Analysis of the Elastic System of Machine-Tools before Remanufacturing

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**Abstract:** The applicative research deployed for determining a methodology for diagnosing, from the dynamical view point, of the machine tools which are proposed to remanufacturing, starts from an analysis of their elastic system as well as from its influence on the working processes that will develop on the new remanufactured machine.

**Keywords:** machine tools, dynamic system, remanufacturing, elastic system.

1 INTRODUCTION

In order of a clear presentation of the study methods of the behavior of the machine tools structures and setting up some of their limits for the remanufacturing process, it is necessary to clarify some specific terms of this area. Some of the structural elements of the machine tools, which make the object of the remanufacturing and integrate an important quantity of materials (80 – 85% of their weight) and labor, are: frames, upright beams, crossbeams, bodies, columns, etc.

The processing precision of the remanufactured machine tool is controlled by the rigidity of the tool – machine tool – part system [6]. The machine tools basis structural elements (frames, upright beams, etc.) comprise the most important role of this chain. [7]

On the other hand, the machine tools structure comprises the whole elements which contribute to sustain the mechanisms of the kinematical chains, and in which the polygon of the forces that appear in the work processes is completing. [9].

2 THE MACHINE TOOLS DYNAMIC SYSTEM

The assemblies of the cutting and friction processes, together with those that take place within the operating engines (electromagnetic, aerodynamic, and/or hydrodynamic) comprise the working process.

The elastic system of a machine tool is comprised of: the machine tool, including all its kinematical transmission elements, the part-tool fixing devices, the semi-finished part, and the tools system [8] [9].

The dynamic system of a machine tool is comprised of its elastic structure, in close interdependence with the working process.

The figure 1. generically shows the interdependence among the elastic system and the working processes.[6]

From the dynamical point of view, the elastic structure of a machine tool could be decomposed into two interdependent elastic systems [3]:

- the elastic system of the part to be processed, composed of the subassemblies of the machine tool, which contribute to execute the movements of the part, the fixing devices and the processed part;

![Fig. 1. The dynamic system of the machine tool.](image-url)
the elastic system of the tool, which comprises the subassemblies of the machine tool that concur to obtain the generating movement of the processed surfaces, the fastening and fixing devices of the tool, and the cutting tool.

During the machine tool exploitation the working processes perturb the balance of the elastic system through the intermediary of the forces and moments, but also through stresses of thermal and electric nature.

The constructive link between the elastic system of the part and that of the tool is set up by the frame of the machine tool. The frame ensures the reciprocating position between the tool and the semi-finished part in the imposed conditions of productivity, dimensional precision and roughness [2]. Besides the reaction and the moments of the cutting processes, on the elastic system are acting also the inertial forces of the rotational moving unbalanced components, of the linear alternative moving parts, the weight of the mechanic assemblies and of the semi-finished part, the clamping forces of the assembling elements, the thermal sources, the shocks and the vibrations transmitted through the foundation from other technologic equipment.

Thus it is required that the rigidity and the stability to vibrations of the basis structure elements of the machine tools to be sufficient, in order that the deformation and the level of the vibrations amplitude not to exceed the admitted limits.

In remanufacturing, the reusable structure elements are in a partially unknown condition from the point of view of the static and dynamic rigidity. The effects of reactions and moments, which appear subsequent to the work processes, as well as of the other perturbing factors during the previous exploitation cycles on the structure elements, should be known before starting the remanufacturing process. The results obtained following the study of the structure elements that are reused, permit to ascertain the kinematical parameters of the remanufactures machine tool, since the remanufacturing projecting stage [5].

Studying the structures before remanufacturing should lead to the verification of the hypothesis of the limit conditions according to which the maximum deformation of every element should not exceed an admissible value imposed according to the new working regimens, in which the remanufactured technologic equipment shall operate.

The results obtained following the study of the structure elements subjected to remanufacturing, permit to establish the working regimens limits of the new remanufactured machine tool; these information back up the decision on the mode in which the technologic equipment remanufacturing will be carried out.

The deformations by the level of the machine tool basic structures depend on many factors. Practically, in order to make a research it impossible to take all of them into account. There are a series of more or less accurate methods of calculating the structure elements, from the point of view of static and dynamic stress. A series of simplifying and assumptions are imposed even in case of using some specialized software for analysis.

### 3 MACHINE TOOLS STRUCTURES STUDY METHODS

Two types of methods can be used for the study of the basic structures of machine tools: analytical methods and numerical methods. [7]

The analytical methods, which are applicable in case of some simple structures, many times lead to unsatisfactory results, sometimes highly different from reality.

These are the numerical methods which are also applicable in case of the complex structures [1]:

- the finite differences method;
- the border elements method;
- the finite elements method.

The finite differences method comprises in replacing the real structure with a simplified model for computing, followed by the transformation of the differential equations, which correspond to the model adopted within a finite difference equation method, which is to be solved by classic methods.

The border elements method has, as its grounds, the theorem of the mechanic work reciprocally, which is valid in case of the bodies with linear behavior, which shows that the mechanic work that is produced by a system of forces on the displacements of another system of forces is equal to the mechanic work produced by the second system of forces on the displacements given by the first. This method comprises in dividing the border of the analysis domain into elements on whose length it is assumed that the movements and the external load have known variations. The differential equation, which describes the behavior of the modeled structure, containing unknowns both within the inner of the domain and on its border, transforms into a contour definite integral equation. These integral equations are subject of discreteness, thus could be solved by numerical methods.

The finite elements method comprises in replacing the real (continuous) structure with an idealized (discontinued) structure, divided or discreted into less subdomains named finite elements [4] [5].

The continuous advance in the computers technology created the conditions for simulating the different components in operational conditions, thus reducing or even totally eliminating the necessary costs of the prototypes carrying out and research.

The method comprises in discretizing the continuous environment, by a finite elements assemble which interact between them in a finite number of nodes. The interacting forces of the nodes of the model characterize the action of the interior forces or of the applied stress on the neighbor elements contour. Therefore, the computing of a strength element considered as a continuous medium with an infinitive number of links is reduced to the computing of a system with a finite number of links or freedom degrees.
A network of finite elements is optimum, when the requested precision is met with a minimum of resources in the analysis and computing process, i.e. it is characterized by economy and order.

Facilitated by the analysis method with finite elements, the issues of whose complexities are given by the complicated geometric configuration of the bodies, the material non-homogeneity, the material anisotropy, the composite materials, etc. can be studied. These problems frequently appear in practice in the different development stages of a machine tool, but even when a product already exists, but the issue of increasing its characteristics it is put on.

4 CONCLUSIONS

In most situations, the connection between the working processes and the elastic system manifests through the action of the force that appear in the work process and affect the elastic system.

The elastic system characteristics are determined by the following fundamental parameters: the mass and the inertial moments; the rigidity of the elastic elements, the non-elastic forces of strength (amortization); the connections between the displacements of different mass in the system with more liberty degrees.

The analysis of the elastic system, as a component element of the dynamic system of the machine tool, consists in meeting the following aspects: determining the own stability of the system, determining the static and dynamic characteristics in the operational conditions and determining the own vibration modes.

REFERENCES


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