5th INTERNATIONAL MEETING OF THE CARPATHIAN REGION SPECIALISTS IN THE FIELD OF GEARS

RELATION BETWEN TOOL IMPACT AND VIBRATIONS DURING GEARS GENERATION BY SHAPING

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Abstract: *The aim of the paper is to point out the efficiency limitations that have been caused by technological process properties in gear shaping. The gear shaper cutter, hitting the face of the gear, creates the vibrations. These vibrations can be limited or intensified. The place the vibrations occur as well as the method of their limitation, have bee presented in the paper.*

Key words: *tool impact, vibrations, gear generation*

1. INTRODUCTION

Most of the gears (with modules $1 < m < 6$) applied in various machine constructions is manufactured by means of shaping (Fellow's method). The significant progress in tool material production created opportunities of the significant increase of the gear quality. Coating of shaper cutter edges with hard layers enables to increase significantly cutting speed with preserving the same feed and cutting depth. This cutting speed increase is limited by the impact character of the cutting edge [1, 2, 3].

2. LOADING DESCRIPTION OF SHAPER EDGES

Evaluation of shaper's work while forming the tooth space enables to state that three or four cutting edges are in direct contact with the work piece. One of these edges is loaded mostly as the three chips cover this edge from three sides interacting with each other. The edge after impact against the gear face enters the work piece. Fig. 1.

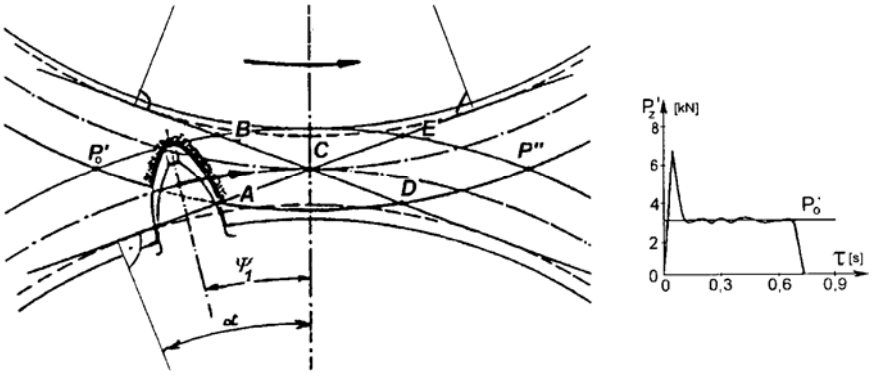

Fig. 1. *Edge location at the highest load*

The vibrations occurring in the process are transmitted onto the other edges and they are reproduced on the involute surface of the tooth. Evaluating the course of work in single stroke for the most loaded edge it is possible to present the sequence course phases [1]. The sequence phases of edge loading have been presented in Fig. 2.

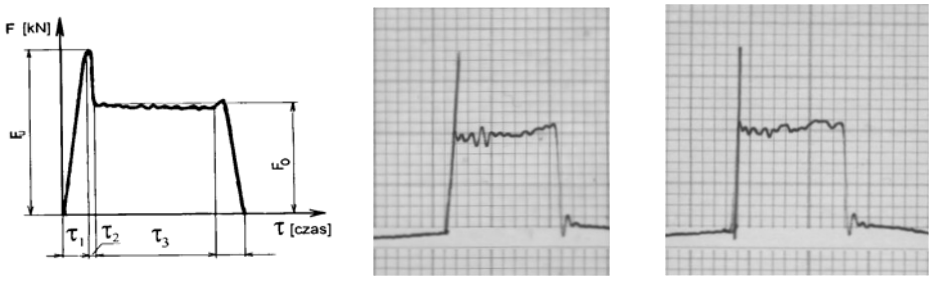

Fig. 2. *Cutting force variations during one edge pitch τ_1 - edge impact duration, τ_2 -load rejection time, τ_3 -shaping time*

The vibrations may occur in τ_3 phase depending on the edge loading value and increasing of the impact force. Depending on edge loading value the vibrations may disappear or multiply in following strokes. The system machine tool - gear shaper - work piece - work piece holder is characterized by certain damping abilities. Anyway, the exceeding of the certain critical loading value of the edge causes the decreasing of damping abilities and intensive increase of vibrations.

3. FACTORS INFLUENCING THE VIBRATION INTENSIFICATION

The significant factor causing the vibration intensification is the cross section of the machined layer. The increases of the feed as well as the cutting depth make the increase of vibrations. The following factor that intensifies the vibrations is the rake angle. The influence of the rake angle upon the impact force of one shaper edge has been presented in Fig. 3.

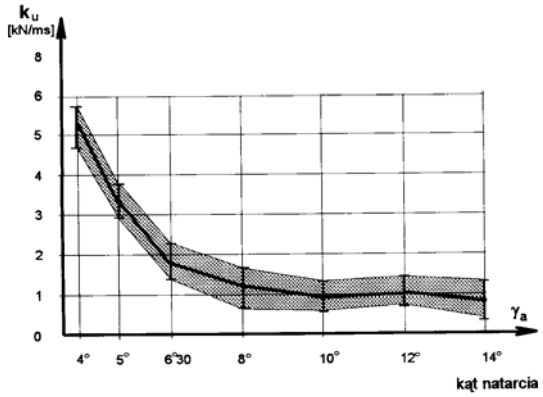

Fig. 3. *The influence of rake angle on edge load factor*

It has been proved that decreasing the rake angle to the value of 4°, caused the increase of impact force from 7 kN to 10 kN but increasing the rake angle to 8° caused the decreasing of impact force to 4,5 kN. The other significant factor causing the vibrations is the construction of the machined gear. All the experiments have been performed for the disc gear supported circumferentially. Such position of the gear enables the vibration damping.

4. INVESTIGATION RESULTS

The course of impact force and cutting force below its critical value has been shown in Fig. 4.

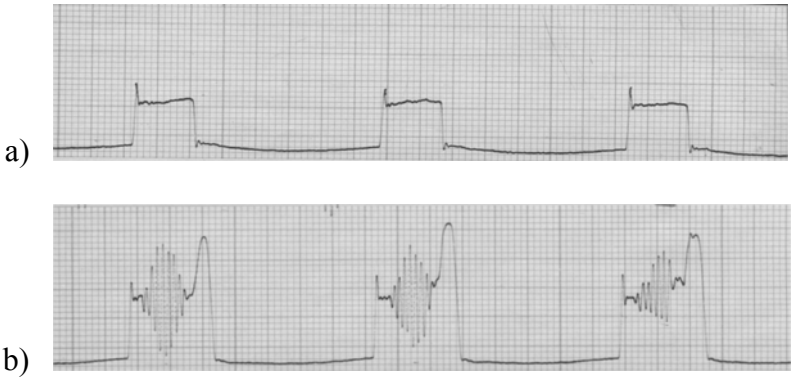

Fig. 4. *Force variations in tooth space shaping process a -without vibrations, b -with damped vibrations*

The vibrations are observed but they are of the decay character. The course of impact force and cutting force over its critical value has been shown in Fig. 5.

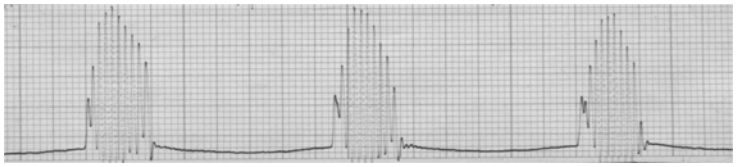

Fig. 5. *Force variations in tooth space shaping process - with increasing vibrations*

As it is shown the vibrations for the following strokes are intensified. As the effect of vibrations the characteristic zones on the involute surface of the tooth are created (see Fig. 6).

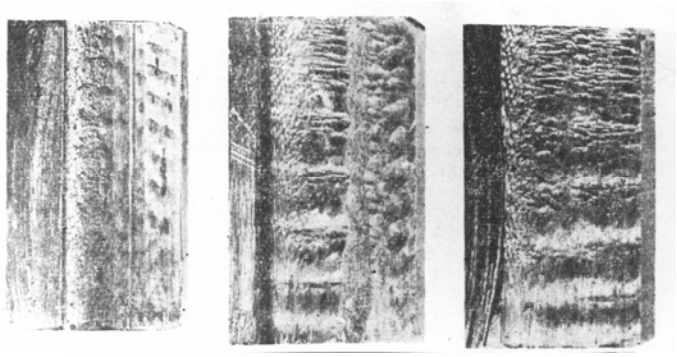

Fig. 6. *The image of vibrations on tooth involute surface*

5. CONCLUSIONS

Basing on the performed investigations it is possible to state that the value of the critical force intensifying vibrations depends on shaping conditions, edge geometry, machined material and construction of the gear. Precise determination of critical force value is practically impossible. The authors described the critical force for shaping the gears with modulus 3 and standard cutting edge geometry by means of the following factor of the edge loading

$$K_{F_u} = \frac{F_u}{\tau_1} = 9{,}5 \cdot 10^3 \frac{kN}{s}.$$

REFERENCES

[1] Kazimierz Wieczorowski, Roman Siecla, Stanislaw Legutko, **The influence of gear shaper cutter wear on the loading of edges**, Abrazivna obrabotka, broj 9, 1999, Varna, Bułgaria, pp. 7-8.

[2] Kazimierz Wieczorowski, Roman Siecla, Stanislaw Legutko, **Impulse stroke identification as a state of matter of gear-shaper cutter wear,** Proceedings of IV World Congress on Gearing and Power Transmission, vol. 2, Paris 1999, pp. 1815-1820.

[3] Kazimierz Wieczorowski, Roman Siecla, **Research of the cutting forces in a gear generating process of an external – teeth cylindrical gears,** Proceedings of 7th international conference "New ways in manufacturing technology", Presov 2004.

[4] Kuric, I., Matuszek, J., Debnár, R.: **Computer Aided Process Planning in Machinery Industr**y, Politechnika Lodzka, Bielsko Biala 1999, ISBN 83-87087-00-9