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THE INFLUENCE OF DIFFERENT PARAMETERS ON SLIDING SPEED AND SPECIFIC SLIDING AT GEAR PAIR WITH EXTERNAL MESHING

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ABSTRACT
The kinematics of a gear pair with external meshing is analysed in this paper. The sliding speed and specific sliding in a meshing range, theoretical and practical as well is elaborated in details. Also, the parameters that influence the improvement of meshing conditions as: number of teeth, displacement coefficient, and gears ratio are discussed.
The results of this study are presented in diagrams with respective comments. The graphically presented results are a good base for further research on this field.

1. INTRODUCTION

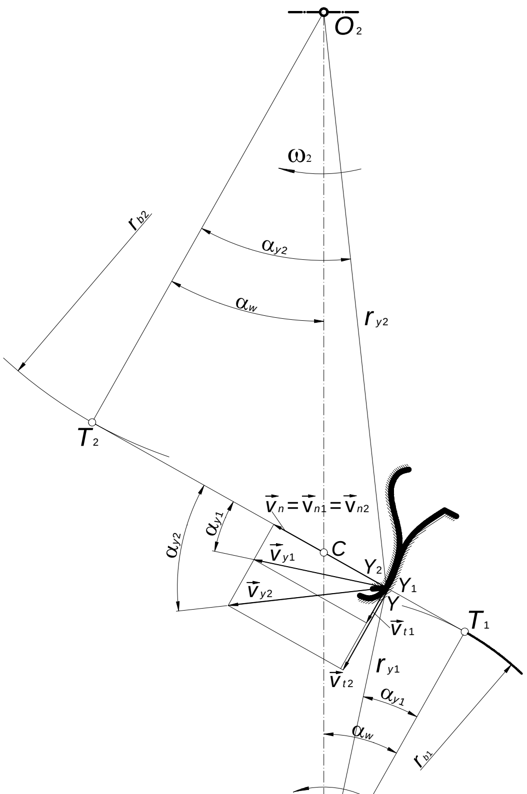


Figure 1. Sliding velocities at the edges of the teeth

During the mesh of the gears, the points at active part of evolvent profile of the pinion tooth come in contact with respective points of the active part of evolvent profile of the gear tooth (Figure 1). The motion of the point Y_1 about the immovable coordinative system is *absolute*, while about the movable coordinative system $O_1x_1y_1$ is *relative*. Therefore, the peripheral velocity at instant contact point Y_1 is determined by expression:

$$\vec{v}_{y1} = \vec{v}_{n1} + \vec{v}_{t1} \qquad \text{... (1.1)}$$

Similarly is analysed the motion at instant contact point Y_2 for the tooth profile of gear. But, to describe the motion at instant contact point Y_2, it must be adopted referent system $O_2x_2y_2$ linked with gear which is rotated about the immovable coordinative system O_1xy. Therefore, the absolute velocity at instant contact point Y_2 is expressed by:

$$\vec{v}_{y2} = \vec{v}_{n2} + \vec{v}_{t2} \qquad \text{... (1.2)}$$

The instant contact points Y_1 and Y_2 at a certain moment come to contact at point Y (Figure 1), which is called the momentary contact point of the meshing gear profile.
Based on kinematics laws, *two bodies that move with different velocities remain in contact only when their perpendicular velocity components to the tangents at momentary contact points have the same direction and if they are equal.*

Continuous meshing of evolvent profile is realized if the components of absolute velocities at momentary contact points Y_1 and Y_2 in the perpendicular direction are equal:

$$\vec{v}_{n1} = \vec{v}_{n2} \qquad \text{... (1.3)}$$

Since at momentary contact point Y, the components of absolute velocities in the direction of tangent of momentary contact points Y_1 and Y_2 have not the same direction and intensity then as the result the sliding of the tooth profile of one gear about the tooth profile of another gear is introduced.
The sliding velocity of tooth profile is calculated by:

$$\vec{v}_{rr1/2} = \vec{v}_{y1} - \vec{v}_{y2} \qquad \text{... (1.4)}$$

Based on above expressions, the sliding velocity at any contact point of meshing gears can be determined by:

$$v_{rr1/2} = \pm\overline{CY}(\omega_1 + \omega_2) \qquad \text{... (1.5)}$$

Sign (+) is taken for meshing interval $\overline{T_1C}$ and sign (-) for meshing interval $\overline{CT_2}$, while at momentary pole of meshing the sliding velocity changes its sign, respectively in this point it has value equal with 0.

2. SPECIFIC SLIDING AT MESHING PROFILES

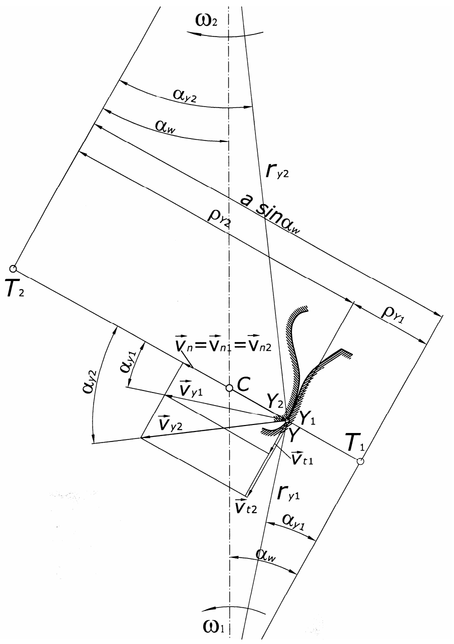


Figure 2. Radii of curves of profiles of the teeth profiles of meshing gears at momentary contact point Y

To analyse and optimize the kinematic parameters of the gears the behavior of sliding velocity changeability at momentary contact point Y about respective components of the relative velocity at the tooth profile point – *specific sliding* is needed to be found.
The specific sliding of the tooth profile of the pinion at arbitrary contact point Y is calculated by expression:

$$\xi_{y1} = \frac{v_{rr1/2}}{v_{t1}} \qquad \text{... (2.1)}$$

After needed substitutions the final expression for the specific sliding of tooth profile of the gear is:

$$\xi_{y1} = 1 - \frac{1}{u} \cdot \frac{\rho_{Y2}}{\rho_{Y1}} \qquad \text{... (2.2)}$$

Similarly, the specific sliding for the tooth profile of the gear is determined:

$$\xi_{y2} = \frac{v_{rr1/2}}{v_{t2}} \qquad \text{... (2.3)}$$

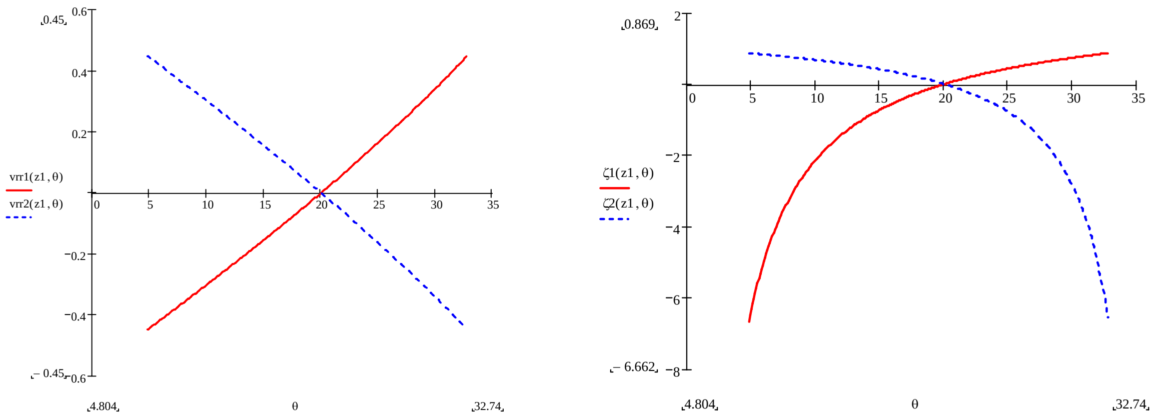
Respectively, after necessary substitutions the specific sliding at the momentary contact point Y_2 of tooth profile for the gear will be calculated by:

$$\xi_{y2} = 1 - u \cdot \frac{\rho_{Y1}}{\rho_{Y2.}} \qquad \text{... (2.4)}$$

3. ANALYSIS OF THE RESULTS

Based on theoretical analysis the respective program for calculation of the peripheral velocities and their components for the teeth profiles of evolvent cylindrical gears with external meshing has been created.
In such analysis, the selection of the most influent factors as teeth number of meshing gears, transmission ratio, contact curve angle and deviation coefficients has been done.
The selection of the parameters is done in the form: z_1 = 14, 17, 20, 25 and 30 having in mind that two first numbers (z_1 = 14 and 17) represent minimal teeth numbers for the gears, while z_1 = 30 represents the used practical upper limit for the pinion and for the teeth number of the gear the relation $z_2 = z_1 \cdot u$ is used.
Deviation coefficients of profile are selected to be within interval $x_1 = 0…1$ for couple XO (x_1=-x_2).

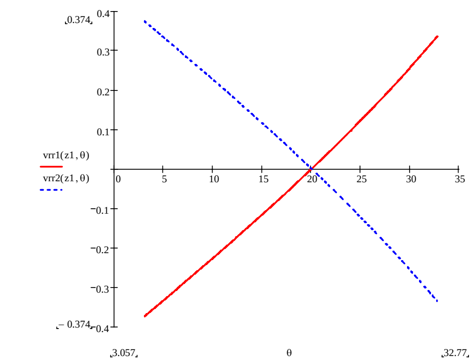
In Figure 3. the graphical presentation of changeability for sliding velocity v_{rr} (Figure 3.*a*); *relative velocity* v_t (Figure 3.*b*) and *specific sliding* ξ (Figure 3.*c*) for entire contact interval $\overline{AE}$ with adopted parameters z_1 = 17; *u* = 1; α_w = 20° is shown.

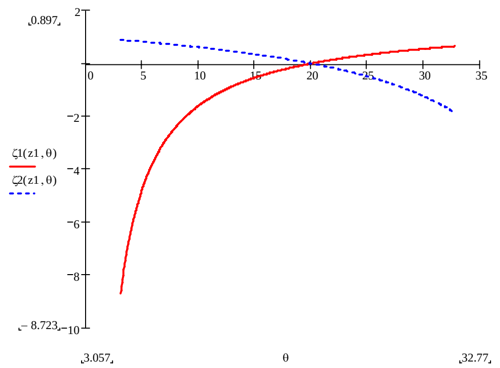


a) *b)*

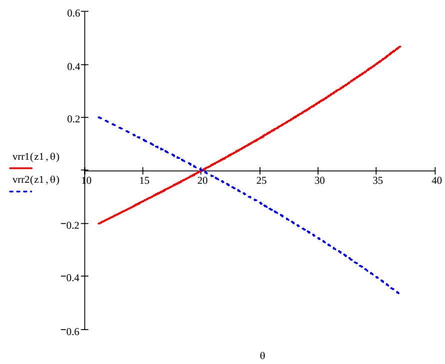
Figure 3.Changeability character: (a)sliding velocity and (b)specific sliding for meshing interval $\overline{AE}$

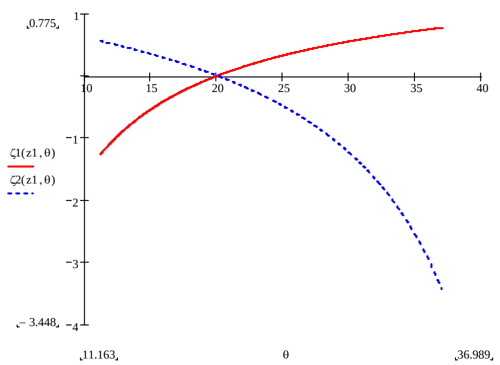
In Figure 4. the graphical presentation of profile deviation coefficients' influence on sliding velocity and specific sliding at meshing interval $\overline{AE}$ is given. The values for profile deviation coefficients are adopted to be x_1 = 0,0; 0,5 and 1,0, while x_2 = -x_1, the teeth number of the pinion is z_1 = 17 and the kinematic transmission ratio is adopted to be *u* = 2.



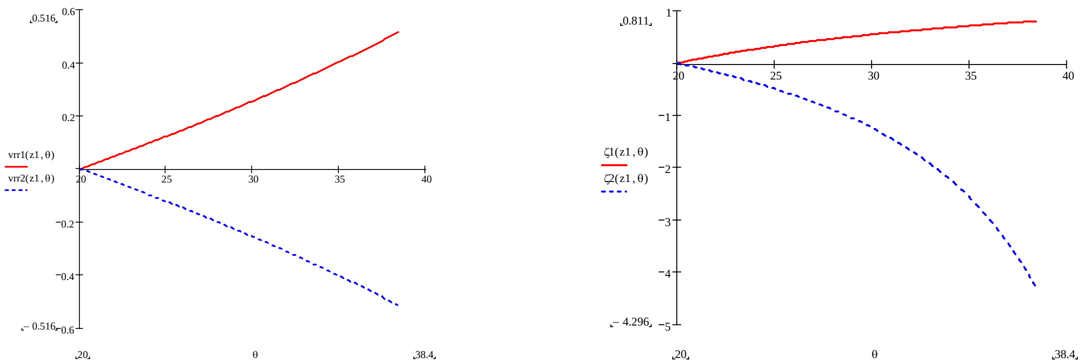


$x_1 = 0$; $x_2 = 0$ $x_1 = 0$; $x_2 = 0$





x_1=0,5; x_2= -0,5 x_1=0,5; x_2= -0,5



x_1= 1,0; x_2= -1,0 x_1= 1,0; x_2= -1,0

Figure 4. Profile deviation coefficients' influence on sliding velocity and specific sliding at meshing interval $\overline{AE}$.

4. CONCLUSIONS

Based on presented results in Figure 3. and Figure 4. on influence of teeth number of gears, profile deviation coefficients and contact line angle to the sliding velocity and specific sliding for the external meshing gears, can be concluded that:

- Profile deviation coefficients is geometric parameter that changes the shape of teeth profile;
- With increase of the profile deviation coefficient kinematic conditions are improved at the beginning (sliding velocity and specific sliding have lower values) that is positive but at the same time length of contact line is shorter that is not desirable.

5. REFERENCES

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