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# THEORETICAL ASPECTS AND EXPERIMENTAL RESEARCH CONCERNING OF THE USE OF DYNAMOMETRIC TABLES IN THE STATICAL RIGIDITY OF TOOTHED-WHEELS MACHINES

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## 1. INTRODUCTION

Within the tooting process the cutting force is being transmitted, in the same time, to the piece under manufacturing and on the cutting. Through these, the cutting force is transmitted forward to the fastening device of the piece and cutting as well as to the base and actuating units of the machine tool.

The cutting force depends on several factors. Among them the most important are: the nature of the material under manufacture, the cutting regime, the tool's wear and the tool's geometry etc.

The tooling precision problems are *sine qua non* connected by knowing of application's real conditions, during the cutting process, of the elastic technological system's components.

In the same time, the machine tool state and cutting supervision can be efficiently and economically achieved only by knowing the cutting force.

From this reason, the cutting force constitutes the starting point to the machine tool design and strength properties dimensioning of the tool, devices and the raw material under manufacture.

## 2. ABOUT THE DYNAMOMETRIC TABLE

For a precision evaluation of the cutting force components evaluation of $F_x$, $F_y$, $F_z$ and $M_t$ cutting force components been conceived and set-up a dynamometric table, using 4 octogonal electrotensometrical sensing devices (fig.1) equipped each of them with 8 electrical strain gauges, mounted in whole Wheatstone bridges. These devices allow the evaluation both of the vertical and horizontal cutting force components [Miskolc1].

Taking into account the octagonal sensing devices placement may be expected a signal interference, from $F_V$ and $F_H$ and vice-versa, interference that only theoretically can be removed by using identical electric balances. In practice, these interferences will cause signal denaturation, consequently the measurement errors of the cutting force's components [Miskolc1].

## 3. **CALIBRATION PROCESS RESULTS**

Starting from the research made by Hsu et al. have been represented the $F_x$, $F_y$, $F_z$ and $M_t$ components of the cutting force and the torsion moment function of corresponding signals (readings) of their $R_x$, $R_y$, $R_z$ and $R_m$ and $\alpha_{ij}$ coefficients that follow to be analytically evaluated:

$$\begin{Bmatrix} F_x \\ F_y \\ F_z \\ M_t \end{Bmatrix} = \begin{bmatrix} \alpha_{11} & \alpha_{12} & \alpha_{13} & \alpha_{14} \\ \alpha_{21} & \alpha_{22} & \alpha_{23} & \alpha_{24} \\ \alpha_{31} & \alpha_{32} & \alpha_{33} & \alpha_{34} \\ \alpha_{41} & \alpha_{42} & \alpha_{43} & \alpha_{44} \end{bmatrix} \cdot \begin{Bmatrix} R_x \\ R_y \\ R_z \\ R_m \end{Bmatrix}. \tag{1}$$

This correlation, as was mentioned in [1], is valid only in the case of slow, statically loading, so within labs trials.

There have been done different combinations of the loading conditions, both for one component and combinations of theirs.

With the aim of $\alpha_{ij}$ constants evaluation (16 components), theoretically was necessary only 4 measurement sets but the authors made 20 versions. Taking into account the results obtained and their weighted average were obtained the $\alpha_{ij}$ coefficients.

In figure 2 is being represented the set-up configuration used for calibration within the laboratory.

For the dynamometric table's calibration have been done the following steps:

- the table had been loaded after the directions given for the $F_x$, $F_y$, $F_z$ and $M_t$ components of the cutting force;
- the loadings have been done for each of the component or combinations of theirs;
- on the table have been established 7 areas of loading conditions corresponding to the following values of the indexing radius that has to be processed: 30, 45, 50, 65, 75, 100 and 130 [mm];
- the table had been loaded with the cutting force's components $F_x$, $F_y$, $F_z$ and $M_t$ having the following values:
    - $F_x$ : 10, 7.5, 5.5, 4 [daN];
    - $F_y$ : 40, 30, 20, 10 [daN];
    - $F_z$ : 100, 75, 50, 25 [daN];
    - $F_z$, $F_y$ : 100, 40 [daN];
    - $F_z$, $F_y$ : 75, 30 [daN];
    - $F_z$, $F_y$ : 100, 40 [daN];
    - $F_z$, $F_y$ : 25, 10 [daN];
- for the loadings have been used calibrated weights;
- the $R_x$, $R_y$, $R_z$ and $R_m$ measured results have been recorded.

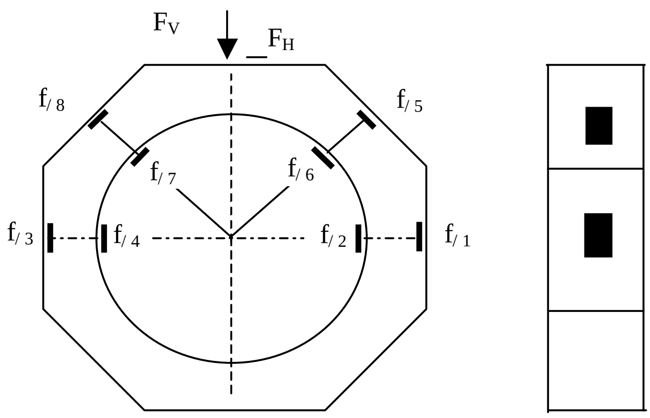


Fig.1

The octagonal sensing device

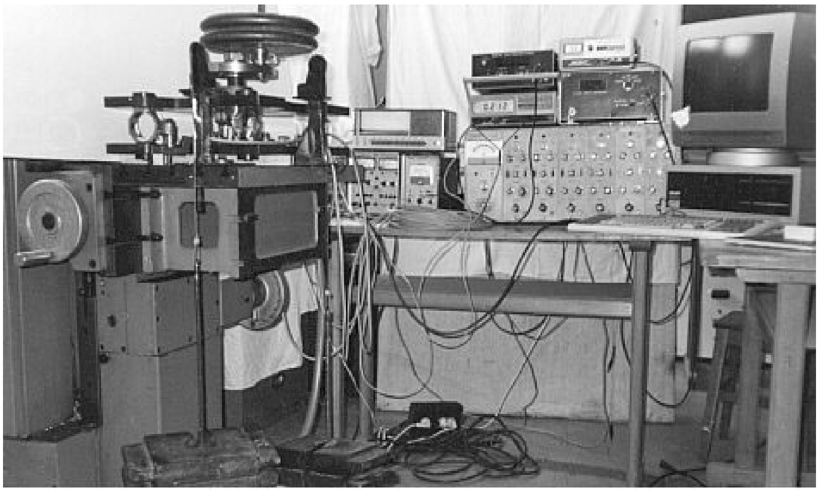

Fig. 2. The set-up used for calibration within the lab

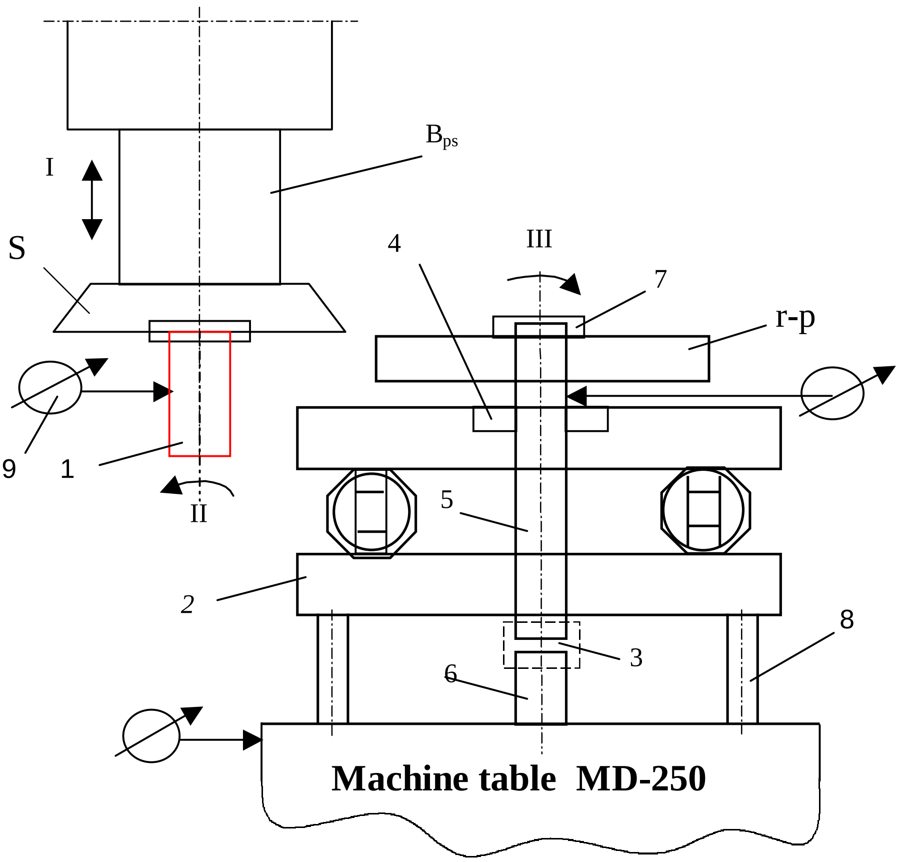


Fig. 3. Set-up for loading conditions rigidity evaluation of the toothed-wheels machine MD-250: I-the mortising movement; II and III- the tool holder movement $B_{ps}$ ,respectively of the machine table; S-knife disk; r-p –disk part;1-special chuck; 2-dynamometric table; 3 –coupling; 4- guiding element;5-6 special chucks; 7-positioning-holding element; 8- distance piece; 9-measurement device with inductive transducers

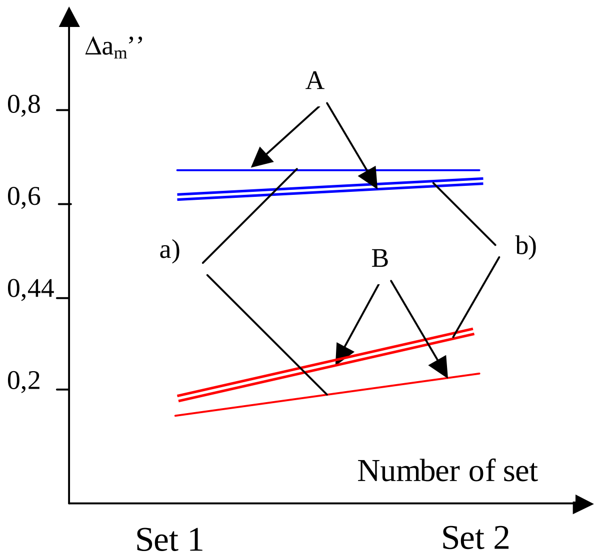


Fig. 4. Experimental evaluation of the
controled level in case of MD 250 machine

## 3. CONCLUSIONS

The problem of precisely evaluation of the components of the cutting force represents one of the major important factors within the manufacturing tool industry. With respect of this, the use of the dynamometric tables for preliminary estimation of the processing tool's quality and durability represents an efficient acting way.

The authors have designed and set-up a dynamometric table for individual and simultaneous evaluation of the cutting force's components during the toothing with the aid of the gear wheel tool.

The dynamometric table has been set-up with the aid of 4 octagonal electron-dynamic strain gauges, having 8 marks.

One of the important aspects, on authors view, concerns with the mutual influence of the signals obtained for different cutting force components. These aspects, usually omitted, have been the conern of intensive studies of the authors.

The calibration diagrams as well as those corresponding to the mutual influence due to the components have been drawn. The diagrams have been drawn for different values of indexing radius of the gear wheels that are going to be manufactured. These diagrams have been used successfully during the real-time toothing process with the aid of the gear wheel.s

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