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THE INFLUENCE OF SLIDING SPEED AND SPECIFIC SLIDING OF THE INTERNAL MESHING GEARS

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ABSTRACT

In this paper was analysed the kinematics of the internal meshing of the gear pairs. In details, the sliding speed and specific sliding of the meshing interval (practical and theoretical) were analysed. Also, the factors that influence in the improvement of the meshing conditions i.e. number of teeth, displacement coefficient, transmission rate, etc. results obtained from this study are presented in a form of a diagram and are followed with the appropriate comments.

Key words: Internal meshing, sliding speed (velocity), specific sliding.

1. INTRODUCTION

Except external mesh of gears, the internal mesh exists as well. In Figure 1. is shown internal mesh of two teeth profiles of the gears.

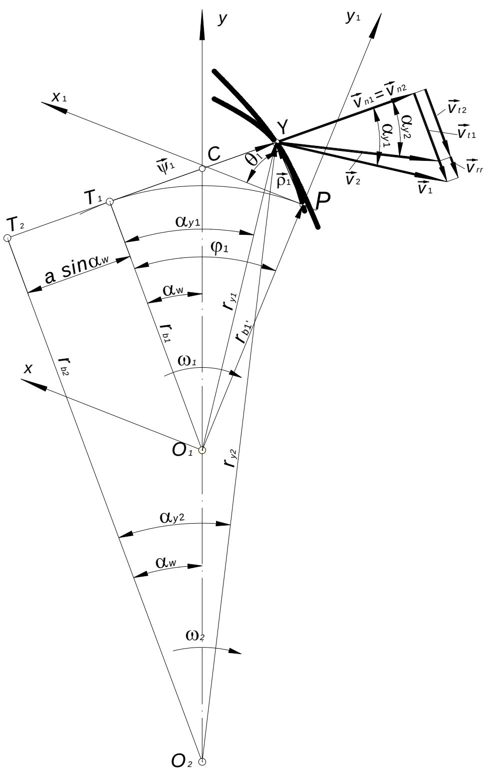


Figure 1. Internal mesh for a couple of gears

Absolute velocity of an instant contact point Y_1 can be expressed by:

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

where:

$\vec{v}_{y1} = \vec{\omega}_1 \times \vec{r}_{y1}$ - is peripheral velocity vector for instant contact point Y_1, $v_{y1} = \omega_1 \cdot r_{y1}$ - is peripheral velocity for instant contact point Y_1, $\vec{v}_{t1}$ - is relative velocity vector for instant contact point Y_1.

In the same way can be determined peripheral velocity for instant contact point Y_2 in the tooth profile of driven gear. Absolute velocity for instant contact point Y_2 can be calculated:

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

where:

$\vec{v}_{y2} = \vec{\omega}_2 \times \vec{r}_{y2}$ - is peripheral velocity vector for instant contact point Y_2, $v_{y2} = \omega_2 \cdot r_{y2}$ - is peripheral velocity for instant contact point Y_2, $\vec{v}_{t2}$ - is relative velocity vector for instant contact point Y_2.

At the instant contact point Y, absolute velocities of meshed teeth profiles of the gears are equal:

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

At the instant contact point Y, peripheral velocities Y_1 and Y_2 have different directions and intensity and as a result of tooth profile sliding at one of the gears in relation to the tooth profile of the other one. Therefore, sliding velocity of tooth profile is:

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

Based on above expressions the sliding velocity at arbitrary contact point can be calculated:

$$v_{rr1/2} = (\omega_2 - \omega_1) \cdot \overline{CY} \quad \text{... (1.5)}$$

At the position when instant contact point of meshed teeth profiles of the gears coincide with point C, then velocity is:

$$v_{rr1/2} = v_{y1} - v_{y2} = 0 \quad \text{... (1.6)}$$

2. SPECIFIC SLIDING ANALYSIS

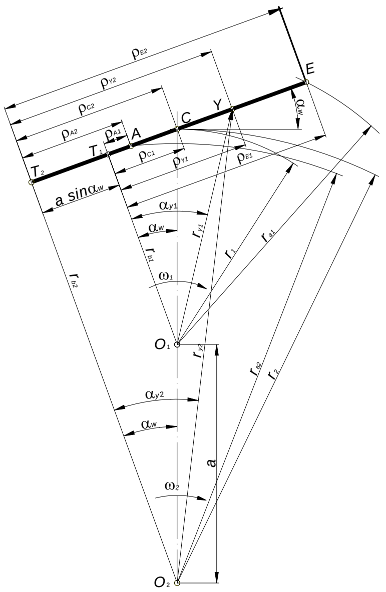


Figure 2. Radii of curves at specific points at contact lines for internal mesh

Parallel with the definition for sliding velocity of teeth profiles also can be determined the sliding velocity of the profile of tooth of the gear at instant contact point *Y* as a proportion between sliding velocity and the respective component of the relative velocity. Therefore specific profile sliding of the driving gear tooth at instant contact point Y_1 is calculated by expression:

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

After necessary substitutions the final expression for the specific sliding at instant contact point Y_1, in the tooth profile of the gear with outside teeth is:

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

Similar, the specific sliding at the instant contact point Y_2, in the tooth profile of the gear with inside teeth can be calculated:

$$\xi_2 = \frac{v_{rr2/1}}{v_{t2}} \quad \text{... (2.3)}$$

Respectively, after needed substitutions the specific sliding at the instant contact point Y_2, in the tooth profile of the gear with inside teeth is given by:

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

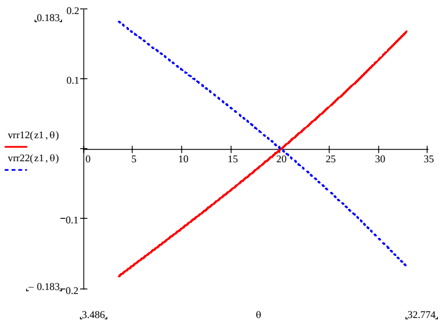
3. RESULT ANALYSIS

Based on theoretical analysis the program for calculation of the velocity for teeth profiles of the evolvent cylindrical gears with internal mesh has been created.

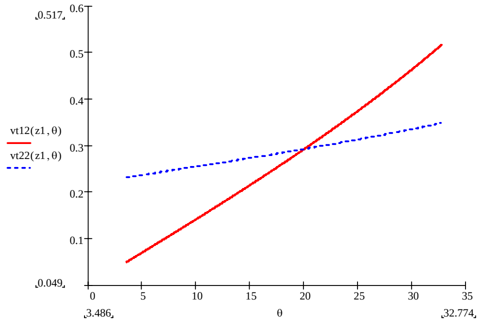
Mathematical model was developed to calculate certain quantities for entire mesh interval. In this paper influences of the number of teeth of meshed gears, kinematical transmission ratio, angel of contact curve, profile deviation ratio etc are analysed.

Analysis for z_1 = 17, 20, 25 and 30, $z_2 = z_1 \cdot u$ and for $u=2 \ldots 6$ has been done, where profile deviation ratio is adopted at interval $x = 0 \ldots 1$, for couple *XO* ($x_1=-x_2$).

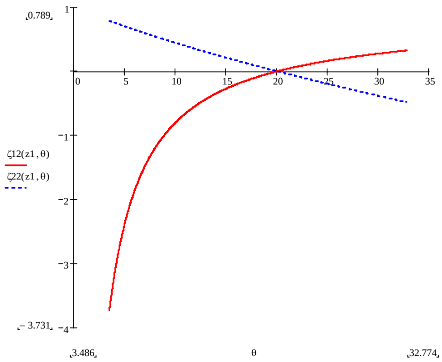
In *Figure 3.* the graphic presentation of the curves for *sliding velocity* v_{rr} (*Figure 3.a*); *relative velocity* v_t (*Figure 3.b*) and *specific sliding* ξ (*Figure 3.c*) at entire contact interval $\overline{AE}$ and parameter values $z_1 = 17$; $u = 2$; $\alpha = 20°$ is given.



a)



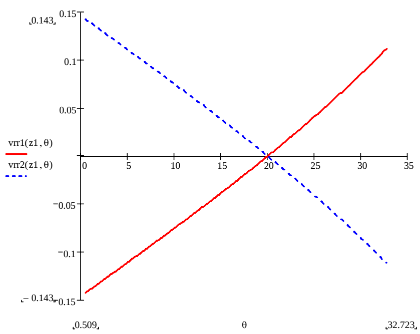
b)



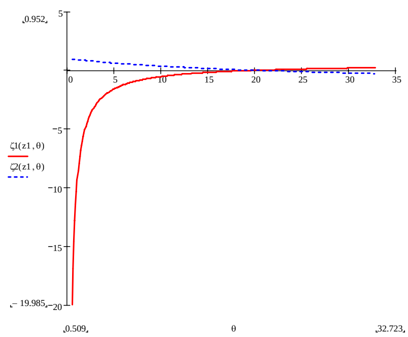
c)

Figure 3. Variability of the sliding velocity (a), relative velocity (b) and specific sliding (c) at mesh interval $\overline{AE}$

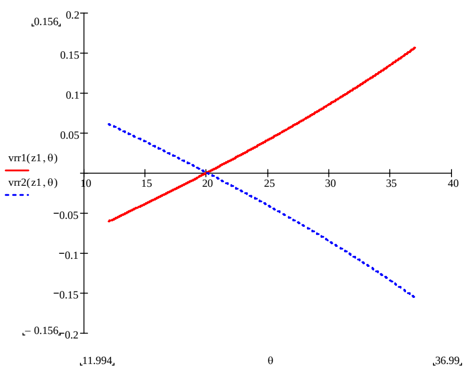
In Figure 4. graphic presentation of profile deviation ratios influence on sliding velocity and specific sliding at mesh interval $\overline{AE}$ is given. Analysis was carried for profile deviation ratios: x_1 = 0,0; 0,5; and 1,0 where $x_2 = -x_1$ and for teeth number of driving gear $z_1 = 17$ with transmission ratio $u = 2$.



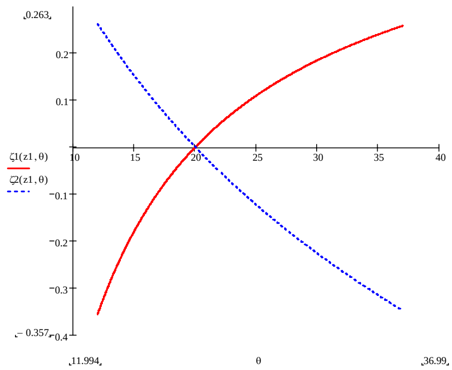
$x_1 = 0$; $x_2 = 0$



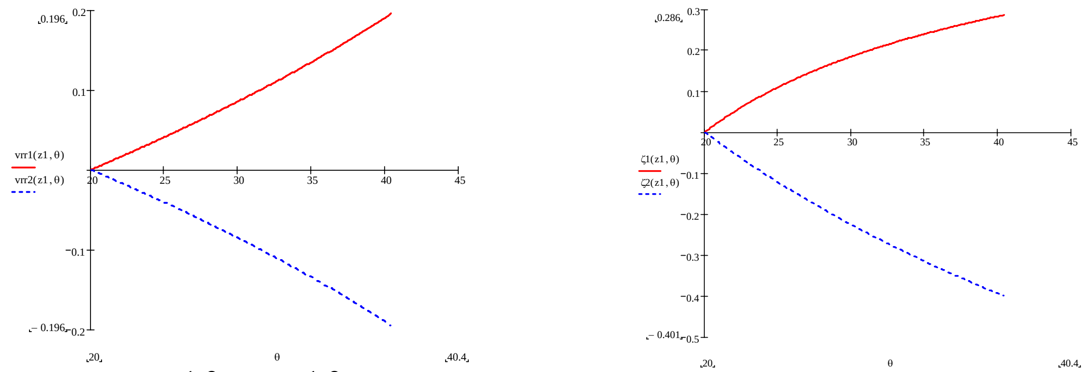
$x_1 = 0$; $x_2 = 0$



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



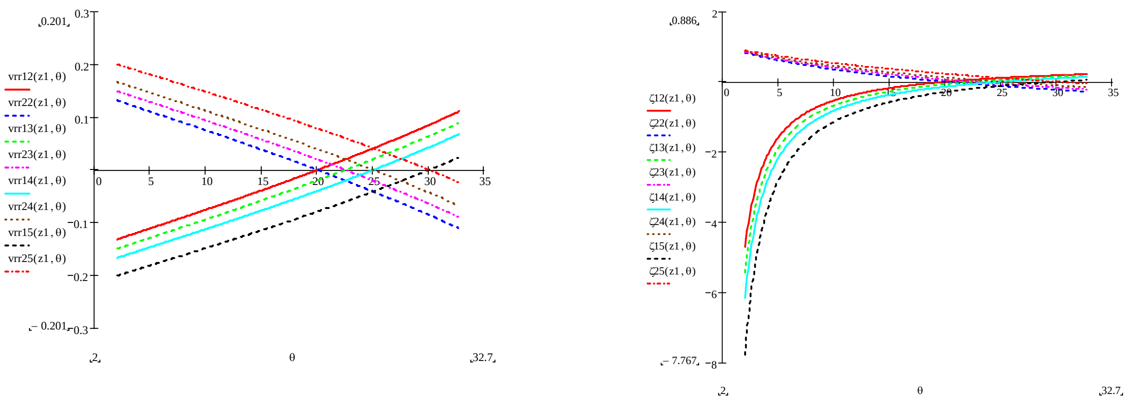
$x_1=0,5$; $x_2= -0,5$



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

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

Graphic presentation of the results on influence of the angle of teeth's contact curve on sliding velocity and specific sliding are given in *Figure 5.*for angle values: α=20°, 22.5°, 25° and 30°.



a) *b)*

Figure 5. Influence of the angle of teeth's contact curve on sliding velocity (a) and specific sliding (b)

4. CONCLUSIONS

Based on results' analysis graphically presented in Figure 3.1, 3.2 and 3.3 on influence of teeth number, deviation ratio and angle of teeth's contact curve on sliding velocity and specific sliding of the gears teeth can be concluded that:

- Profile deviation ratios are geometric parameters which change shape of the tooth profile;
- With increase of the profile deviation ratios the cinematic conditions at the start of meshing are improved (values for sliding velocity and specific sliding are lower) which is positive but active distance of contact line is shortened;
- Profile deviation influences on increase of the consistency of gears couple;
- Angle of the contact line of α = 20° is most acceptable value, because sliding velocity and specific sliding decreases.

5. REFERENCES

[1] Avdiu, S.: Ndikimi i shkallës së ingranimit dhe shpejtësisë së rrëshqitjes në bartjen e dhëmbëve të dhëmbëzorëve, Disertacion i doktoraturës, Prishtinë, 2002.
[2] Buckingham, E.: Analytical Mechanics of Gears, McGraw-Hill, 1988.
[3] Dudley, D.: Handbook of Practical Gear Design, McGraw-Hill, 1984.
[4] Norton, R.: Machine Design, An Integrated Approach, Prentice-Hall, Inc., 1998.
[5] Faydor Litvin: Gear Geometry and Applied Theory, Prentice-Hall, Inc., 1994.
[6] Niemann, G., Winter, H.: Maschinenelemente, Band II, Springer-Verlag, Berlin, 1985.
[7] Ibrahimi, N.: Detalet e makinave, Pjesa II, Prishtinë, 1996.