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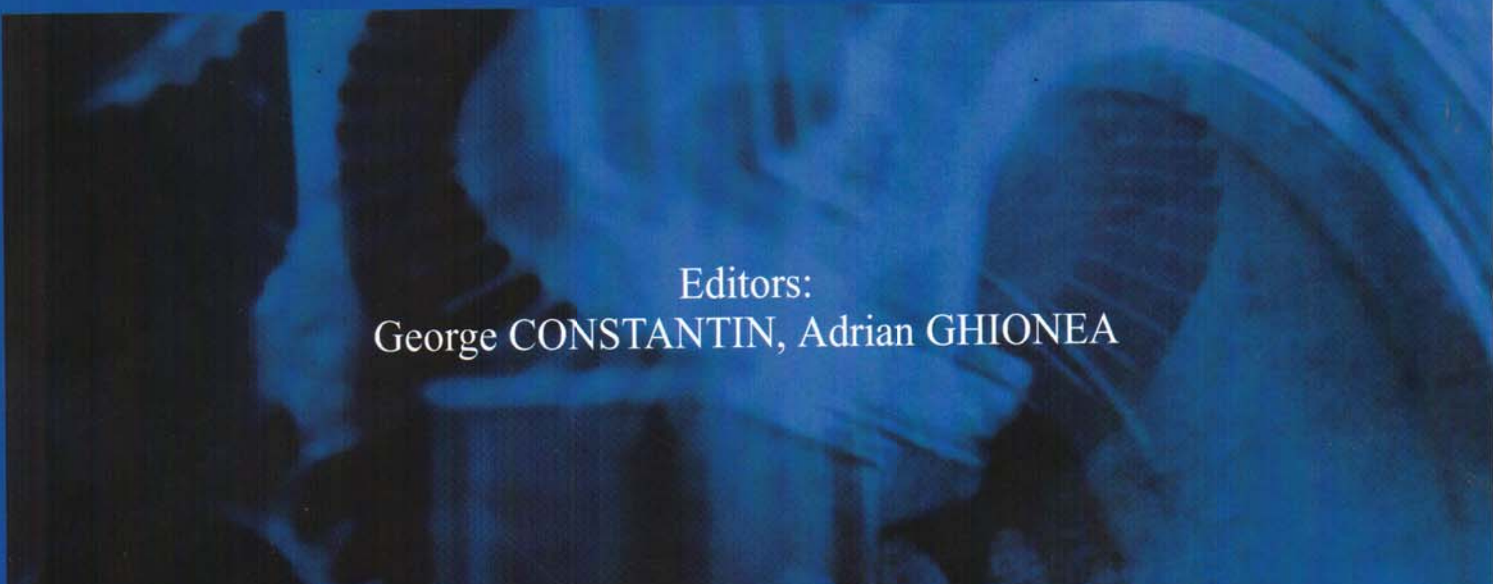

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ASPECTES REGARDING OPTIMAL DESIGN OF MACHINE TOOL FEED DRIVES

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Abstract: *The paper presents some of the main aspects concerning the design of feed drives of machine tools in optimum conditions. Some general considerations about the optimization vector including a set of parameters are presented. Also the optimization vector is analyzed and purpose function discussed, revealing the optimization vector as a favourable one having a limited number of parameters. Starting from the dynamic equation of the feed drives having as final mechanism the screw nut and pinion rack, respectively, the relation of the reduced moment of inertia to the electric motor rotor axis together with the expression of acceleration of the speed are presented. For four cases of transmission between motor and final mechanism in the feed drive, the relations of the optimum values for the optimization parameters (gear ratios, belt transmission ration, screw pitch, pinion diameter) are given. The problem of optimization is treated also by considering the expression of rotor acceleration as a function of two variables (where possible) and by finding its maximum together with the optimum parameters. Finally, the CAD models for the studied cases are used to obtain other information, such as the maximum torque supplied by the electric motor in optimum conditions. All applications are considered for an industrial project of refabrication of a machine for processing wheel set running profiles by turning, especially the feed drives that become specific for numerical control.*

Key words: *feed drive, dynamic equation, moment of inertia, acceleration, parameters, optimization.*

1. INTRODUCTION

To use the optimum technological potential created by processing with high speed cutting, machine tools are imposed new requirements regarding the construction, kinematics, driving and control, requirements that define a new conception of the machine tool. These requirements have as response on bringing on the market milling machining centers, machining centers by roto-milling, multifunctional machine tools and machine tools of hexapod type.

After choosing an F/P KC structure, in the design practice it goes to the next step consisting of optimizing the prototype. Consequently, the design of the mechanical structure of F/P KC in which the lead screw is supported by bearings the technical parameters indicated by the beneficiary must be considered, i.e. the length of travel l of the mobile element, mass-mass m_s of the assembly table-part; external load F_{max}, speed n_{sc} of the lead screw, the torque M_t, temperature increase Δt, and other factors that influence the behavior of static, dynamic and thermal behavior.

Regarding the total stiffness k_{tot}, life in hours $L_{H,}$ natural frequency f_s, amplitude of external vibrations q_s, stability in buckling, and critical speed of the lead screw, the diameter d_{sc} should be chosen as high as possible. Instead, considering the acceleration time t_a, braking length l_f, thermal rigidity, and especially low purchasing costs, it is required the choice of a screw with a diameter as small as possible.

These contradictory trends require optimization of screw-nut-bearings assembly to satisfy part or all of the previously mentioned goals required by the customer. Consequently, it must optimize the construction depending on the diameter lead screw d_{sc}, experience and designers' "feel" being proven unsatisfactory.

The optimization of a mechanical structure of the F/P KC, in which the mechanism for converting the rotary motion into linear one is of ball-screw nut type, requires grounding of specific terms.

1.1. Optimization vector $p = [p_i]$

This vector contains all the parameters p_i of free factors or factors with a limited share on the dynamic behavior of F/P KC. According to studies recently achieved [1], the vector optimization p is defined as:

$$p = [p_i] = \left[d_{sc}, p_{sc}, z_{sp}, C_{din\ ax}, k_2, D_j\right]^T; i = 1, 2, ..., n_p, \quad (1)$$

where $C_{din\ ax}$ is the dynamic capacity of the axial bearings, k_z – stiffness of the balancing system of the masses with translation motion; D_j – pitch diameter of the gears from reducer structure (j = 1, 2,…, N; $N \geq 0$); z_{sp} – number of turns of the nut.

Depending on the purpose, the vector $[p_i]$ is defined by all parameters n_p or only by some of them ((n^*_p).

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