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ASSISTED RESEARCH OF THE RIGIDITY AMPLITUDE OF WORM-GEARING TOOTH

Assoc.Prof.Dr.Eng. Ghelase Daniela,
Assoc.Prof.Dr.Eng. Daschievici Luiza
"Dunarea de Jos" University of Galati

ABSTRACT

By means of own software, which evaluates the rigidity of the worm-gear-tooth system, the paper presents some aspects regarding the amplitude of rigidity. The study was made on the elasticity characteristic of worm-gearing tooth. On the basis of obtained results, the paper presents the influence of the geometrical parameters on the amplitude in order to increase the gearing tooth rigidity.

1. Elasticity characteristic of worm-gear tooth system

Using our computer program, the diagram of the worm-gear-tooth system rigidity was obtained, as may be seen in the figure 1, "j" being the rolling angular parameter. The elasticity characteristic represents the variation of the worm-gear-tooth system rigidity depending on the rolling angle (j·Δφ), where "j" is the rolling angular parameter [1]. It is a cvasisinusoidal curve with the high jumps when a tooth binds or recesses and it was performed for a cylindrical worm-gear drive having arch profile (fig. 2) with the following parameters:

- number of worm threads: $z_1 = 1$;
- number of gear teeth: $z_2 = 53$;
- axial module: $m_x = 10$ mm;
- diametral quotient: q = 10;
- constructive parameter: a=70 mm;
- angular increment: $\Delta\varphi = \pi/3240$;
- profile angle: $\alpha = 20°$.

Figure 2 presents the axial section of the worm with constant pitch, having a circular arch profile with center O_1 for the right flank and O_2 for the left flank [2], where :

$$
\begin{aligned}
&u = 1.25 \cdot m / \cos\alpha; \\
&p = m/2; \\
&b = \pi \cdot m/4 - 1.25 \cdot tg\,\alpha \\
&R = \sqrt{a^2 + u^2}
\end{aligned}
\tag{1}
$$

2. Amplitude of rigidity of worm-gearing tooth

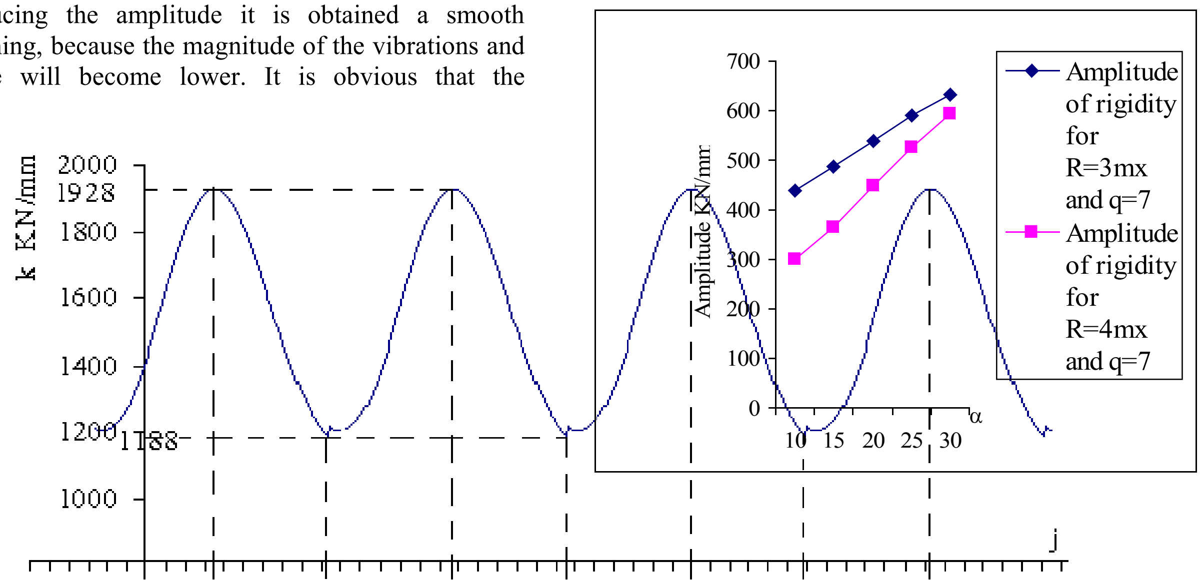
The influence of the geometrical parameters on the rigidity of the worm-gearing tooth was studied in [3] by means of computer simulation.

Hence, the amplitude of the rigidity reduces if:

- number of gear teeth z_2 increases (see table 1, fig.3);
- profile angle α reduces (table 2 and fig. 4);
- diametral quotient q reduces (table 3, fig. 5, fig. 6);
- radius of profile curvature R increases (table 3, table 4, fig. 5, fig. 6).

Fig. 1. Elasticity characteristic of worm-gear tooth system

Reducing the amplitude it is obtained a smooth meshing, because the magnitude of the vibrations and noise will become lower. It is obvious that the



reduction of amplitude of rigidity curve is a mode to obtain high rigidity for the gearing tooth.

Table 1

Influence of number of gear teeth z_2 on amplitude

z_2	Maximum Rigidity	Minimum Rigidity	Amplitude of rigidity [KN/mm]
			45
			2
			0
			5
			4

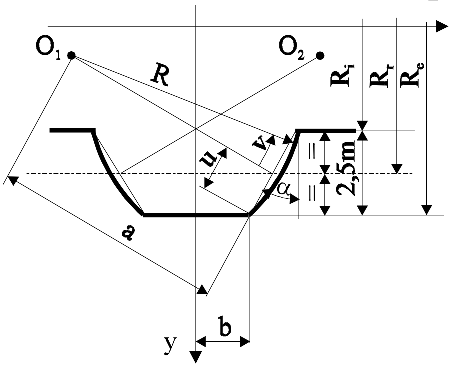


Fig. 2. Worm flank geometry.

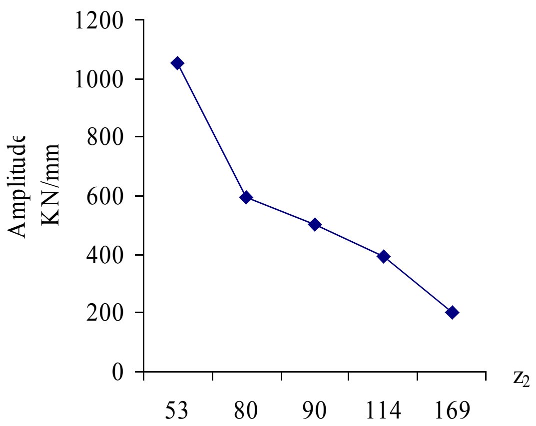


Fig. 3. Amplitude of rigidity depending on z_2

Fig. 4. Amplitude of rigidity depending on profile angle

Table 2

Influence of profile angle on amplitude

α[°]	Amplitude of rigidity [KN/mm] for $R=3 \cdot m_x$ and q=7	Amplitude of rigidity [KN/mm] for $R=4 \cdot m_x$ and q=7
10	439,768	300,690
15	487,297	365,662
20	537,490	449,511
25	590,143	525,614
30	632,843	593,135

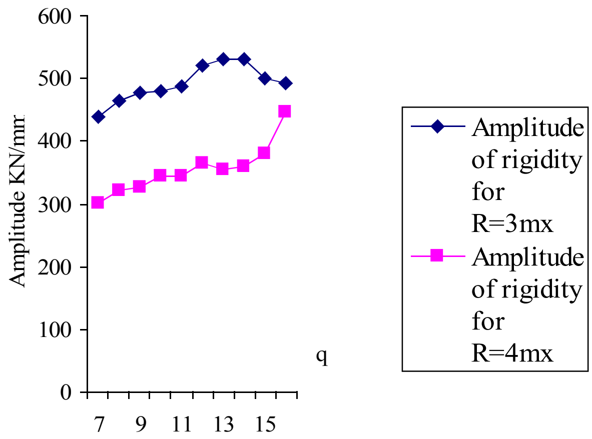


Fig. 5. Amplitude depending on q, R, α=10°

Table 3

Influence of diametral quotient and radius of profile curvature on amplitude

q	m_x [mm]	Amplitude of rigidity [KN/mm] for $R=3 \cdot m_x$, α=10°	Amplitude of rigidity [KN/mm] for $R=4 \cdot m_x$, α=10°	Amplitude of rigidity [KN/mm] for $R=3 \cdot m_x$, α=20°	Amplitude of rigidity [KN/mm] for $R=4 \cdot m_x$, α=20°
7	5,20	439,768	300,690	537,490	449,511
8	5,16	463,877	320,888	580,426	486,240
9	5,12	476,271	326,327	617,484	508,882
10	5,08	480,393	343,617	631,263	515,258
11	5,04	488,338	345,394	635,026	523,156
12	5	521,871	365,301	640,248	546,103
13	4,96	532,208	354,449	656,227	581,251
14	4,92	530,959	361,054	689,048	611,675
15	4,88	500,997	381,046	716,582	618,388
16	4,84	493,212	446,091	722,285	609,272

Table 4

Influence of radius of profile curvature, which depends on axial module, on rigidity

z_2	m_x [mm]	$R=3\cdot m_x$, q=7, α=20°				$R=4\cdot m_x$, q=7, α=20°			
		Maximum Rigidity	RigidityMinimum	Medium Rigidity	Amplitude	Maximum Rigidity	Minimum Rigidity	Medium Rigidity	Amplitude
53	10,5	1533,2	470,56	1001,8	1062,6	1608,6	721,91	1165,2	886,70
114	5,2	817,64	280,15	548,89	537,49	861,19	411,68	636,43	449,51

Studding the influence of geometrical parameters on amplitude of rigidity of the worm-gearing tooth [4], we can perform a design algorithm which ensures a constant rigidity for the gear drive.

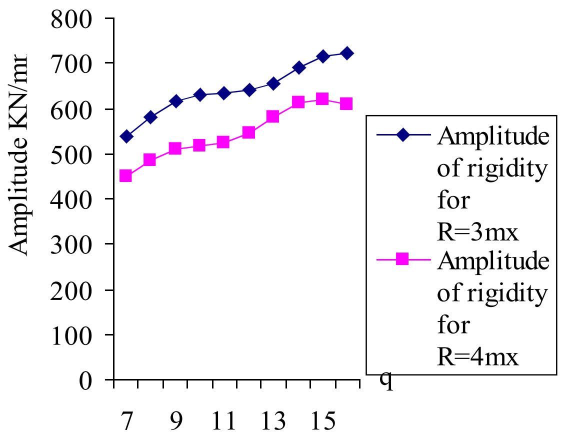


Fig. 6. Amplitude depending on q, R, α=20°

3. Conclusion

Based on the performed research, the following conclusions might be drawn:

a) the amplitude of the rigidity reduces if:
- number of gear teeth z_2 increases;
- profile angle α reduces;
- diametral quotient q reduces;
- radius of profile curvature R increases.

b) taking into account the influence of each geometrical parameter on te rigidity of worm-gearing tooth, we can obtain a optimal design algorithm to improve the performances of worm-gearing

c) the study leads to increase of the gearing tooth rigidity, improving the accuracy of the machine-tool and robot linkages.

References

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