THE PROFESSIONAL FORMATION OF SPECIALISTS FOR THE FABRICATION OF GEAR WHEELS BY MEANS OF EXEPERIMENTAL RESEARCH

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ABSTRACT: *This paper presents the processing procedure of gear wheels by means of wheel-tool mortising within the Machine-Line-up-Tool-Part "MLTP" system. In order to avoid the complex calculations requested by the fabrication of gear wheels I have set up a model of experimental research that allows the specialist to use a measuring chain of geometrical parameters with the help of competitive machinery.*

Thus, the results of experimental research performed on a lot of 2000 gear wheels are being presented. This is done by using different cutting modes: Cs, Cf (Cs – cutting speed, m/min., Cf – circular feed, mm/cd, dc – double course per minute).

These results have led to establishing an optimal cutting mode Cs, Cf on the basis of the parameters that have been taken into consideration.

The paper is as a pattern in the determining process of other important geometrical parameters of gear wheels such as: toothing radial clatter, the above "n' quota, "tn" – teeth number, the width between centres, the flank and profile toothing roughness.

Key words: *mortising, parameters, gear, cutting.*

1. GENERAL ISSUES

Specialized literature [2] and a series of recent standards have tried to establish a link between the precision of processed gear wheels and that of the half-finished material, the precision of the machine-tool and the improvement of the tool's geometry. Among the subjects that were not discussed were: the influence of the cutting mode upon toothing precision, the influence of the cutting mode upon the deformations of the tool-supporting and piece-supporting bolts, the tool's variation of acceleration during its stroke; these are the issues that will be developed in this paper by means of experimental research.

The result of experimental research taking into account some theoretical assertions was that the variation of the cutting mode (V, Sc) influences the precision of the processed gear wheel [5] so that during the fabrication processed based on this procedure these parameters have to be taken into consideration.

Due to practical reasons in the context of sustained improvement of technological installations' functional parameters, some research was made on a large number of gear wheels (approximately 2000 pcs m=4mm, Z_1=11 and m=2,5, Z_2=9 teeth, 13CN35 material) using the cutting-wheel tool, AA precision class, α_d=20°, Rp3 material.

The teeth mortising was done on a TOS OH-6 machine employing the following cutting modes:

Cs=8,8; 11,0; 13,7; 17,6; 22,0; 27,5; 34,6m/min;

Cf=0,16; 0,20; 0,25; 0,32; 0,40; 0,50 mm/dc;

The influence of the cutting mode upon the deformations of the tool-supporting and piece-supporting bolts, upon the above-2 teeth quota, upon radial clatter and upon the variation of the width between axes.

2.THE MEASUREMENT OF GEAR WHEELS' PRECISION USING A SYSTEM CONSISTING OF TOOTHING MACHINE, MEASURING CHAIN-COMPUTER

Theoretical and experimental research regarding the influence of the cutting mode and implicitly of the deformations of the tool-supporting and piece-supporting bolts, are few and they refer to cutting-based toothing [3].

One of the causes that generated this drawback was that a high-precision electronic gear able to do precise measurements was conceived and produced only recently [4].

The deformation of the tool-supporting bolt can be calculated using the well-known relation taken from the field of material resistance studies [1]:

$$fd_s = F \cdot l_{d_s}^3 / 3EI_z \qquad (2.1.)$$

of which: F is the force that acts upon the bolt and causes the deformation; l_{d_s} –the length of the bolt undergoing deformation (variable in the case of the tool); E – elasticity module; I_z – stagnation moment.

In order to apply the method of deformation establishment for all types of machine-tools, employed tools and fabricated gear wheels, analytical calculations would get so complicated that it would become inefficient and would require to be abandoned as far as production use is concerned.

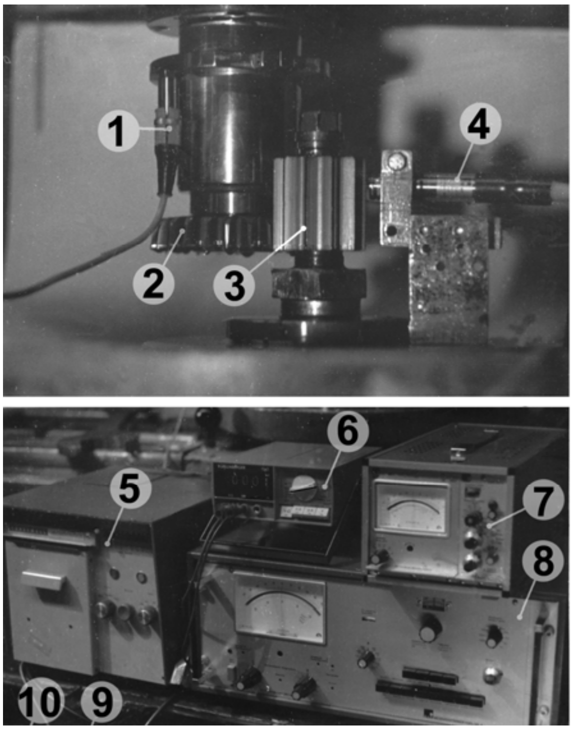
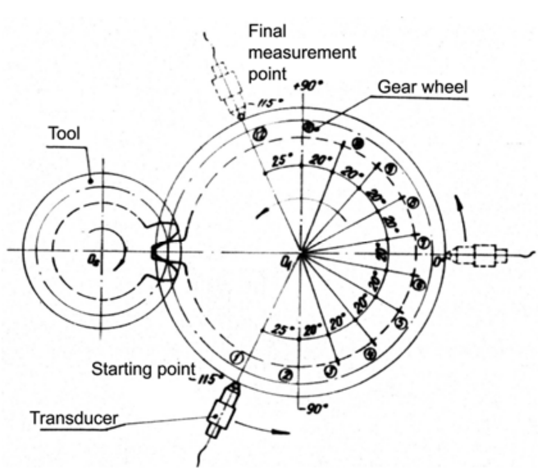


Fig.1. The system: mortising machine, measuring chain, data acquisition board, computer.

1 – Accelerometer
2 – Cutting-wheel tool
3 – Processed gear wheel
4 – HBM, W1T2 type scrolling transducer, 0,1 separation power, 1% precision class;
5 – Visikorder V1706 oscillograph;
6 – Digital voltmeter;
7 – Amplifier;
8 – MBH, KWS 3072 type measurement amplifier, designed for measurements with resistive and inductive transducers;
9 – data acquisition board;
10 – computer.



Due to the above-mentioned theoretical reasons and to practical exigencies a practical method which is precise and economic is being proposed for the measurement of tool-supporting and piece-supporting bolts applicable in the sector of gear wheel production. Consequently a measuring chain has been developed using the necessary gear capable of insuring a 0,1 μm measurement precision, figure 1, [4].

The position of the transducer during the measurement of the gear wheel's precision parameters at a 230˚ possible rotation is presented in figure 2:

Fig.2 Position of the transducer at a 230˚ rotation of the processed gear wheel.

With this system the oscillogram of the deformation of the tool-supporting bolt is being traced. See fig.3

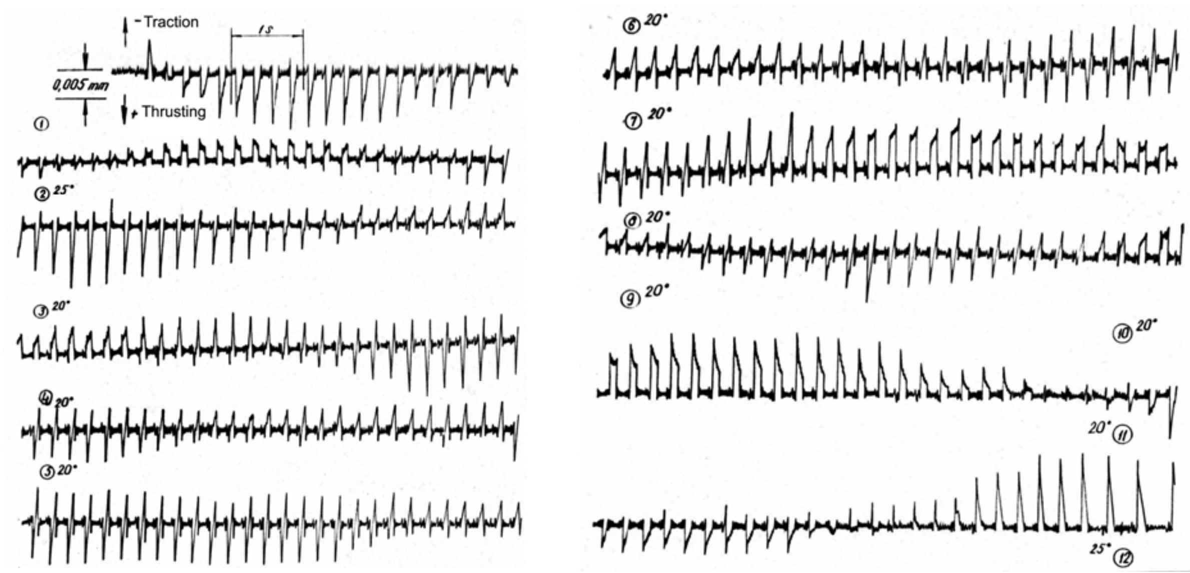


Fig.3 (a,b) Oscillogram of the deformation of the tool-supporting bolt for a 230˚ rotation and a Cs=27,5 m/min, Cf=0,25 mm/dc cutting mode.

The data acquisition board and the computer, fig. 1-9 and 9-10 present, according to the oscillogram, the quality and the deformation parameters of the tool-supporting and piece-supporting bolts based on the various cutting modes.

Similarly, and after the completion of specific adaptations, the above 2 teeth quota, the radial clatter of the toothing and the width between axes may also be measured.

3. THE INFLEUNCE OF THE CUTTING MODE UPON PROFILE AND FLANK ROUGHNESS, A RESULT OF TEETH MORTISING WITH THE CUTTING WHEEL

The roughness criteria of body surfaces are included in ISO/R 468-1966 and STAS 5730/2-75.

In the field of milling intensive research has been carried out leading to the deduction of formulas for the calculation of asperity height; these calculations demonstrated that the theoretical roughness is much more reduced than the practical one [2].

The diversity of studies has shown that roughness that is too elevated leads to a decrease of the tooth flanks' participation ratio to the lifting power and causes a reduction of the flanks' lifting capacity. At the same time, it is well-known that the surface roughness may be employed to evaluate the lifting capacity of the flanks [4] this in case there are no tooth direction errors or evolvent deviations whatsoever (a goal that is extremely hard to attain).

Based on the aspects presented above and having finalized the theoretical method to determine the roughness R_a of the flank resulting from toothing mortising, a complex program of flank and profile roughness measurements has been set up based on the cutting mode and the tool wear and tear.

In order to measure the R_a in our case we employed the Taylor-Hobson electronic roughness tester (fig.4); this tester obtains, by means of a perception head, the roughness parameters shown on a screen in μm with a 1 μm precision [5].

Specialized studies have discussed mostly the influence of the cutting mode upon the roughness of processed surface but the states for which these measurements were made are inferior to those employed in actual technical areas of investigation.

Taking into account all aspects presented in this paper, measurements of the roughness parameter R_a were performed on the flanks and profiles of a large number of gear wheels.

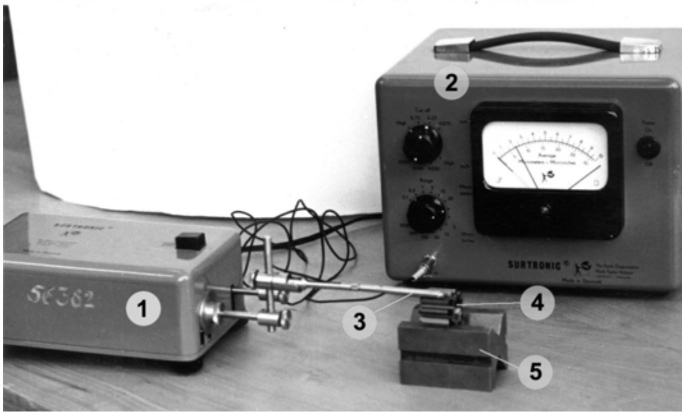


Fig.4. The measurement of gear wheels flanks' roughness M=2,5mm, Z=9 teeth using the Taylor Hobson, roughness tester, made in England.

1,2 – measuring device; 3 – perception head; 4 – gear wheel; 5 – prop.

With the results achieved as a result of toothing mortising with 6 types of circular feed and 5 cutting speeds, the flank and profile roughness was traced; all this based on the cutting speed and the R_a diagrams for both flank and profile according to the circular feed [3].

4. CONCLUSIONS

From the perspective of processing precision the following aspects were developed and researched during the cylindrical mortising process:

- the influence of the cutting mode upon the deformation of the tool-supporting and piece-supporting bolts;
- the acceleration of the cutting-wheel tool during toothing mortising;
- the influence of the cutting mode upon toothing radial clatter, upon the above 2 teeth quota and upon the width between axes;

The result is that flank roughness is influenced by both the cutting feed and the cutting speed. It has also been noticed the presence of a tendency of roughness increase along with the increase of cutting speed; at the same time profile roughness is influenced firstly by the peculiarities of the cutting tool (mode, number of teeth) and secondly by the cutting mode.

In the case of cutting-wheel mortising, the calculated roughness (theoretical) is 10…50 times smaller than the effective (measured) roughness; this fact shows that besides geometrical roughness there are a series of other factors that have a significant influence such as: chipped material deformation, stock formation on the cutting-edge, vibrations, etc.

REFERENCES

1. Botez, E, - Basics of generating surfaces with the use of machine tools, Bucuresti, Editura Tehnica, 1966;
2. Lăzărescu, I., Pay, E. – Studies of Applie Mechanics, 28 (1969), 1147;
3. Matiusin, V.M. – Gear wheels mortising, Bucuresti, Institutul central de documentare tehnica, 1953;
4. Tiplea, V. – Pinion cutter mortising of cylinder gear wheels, U.T.PRES, Cluj-Napoca, 2002, p.21;
5. Tiplea, V. – Doctoral dissertation, 1997, Polytechnic Institute of Cluj Napoca, p.15;