Proceedings of the 17th International Conference on Manufacturing Systems – ICMaS
ISSN 1842-3183
University POLITEHNICA of Bucharest, Machine and Manufacturing Systems Department
Bucharest, Romania

THE COLUMN OPTIMIZATION OF ELER 01 ELECTRO-DISCHARGE MACHINE

Laurențiu BĂLUȚĂ, Traian AURITE

Abstract: *Static and dynamic behavior of the main elements of the structure has a direct impact on the accuracy of machine-tools processing. Therefore knowledge of their behavior allows the achievement of an optimal structure of the machine-tools needs. In the present paper we will approach the column optimization of the electro-discharged machine ELER 01. We will focus on the column optimization in terms of static and dynamic. The goal of this paper is to reduce the weight of the column structure in order to reduce the loading forces which press the bed of ELER 01 machine without affecting its static and dynamic behavior.*
Key words: *Structure, optimization, electro - discharge machine.*

1. INTRODUCTION

ELER 01 [1] is a machine for electro – discharged machining (EDM) with the electrode-type tools (solid, tubular, plate) of surfaces / parts that can not be processed by classical methods and processes (hard pieces, complex surfaces, etc.).

The Romanian equipment for electro – discharged machining ELER 01 is equipped with GEP50 F generator and can be used for rough processing or finishing holes of all types [1]. Using this type of equipment covers a very wide field of applications: plate processing assets from stamps and dies, processing metallic carbide die treading used to hold or extruding various shapes, reconditioning of cavities in different moulds, the processing of special materials parts in aeronautics industry, nuclear reactors, processing of holes and dude with very small dimensions (0.2 ... 0.4 mm), removal of broken tools that tap threading, auger, broach etc [2].

With this type of the machine can be processed a huge variety of metallic materials, such as all types of steel and cast iron, metal carbides and non-ferrous metal materials.

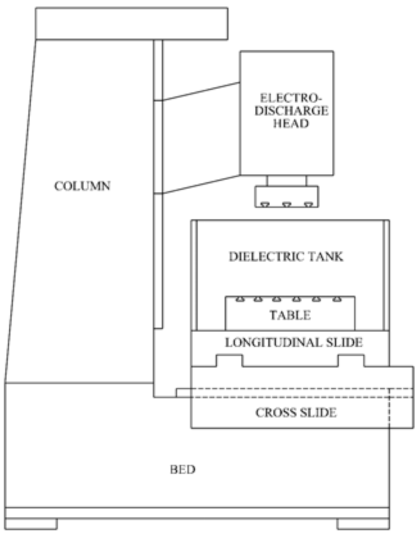

Fig. 1. Block sketch of ELER01 machine.

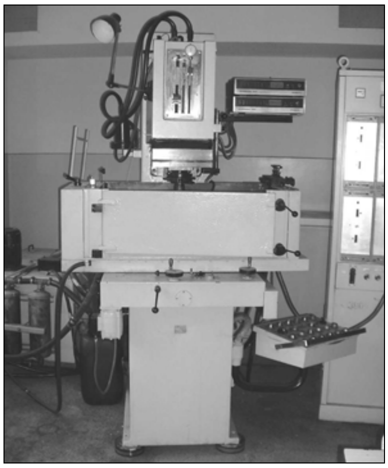

Fig. 2. ELER01 machine.

Electro-discharged machine ELER 01, whose block sketch is shown in Fig. 1 is made of the following subassemblies [1, 2]:

- structural - bed, column, electro-discharged head, the cross slide, longitudinal slide, table, dielectric tank;
- operating - hydraulic actuators equipment, unit to sue the working head, the panel for action, command panel, the pulse generator, the aggregate circulation and filtration of dielectric liquid, connecting cables.

The technology equipment of the electro-discharged machine ELER-01 covers various devices to increase work efficiency and accuracy of processing, such as picking-up electrodes quickly, an electrode rotating device during processing, path kits for the positioning of parts, centering top, universal program, rotating plate and universal program, centering microscope.

2. THE COLUMN

The column is the structural element of ELER 01 (Fig. 3) electro-discharged machine to ensure proper vertical movement of the head which supports the electrode tool. Its height determines the vertical size of the part that can be semi-processed with this type of machine. The column

Fig. 3. The column – 3D model [3].

must ensure the condition of perpendicularity of travel between the electrodes tool and the horizontal table that the half-finished part is placed on.

The column has a parallelepiped form, made in welded construction and ribs. The material used in column construction is carbon steel construction OL 42.

The column section sizes vary for height; shrinking from the bottom-up. At the top the section is closed to square. Since the process is carried out by electro- discharge without physical contact between the electrodes and the part, it is considered that semi-forces resulting from the processing are void.

Therefore, only static forces can be considered such as weight of the electro-discharge head, of the mechanisms of action, of both the head work and inside column.

3. GENERATION THE MATHEMATICAL MODEL FOR FINITE ELEMENTS CALCULATION

The program used for finite element analysis is ANSYS [5]. It is one of the most popular and accurate computing programs.

The column was meshed in 26.947 finite elements using surface type Sheel63 and 27.374 nodes [5]. The structure is homogeneous and is shown in Fig. 4.

The column is provided with an intermediate wall and more horizontal ribs as diaphragms. The model was obtained by successive meshing of flat surfaces so that the result is a structure with finite quadrilateral elements in the proportion of 99% and only 1% triangular elements [4].

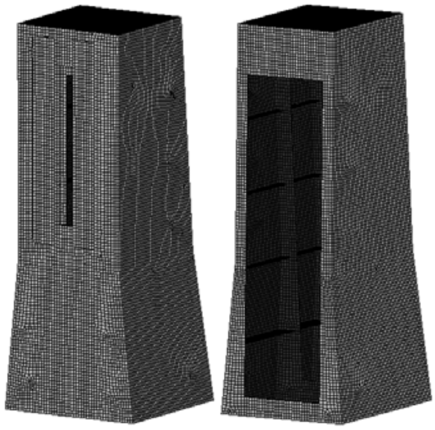

Fig. 4. The column – finite element model.

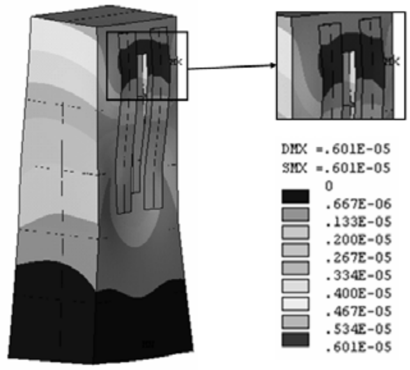

Fig. 5. Static deformation of the column.

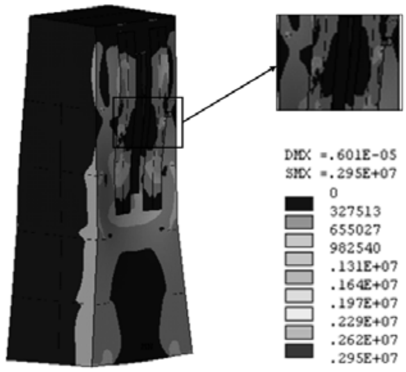

Fig. 6. Von Mises equivalent stress.

4. THE COLUMN STATIC ANALYSIS

The static analysis implies it's loading with the forces of gravity, of the electro-discharge head and working mechanisms of action, and a generator that is built on top of the working head. The deformation of the column is shown in Fig. 5. The maximum deformation is 6 μm in the upper area of the guides.

The Von Mises equivalent stresses is shown in Fig. 6. Maximum Von Mises stresses is 2.95×10^6 N/m^2. This value does not exceed the allowable tension of a material that is executed the column [4].

5. THE COLUMN DYNAMIC ANALYSIS

The dynamic analysis involves determining of its structure's own frequency, frequency at which the column structure may come into resonance with the implications of the working process.

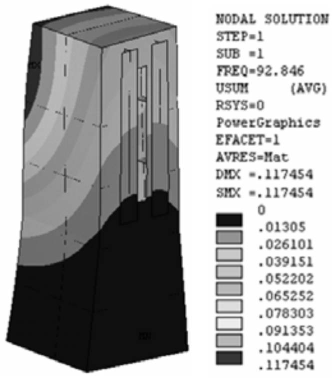

Fig. 7. First own frequency (92.8 Hz).

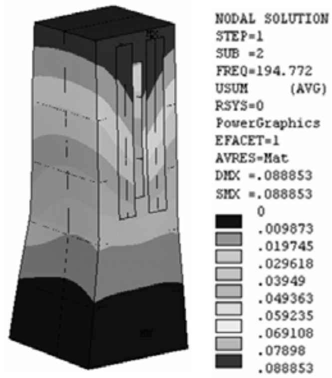

Fig. 8. Second own frequency (194.7 Hz).

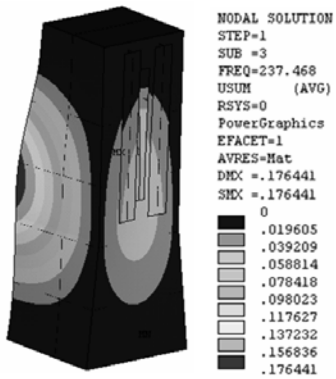

Fig. 9. Third own frequency (237.4 Hz).

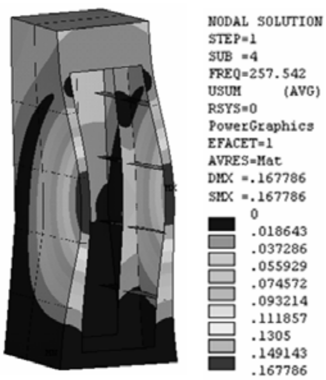

Fig. 10. Fourth own frequency (257.5 Hz).

At resonance frequency the column strains may be much higher than static strains, leading them to very high processing errors. The first four own frequencies of the structure have been determined. In Figs. 7, 8, 9, 10, the frequencies of the column structure are given [4].

6. THE COLUMN OPTIMIZATION

The maximum deformation of the column under the static forces (the forces of gravity of the head of the working mechanisms and systems inside it) is 6 μm. This value is low, thus the column optimizing aims to decrease the weight structure, but without affecting rigidity [4]. The initial weight of the column is 4090 N.

The column optimizing was done by successive discrete calculations/runs, until the result was acceptable. Further, we present the main actions taken for optimizing.

Decrease weight by reducing the thickness of walls, ribbed structure. The mathematical finite element model was developed with elements of surface type SHELL 63, the thickness of walls was introduced as a real constant. To simulate a structure as close to reality 5 real constants have been used of thicknesses 20, 25, 30, 35 and 40 mm. The thickness of the walls has been amended as follows:

- plate at the bottom (of the settlement on the bed) was reduced from 25 to 20 mm;
- side walls, longitudinal and transverse ribs have been reduced from 20 to 16 mm;
- wall behind the guides has been increased from 25 to 30 mm, as a direct influence was observed on the deformation of the column.

The further ribbing in the area behind the guides to increase the rigidity of the structure, lost through the decrease of the wall thickness. The ribbing of the column is shown in Fig. 11.

The ribs were conducted over the entire height of the column, rib sizes section is 16 × 70 [mm × mm].

Following the optimization process the column weight was reduced with 12.7 % (weight after optimization 3570 N) while preserving its static rigidity [4]. The deformation of the column and maximum strains after optimization are shown in Fig. 12. The maximum deformation of structure optimized in terms of weight reduction is 5.94 μm.

As a structural optimization result of (reducing weight) we must analyze how the behavior of the dynamic new structure is influenced. For this the first four own frequencies of the optimized column and their

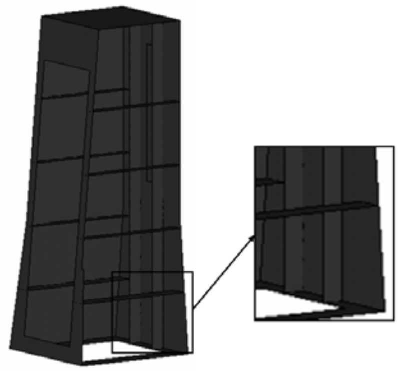

Fig. 11. The ribs in the area behind guides.

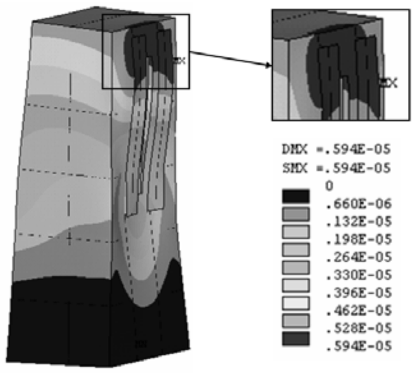

Fig. 12. Static deformation of the column after optimization.

modes of vibration that are presented in Figs. 13, 14, 15 and 16 were calculated.

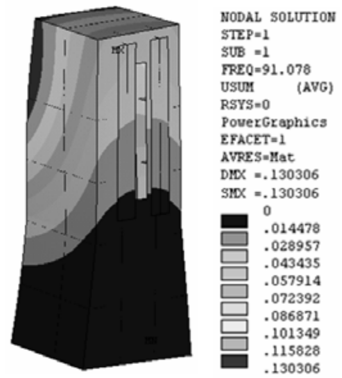

Fig. 13. First own frequency after optimization (91.07 Hz).

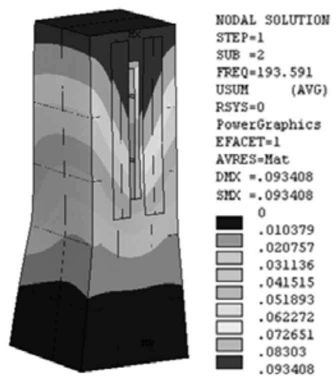

Fig. 14. Second own frequency after optimization (193.5 Hz).

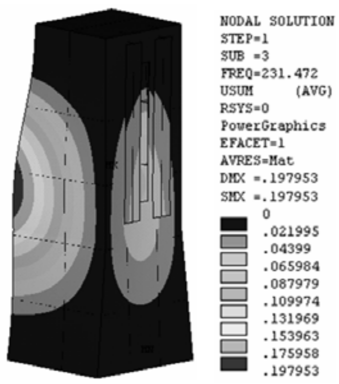

Fig. 15. Third own frequency after optimization (231.4 Hz).

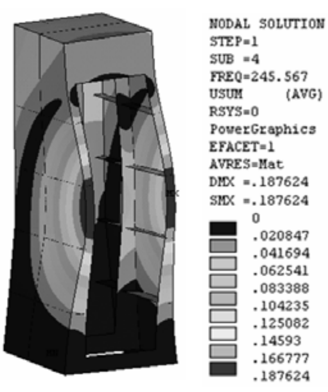

Fig. 16. Fourth own frequency after optimization (245.5 Hz).

Table 1

Comparison between initial and optimized frequencies

Freq. No.	**Before opt. [Hz]**	**After opt. [Hz]**	**Diference [%]**
1	92.8	91.07	–1.86
2	194.7	193.5	–0.61
3	237.4	231.4	–2.52
4	257.5	245.5	–4.66

It can be noted, that in terms of vibration, all modes remain identical. In terms of value frequencies they have closely similar values. In Table 1 [4] are compared the column's own frequencies before and after optimization.

7. CONCLUSIONS

The column optimization assumed adding additional ribs in maximum elastic deformation area, wall thickness reduction for lower elastic deformation area and increasing the wall thickness in area where we could not add additional ribs.

Knowing in detail the electro-discharged machine ELER01, allowed us achieving optimizations of the internal column configuration, as well as taking into consideration equipment and shareholders that are mounted inside the column.

The dynamic study showed a slight decrease in the frequency of its structure;

The column weight reduction with 12.7 % was achieved with a minor influence on the dynamic behavior of the structure, but keeping static rigidity [4].

REFERENCES

[1] *** (1982). *Instrucţiuni de folosire pentru Maşini de prelucrat prin electroeroziune ELER01-GEP50F* (Instruction guide for electro-discharge machine ELER 01-GEP50F), Electrotimiş Timişoara, Romania.

[2] Gavrilaş, I., Marinescu, N. I. (1991). *Prelucrări neconvenţionale în construcţia de maşini* (Electro physical technologies on machine building), Edit. Tehnică, Bucharest.

[3] Aurite, T., Pupăză, C., Băluţă, L. (1999). *Cercetări privind comportare elementelor portante din construcţia maşinilor de prelucrat prin electroeroziune* (Researches about the structure elements behavior of electro – discharge machine), Conference on electro physical technologies, University "Politehnica" of Timisoara.

[4] Băluţă, L. (2007). *Studii privind comportarea elementelor de structură ale maşinilor de prelucrat prin electroeroziune* (The studies about behavior of electro – discharge machines structure elements), PhD thesis, University "Politehnica" of Bucharest.

[5] *** *ANSYS Theory Manual,* Swanson Analysis Systems, Inc. PO Box 65, Johnson Road, Houston. PA 15342 -0065.

Authors:

Eng., Laurenţiu BĂLUŢĂ, PhD student, Mechanical Design Engineer, Honeywell Garrett Romania, Balancing Center of Excellence (BCOE),

E-mail: laurentiu_baluta@yahoo.com

PhD., Traian AURITE, Professor, University "Politehnica" of Bucharest, Machine and Production Systems Department,

E-mail aurite@imst.msp.pub.ro