioration of cutting edges proceeds in regular intervals and the stability of the tool raises. At rapprochement sheaving and the processed wheel being due to radial submission the stain of contact is formed. During the sheaving process, the forms and sizes of the processed wheel's teeth continuously change, which results in a constant change of conditions of contact of the working surfaces during sheaving and preparations. Significant efforts at the processing cause elastic deformations of technological system's elements; the size of deformation of elements of technological system decreases with an increase of the number of passes [Suhorukov 1983]. It results in a change of position of the centre of crossing during furnishing and as a consequence to an occurrence of an error of a direction of a tooth [A.L. measurement's, 1968]. During incision sheaving in the processing preparation (Fig. 2) the size cutting allowance is maximal, which results in an increase of a stain of contact during processing.

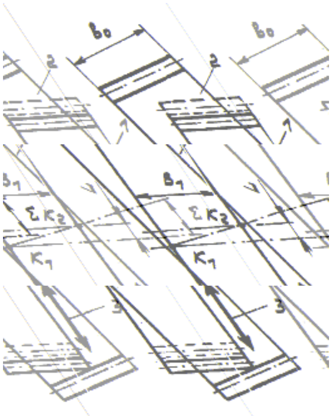

Fig.1. The circuit tangential sheaving

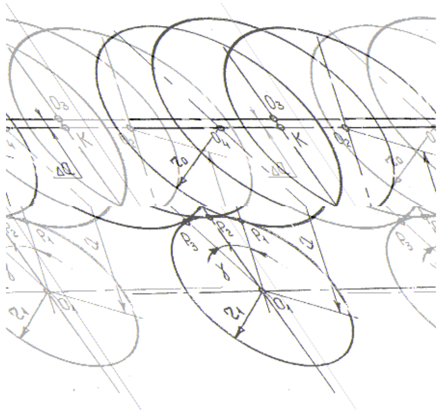

Fig. 2. A change of the inter-axial distance

THE STATEMENT OF THE PROBLEM

It results in an increase of efforts of the cutting causing elastic deformations of elements of technological system, change of position of the centre of crossing of axes of preparation and sheaving. Further, due to an increase of a the stain of contact, effort of cutting reaches the maximal values, and the further introduction of cutting teeth sheaving in the processing preparation does not occur (T. P_2). In this phase of sheaving the cylinder will be rolled on the divide to the cylinder of the processing preparation [Lycshin 1967]. In the beginning of a working course (T. P_1) the corner of crossing of axes sheaving and preparations Σ' formed by a projection of these axes to plane Π is not equal to a settlement corner of crossing Σ (the skew of axes sheaving takes place in preparations), and forming a divide, the cylinder sheaving makes with the plane Π corner ΔV, (a deviation from parallelism axes), i.e. the combined skew of axes of preparation and the tool takes place (Fig. 3). Planes Π are carried out through points of contact P_1 and P_3 on the divide cylinders sheaving both preparations in the beginning and the end of an operation cycle, and are tangents to divide to the cylinder of preparation. Planes F are carried out through axes sheaving in the beginning and the end rolling and through points P_1 and P_3. Planes E_2 are carried out through an axis of preparation and a point of contact P_1 and P_3. Plane E_1 is carried out concerning to the divide to cylinders sheaving and preparations at processing on the average position. Plane Q is carried out through points of contact P_1 and P_3 in parallel plane E_1. O_1O_1 – an axis of preparation; O_2O_2 – an axis sheaving in the beginning of an operation cycle; O_3O_3 – an axis sheaving in the middle of an operation cycle; O_4O_4 – an axis sheaving at the end of an operation cycle.

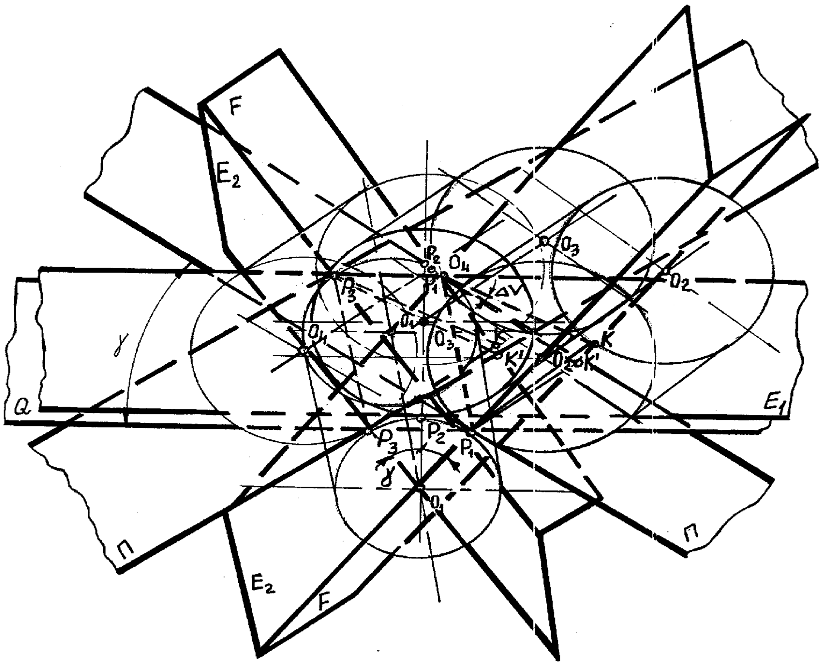

Fig. 3. Change of position of the centre of crossing at tangential sheaving

RESULTS OF RESERCH

From the constructions given in Fig. 3 it follows, that the greatest deviation of an axis sheaving from settlement value is reached in the beginning and the end of an operation cycle (P_1 and P_3). In the middle of an operation cycle (T P_2) the axis sheaving O_3O_3 practically will not have deviations and remains to a parallel plane of item. In this phase the plane П and E_1 coincide [Uminski 2003]. For a definition of the maximal corner deviation from parallelism axes sheaving and preparations it is necessary to carry out tests for an axis of preparation and the tool at the moment of the beginning rolling on plane E_1 (P_1K' and $P_1P_1^1$). As a result of displaying $P_1P_1^1$ on plane F we receive piece P_1K. The corner K P_1K' is the maximal size deviation from parallelism axes sheaving and preparations. From constructions given in Fig. 4 it follows, that

$$KK' = P_1P_1^1 \operatorname{tg} \gamma \ ;$$

$$\mathrm{tg}\ \Delta V = KK' / P_1K'$$
$$\mathrm{tg}\ \Delta V = \mathrm{tg}\ \gamma\ \sin \Sigma' \qquad (1)$$

In the formula (1) Σ' – the valid value of a corner of crossing of axes of preparation and the tool in the beginning of an operation cycle. Besides, from the constructions in Fig. 3–5.

$$\mathrm{tg}\ \Sigma' = \mathrm{tg}\ \Sigma \cos \gamma$$

$$\sin \Sigma' = (\mathrm{tg}\ \Sigma \cos \gamma) / \sqrt{1 + \mathrm{tg}^2 \Sigma \cos^2 \gamma} \qquad (2)$$

From constructions in Fig. 2 the distances

$$O_1O_2 = r_{11} + r_0$$

$$O_1K = r_{11} + r_0 - \Delta \alpha$$

where:

$r_{11} = r_1 / \cos^2 \Sigma$ the mm is in the given radius of curvature of the processing preparation;
r_1 – radius divide circles of preparation, mm;
r_0 – radius divide circles sheaving, mm;
Δa – change of position of the centre of crossing of axes of preparation and the tool, mm.

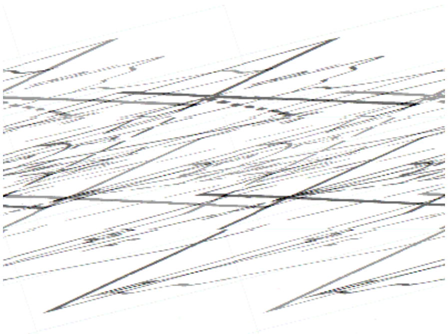

Fig. 4. The circuit for a definition of a corner deviation from parallelism axes

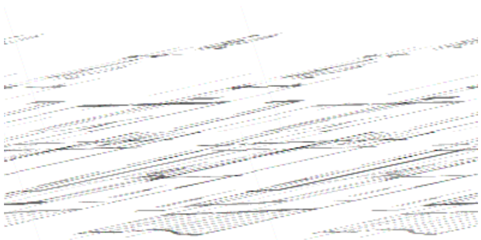

Fig. 5. The circuit for a definition of an arising error of a direction of a tooth

$$\cos \gamma = \frac{r_0 \cos^2 \Sigma + r_1 - \Delta \alpha \cos^2 \Sigma}{r_0 \cos^2 \Sigma + r_1}$$

$$\mathrm{tg}\gamma = \frac{\cos\Sigma\sqrt{\Delta\alpha(2(\mathrm{r}_0\cos^2\Sigma + \mathrm{r}_1) - \Delta\alpha\cos^2\Sigma)}}{\mathrm{r}_0\cos^2\Sigma + \mathrm{r}_1 - \Delta\alpha\cos^2\Sigma} \tag{3}$$

Substituting expressions (2) and (3) in the formula (1) we shall receive expressions for a definition of a corner deviation from parallelism axes, a skew of axes sheaving and preparations:

$$\mathrm{tg}\Delta V = \sin\Sigma\sqrt{\frac{\Delta\alpha(2c - \cos^2\Sigma)}{c(1+\mathrm{tg}^2\Sigma)(c - \Delta\alpha\cos^2\Sigma)}} \tag{4}$$

$$\sin\Sigma' = \mathrm{tg}\Sigma\sqrt{\frac{c - \Delta\alpha\cos^2\Sigma}{c(1+\mathrm{tg}^2\Sigma)}} \tag{5}$$

where:

$$C = \mathrm{r}_0\cos^2\Sigma + \mathrm{r}_1 \tag{6}$$

During tangential shevings corner ΔV reaches the greatest value at incision and an output sheving (P_1 and P_3), also comes nearer to zero value at the maximal defor-mations of the technological system (T. P_2). In these points the error of a direction of a tooth will be maximal as a result of an arising skew of axes sheaving and preparations there will be a change of the area of a stain of contact. The length of a stain of contact in this case decreases, which results in an incision cutting tooth sheaving at a big depth in the be-ginning and the end of an operation cycle. The length of a stain of contact according to works [Sokolov 1954, Suhorukov and Evstegneev 1983] depends on the parameters of tools gearings. Thereof, for a case of processing by a tangential method sheaving the length of a line of contact will make not less than half of width of a tooth of preparation. In this case from the constructions given it follows, that

$$F_\beta = b_1\mathrm{tg}\alpha_n\mathrm{tg}\Delta V \tag{7}$$

where:

- F_β – an error of a direction of a tooth, mm;
- α_n – a normal corner of gearing, a hailstones;
- b_1 – width of a gear wreath of preparation, mm;
- ΔV – size of a corner deviation from parallelism axes, a hailstones.

Substituting the above-found value of the corner ΔV from dependence (4), we re-ceive:

$$F_{\beta} = b_{1}\text{tg}\alpha_{n}\, sin\,\Sigma \sqrt{\frac{\Delta\alpha(2c - cos^{2}\Sigma)}{c(1+\text{tg}^{2}\Sigma)(c-\Delta\alpha\, cos^{2}\Sigma)}} \tag{8}$$

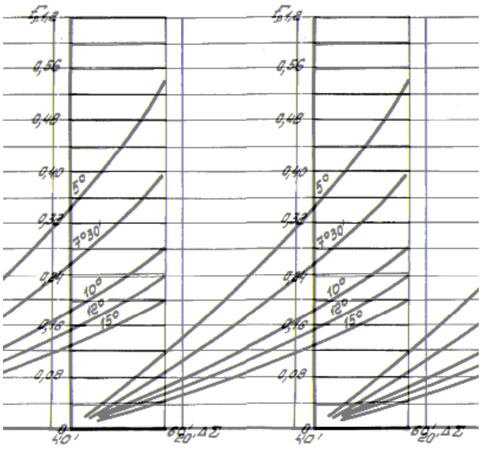

Fig. 6. Change of the size of a hollow at different corners of crossing of axes

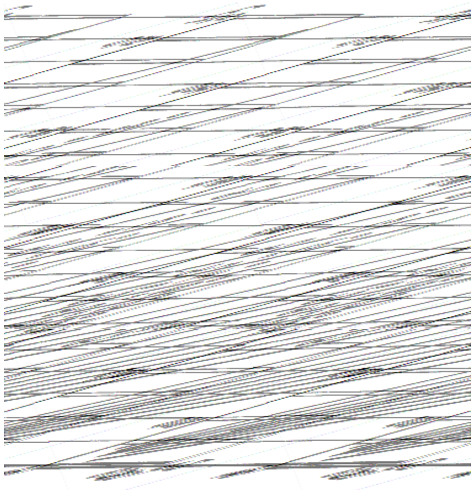

Fig. 7. Change of the size of a hollow at different corners of gearing

In Fig. 6. the diagram of change of width of a hollow is shown at different corners of crossing ΔΣ. With an increase of an additional corner of crossing of axes the size of an error of a direction of a tooth is increased, the greatest size of an error corresponds to processing with small corners of crossing of axes (7, 8, 9). In Fig. 7 the diagram of change of width of a hollow is submitted at different corners of gearing depending on an additional corner of crossing of axes $\Delta\Sigma$. At an increase of an additional corner of crossing of axes and a corner of gearing, the size of an error of a direction of a tooth is also increased. With an increase of the length of a line of gearing, the length of a line of contact sheaving and preparations is also increased (8, 9, 10). In Fig. 8. the diagram of change of width of a hollow is shown at a different length of a line of gearing and change of an additional corner of crossing of axes $\Delta\Sigma$. Analytical and experimental researches of joint influence error of a direction of a tooth from appearing change of a corner of crossing of axes $\Delta\Sigma$ and deviation from parallelism axes ΔV at tangential and „a short course" methods sheaving have shown that with an increase of the size of the combined skew of axes ($\Delta\Sigma + \Delta V$), the size of an error of a direction of a tooth is increased (Fig. 9). The greatest error is characteristic for the least and the greatest corner gearings. At an increase of a corner of crossing of axes, both the size of the combined skew ($\Delta\Sigma + \Delta V$) and an error of a direction of a tooth are increased.

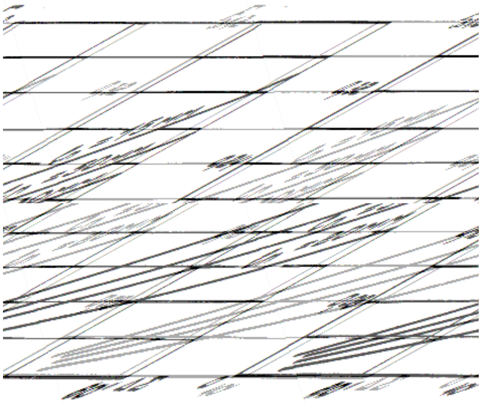

Fig. 8. Change of the size of a hollow depending on the length of a line of gearing

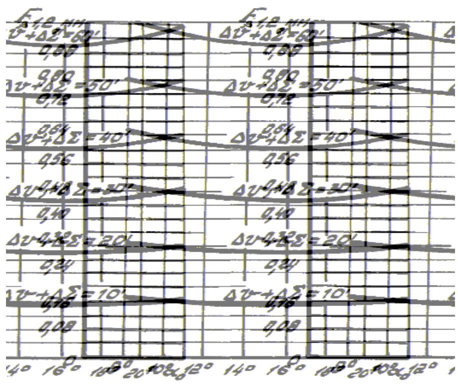

Fig. 9. Change of the size of a hollow at the combined skew of axes of preparation and the tool

CONCLUSIONS

The received dependences (4), (5), (8) allow to estimate an influence of tools gearings parameters on an error of a direction of a tooth at a tangential method sheaving, size of a corner deviation from parallelism axes, change of a corner of crossing of axes sheaving and preparations during processing. The carried out analytical and experimental researches allow to draw a conclusion that at tangential sheaving arising in the beginning and the end of an operation, the cycle of deformation of technological system result in a change of a corner of crossing of axes sheaving and preparations and as a consequence to an occurrence of an error of a direction of a tooth. Change of size cuttings allowance during furnishing results in a displacement of a stain of contact along a tooth of preparation. The greatest error of a direction of a tooth will correspond to preparations having the greatest radial palpation. Reduction of an error of a direction of a tooth is reached at an increase of the teeth number in the tool. The least error of a direction of a tooth at tangential sheaving corresponds to the processing with small corners of crossing of axes of preparation and the tool.

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