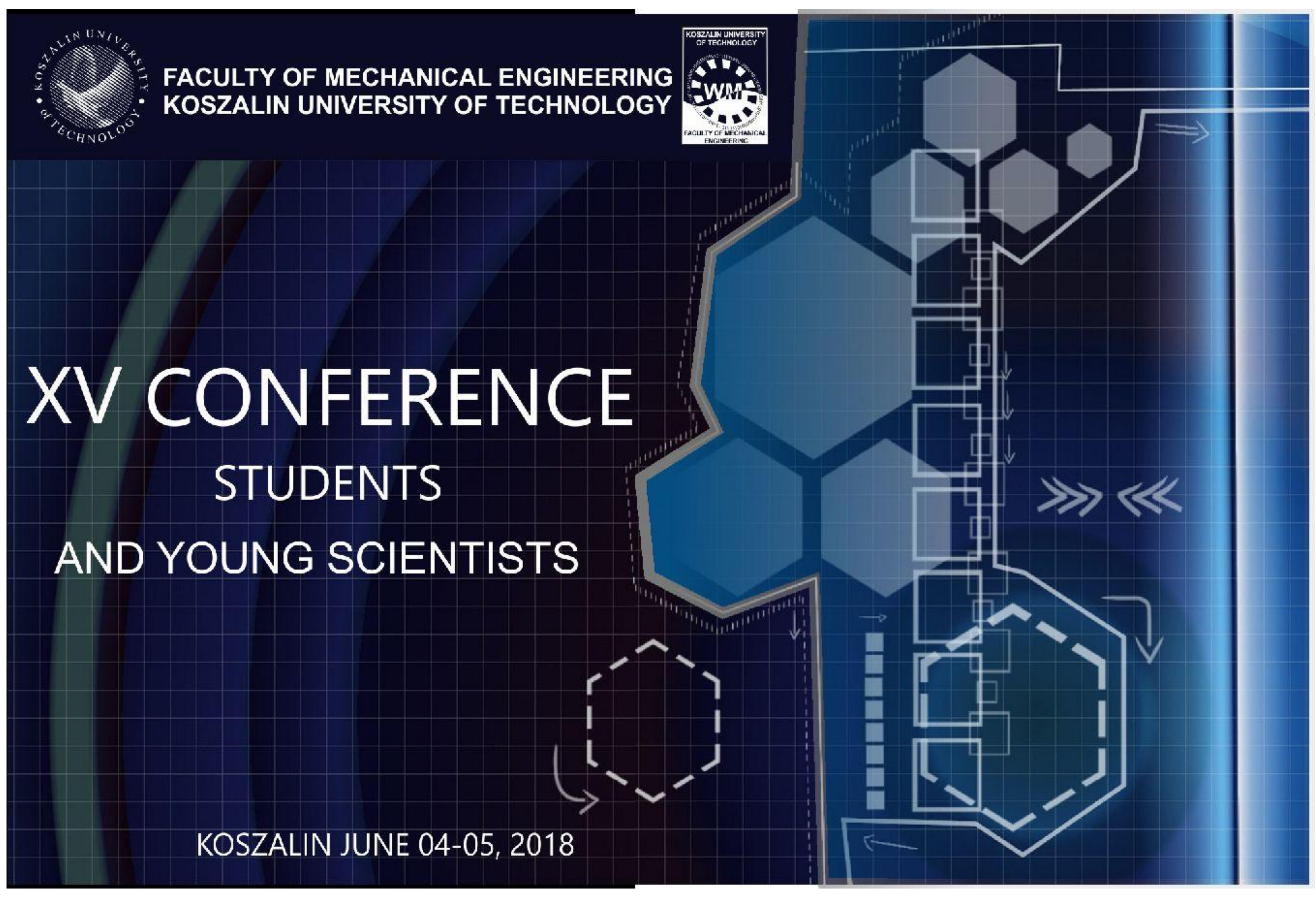

OPTIMIZATION OF THE STRUCTURE AND CONSTRUCTION PARAMETERS OF THE MACHINE BODY

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SUMMARY

Static stiffness of the machine bodies, being the machine support system is one of the most important features, determining the dimensional accuracy of the workpieces. The insufficient stiffness of the system Machine-Holder-Object-Tool causes the generating of machining errors. The purpose of the simulation was to optimize the structure and construction parameters of the machine construction. The optimization criteria resulted from the function what the machine body should have and minimize the mass while maintaining the appropriate static stiffness. Finite element methods were used for optimization process, which was realized in engineering simulation software ANSYS for this purpose.

INTRODUCTION

One of the ways to reduce the weight of the machine bodies while ensuring sufficient rigidity is the use of ribbing. It is necessary to analyze the influence of the wall thickness of the body and the dimensions of the ribs on the stiffness of the machine tool.

Optimization criteria : **the mass of the body structure should be less than 1295.1 kg while maintaining the appropriate stiffness resulting from the deflection of the machine body surface, to which forces were applied, no more than 40 µm**.

To solve such a formulated problem in the system ANSYS, the method *screening was used*. This method involves receiving and sorting results samples and allows to handle many optimization goals as well as all types of input parameters.

In figure 1 the geometrical features of the optimized body are presented and in the Tab. 1. range of variability of optimization parameters are given.

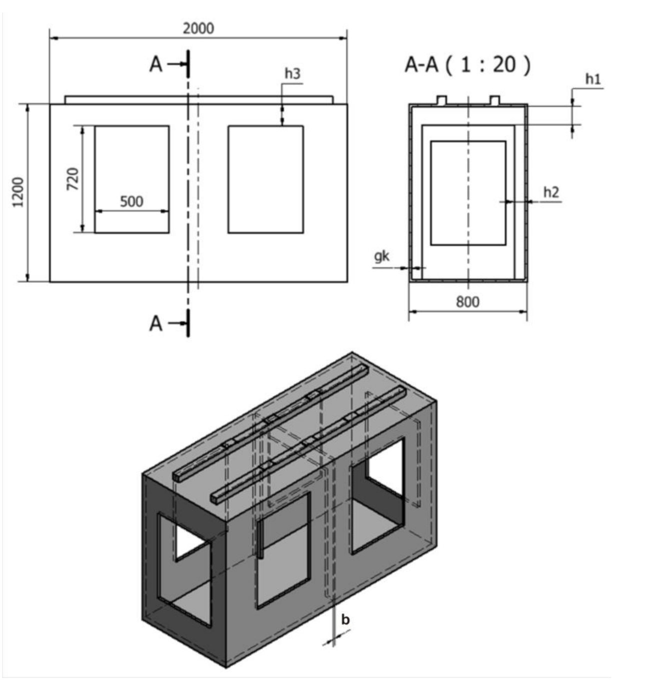

Fig. 1. Geometric features of the machine body

Tab. 1. Variables of optimization parameters

Minimum value, mm	Designation parameter	Maximum value, mm
100	h_1 – width of ribbing	250
50	h_2 - width of ribbing	70
150	h_3 – withdrawal of notch	360
8	g_k – thickness of machine body	12
8	**b** – thickness of reinforcing ribs	12

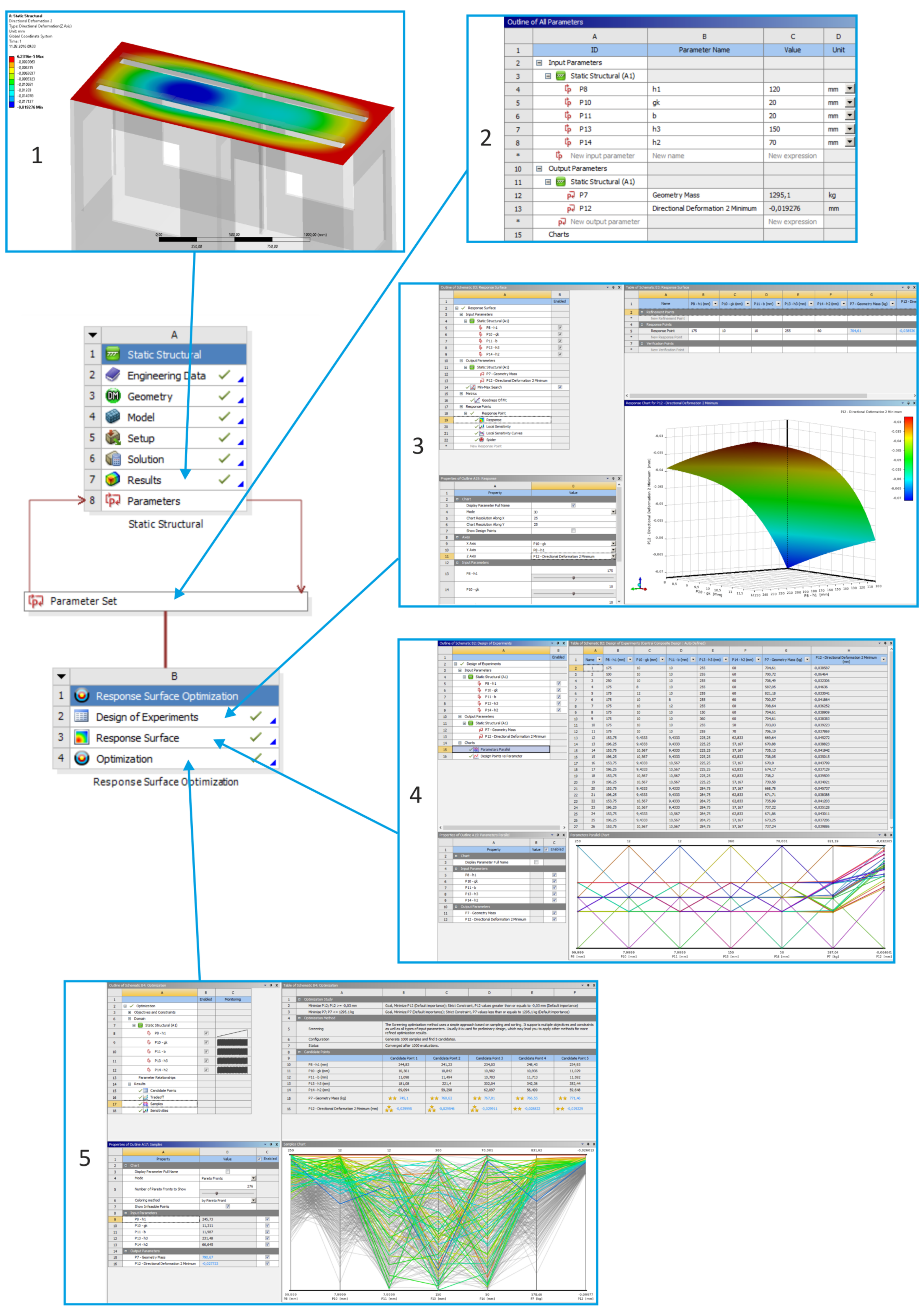

Fig. 2. Stages of modeling optimization of structural features of the machine body:
1. Strength analysis of the machine body structure.
2. Identification of optimization variables.
3. Insertion of variable optimization limits.
4. Analysis of the surface.
5. Analysis of the optimization due to the introduced criteria.

In figure 3 the stages of modeling the optimization of the machine body structure was presented. Figs. 3-5 present a solution to the previously formulated optimization task. The results for the optimal structure of the machine body are shown in the figure 6, they were compared with the initial variant.

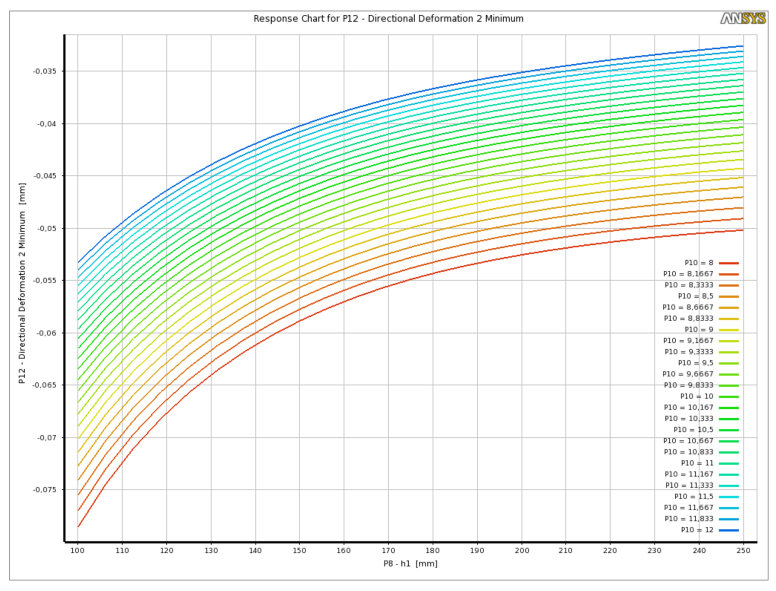

Fig. 3. Effect of parameter change h_1 (width of ribbing) on deflection of the machine body

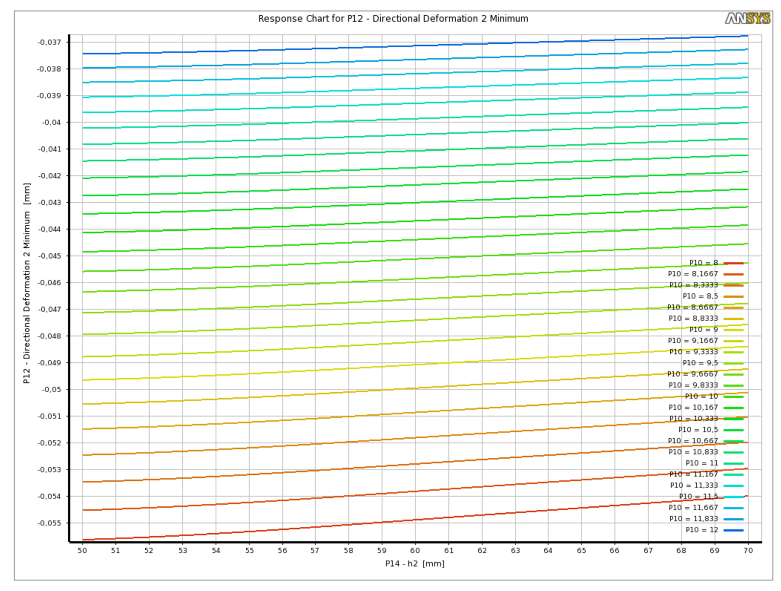

Fig. 4. Effect of parameter change h_2 (width of ribbing) on deflection of the machine body

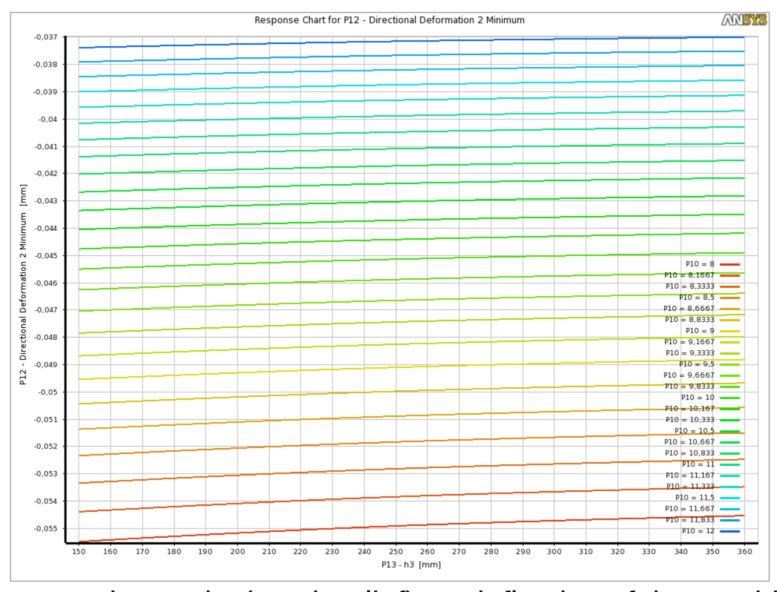

Fig. 5. Effect of parameter change h_3 (notch relief) on deflection of the machine body

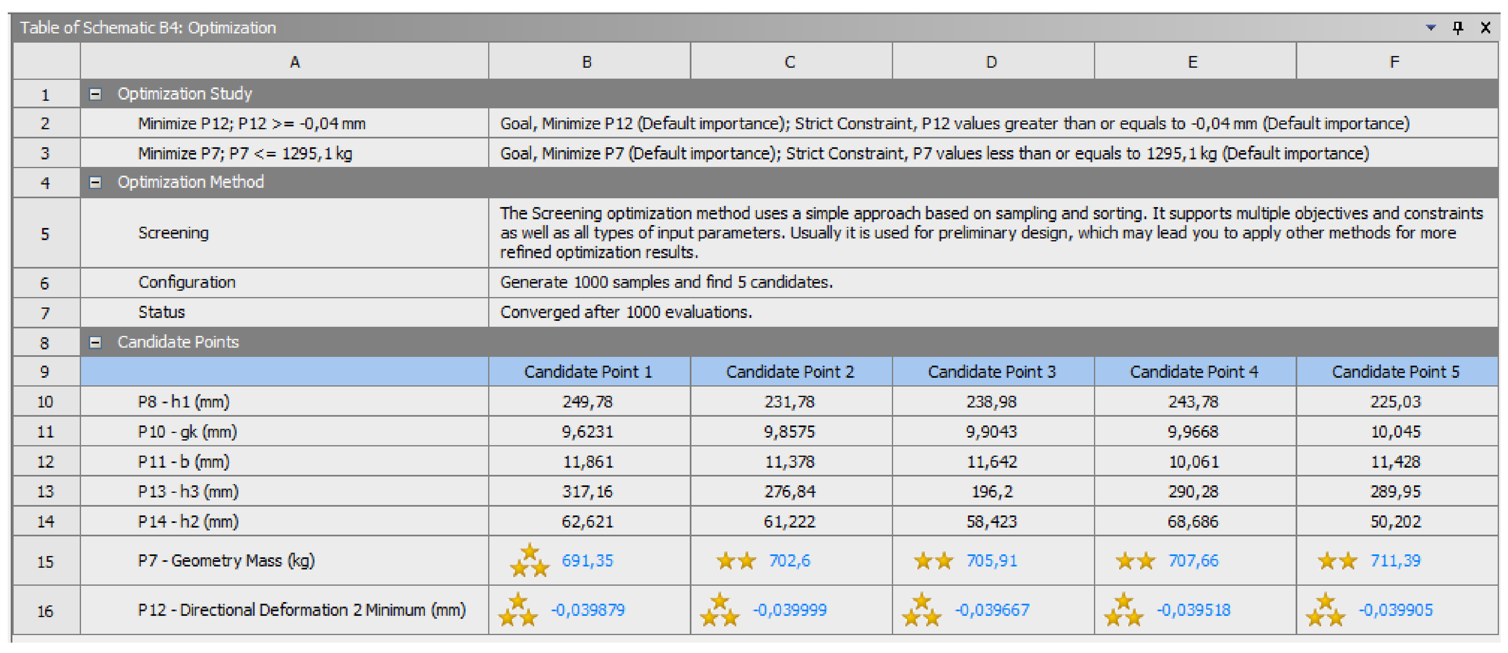

Table of Schematic B4: Optimization

	A	B	C	D	E	F
1	Optimization Study					
2	Minimize P12; P12 >= -0,04 mm	Goal, Minimize P12 (Default importance); Strict Constraint, P12 values greater than or equals to -0,04 mm (Default importance)				
3	Minimize P7; P7 <= 1295,1 kg	Goal, Minimize P7 (Default importance); Strict Constraint, P7 values less than or equals to 1295,1 kg (Default importance)				
4	Optimization Method					
5	Screening	The Screening optimization method uses a simple approach based on sampling and sorting. It supports multiple objectives and constraints as well as all types of input parameters. Usually it is used for preliminary design, which may lead you to apply other methods for more refined optimization results.				
6	Configuration	Generate 1000 samples and find 5 candidates.				
7	Status	Converged after 1000 evaluations.				
8	Candidate Points					
9		Candidate Point 1	Candidate Point 2	Candidate Point 3	Candidate Point 4	Candidate Point 5
10	P8 - h1 (mm)	249,78	231,78	238,98	243,78	225,03
11	P10 - gk (mm)	9,6231	9,8575	9,9043	9,9668	10,045
12	P11 - b (mm)	11,861	11,378	11,642	10,061	11,428
13	P13 - h3 (mm)	317,16	276,84	196,2	290,28	289,95
14	P14 - h2 (mm)	62,621	61,222	58,423	68,686	50,202
15	P7 - Geometry Mass (kg)	691,35	702,6	705,91	707,66	711,39
16	P12 - Directional Deformation 2 Minimum (mm)	-0,039879	-0,039999	-0,039667	-0,039518	-0,039905

Fig. 6. Result of optimization

CONCLUSION

Finite element method allows to relatively quick variation and analysis of calculated results. It allows to also find the optimal solution or family of solutions for the considered element and load unit. Parametric analysis was conducted, which includes variability of input data, thanks to which a large amount of information was obtained on the impact of changing these parameters on the behavior of the analyzed structure. The final result of optimizing the dimensions of the ribs and the thickness of the machine body is a compromise between high stiffness and low weight.

The initial mass of the optimized machine body was **1295.1 kg,** and the body mass after dimensional optimization is **691.35 kg**. In the optimization process, the mass was reduced by 46,6%, which leads to measurable financial consequences for the manufacturer of the structure being analyzed (saving materials and thus cheaper production - greater competitiveness and greater profit).

LITERATURE

1. Tarnowski W., Podstawy projektowania technicznego, WNT, Warszawa 1997.
2. Kacalak W., Majewski M., New Intelligent Interactive Automated Systems for Design of Machine Elements and Assemblies. 19th International Conference on Neural Information Processing - ICONIP 2012, Doha, Qatar, 12-15 November 2012. Lecture Notes in Computer Science Volume 7666 - Neural Information Processing. Springer 2012. 115-122.
3. Kosmol J., Wilk P., Próba optymalizacji korpusu obrabiarki z zastosowaniem MES i algorytmu genetycznego. Modelowanie Inżynierskie, Polskie Towarzystwo Mechaniki Teoretycznej i Stosowanej, nr 35, s. 59-66, Gliwice 2008.