USING THE FINITE ELEMENT METHOD FOR CONSTRUCTIVE OPTIMIZATION OF THE ELASTIC ELEMENT COMPRISED IN A MECHANIC DYNAMOMETER

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Abstract: This paper presented a constructive optimization for the the elastic element comprised in a mechanic dynamometer, using the finite element method. The purpose of this paper is the determination of the optimal geometrical configuration thus the difference between the specific deformation on the outer surface and the specific deformation on the inner surface to be minim under the condition of satisfying the structure resistance.

Keywords: elastic element, mechanic dynamometer, finite element, iteration optimal set, equivalent stress, objective function, optimization

1. INTRODUCTION

The ANSYS software was used for the analysis, the complex spatial structure of the mass being shaped with the use of SOLID 45 finite elements [2]. The geometrical model of the dynamometric mass was generated parametrically in the ANSYS APDL language. The model was discretised in finite elements by "mapped mesh" method. The model was conceived in such way that during optimization the functional dimensions and those connected to the other components of the plant which was determining the forces from process had not to be affected. The starting model with a view to optimization is presented in fig. 1.

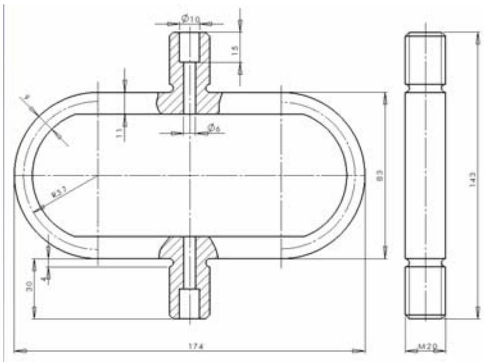

Fig.1 Initial geometry of the elastic ring

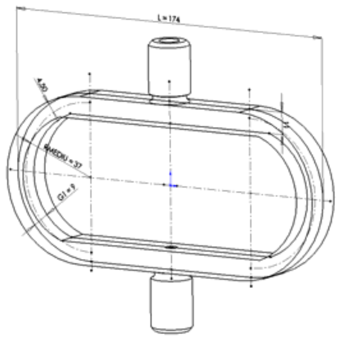

Fig.2 Design variables for the elastic ring

In the first stage a static analysis was made having as purpose the determination of stress and deformations when loading the model in static situation. The applied constraints consist in annulment of the degrees of freedom on the areas situated on the thread clamping area of the ring. On the superior side of the clamping area from the upper part of the ring is applied a uniformly distributed 3 kN force. During this analysis there were determined the maximum values of the specific deformation on Oy direction (stress direction) in the maximum curvature area on the inner and outside surface of the ring.

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It can be observed that the maximum value of von Mises equivalent stress is 290.57 N/mm^2, a smaller value than the flow limit of the material from which is made the ring, i.e. 400 N/mm^2 .

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2. OPTIMIZATION BY F.E.M.

The purpose of this paper is the determination of the optimal geometrical configuration thus the difference between the specific deformation on the outer surface and the specific deformation on the inner surface to be minim under the condition of satisfying the structure resistance.

Design variables considered in the construction of the model and which will be varied during the optimization process are: the total length of the ring *L*, the medium radius of it in the curved area *Rmedium* and the thickness of the ring in the same area *T1* (fig. 2).

For the optimization analysis the *approximation sub-problem method* was used as solving algorithm. The maximum number of iterations chosen was 30 and the maximum number of feasible sets admitted was 7. The analysis contained 11 iterations (all feasible), the optimum set being the set no. 11.

Table 1: The entry data for the optimization analysis

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Type of variable	Symbol	Initial value	Interval of variation
Design variables	*RMEDIUM*	37	34...40
	T1	9	7...11
	L	174	170...178
State variable	*SVM*	290,57	$\leq$ 400
Objective function	*DIF*	0,0014	-

The values of Design variables, State variable and Objective function for the optimum set are presented in table 2.

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Table 2: The values for the optimum set

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Type of variable	Symbol	Optimum value
Design variables	*RMEDIUM*	39,978
	T1	10,992
	L	170,05
State variable	*SVM*	216,89
Objective function	*DIF*	0,00097

In fig. 3 is presented the discretised model of the elastic element comprised in a mechanic dynamometer, with constrain and external forces.

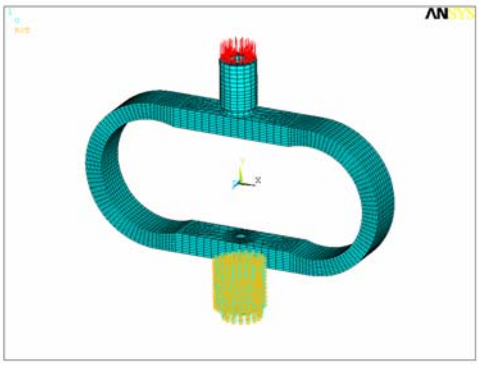

Fig.3 Discretised model with constrain and external forces

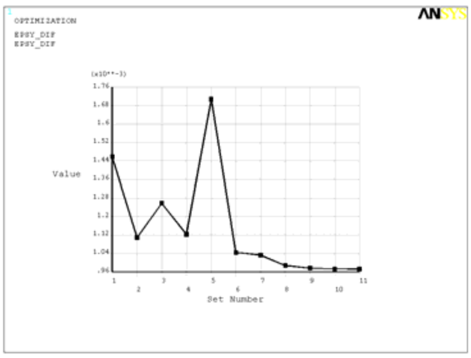

Fig.4 Variation of objective function during optimization

The variation pattern of the objective function during the optimization analysis is presented in fig. 4. In fig. 5 is presented variation of thickness of the ring *(T1)* during optimization. The variation of medium radius of it in the curved area (*Rmedium)* during optimization is presented in fig. 6. The variation of the total length of the ring (*L)* during optimization is presented in fig. 7, and the variation of von Mises equivalent stresses during optimization is presented in fig. 8.

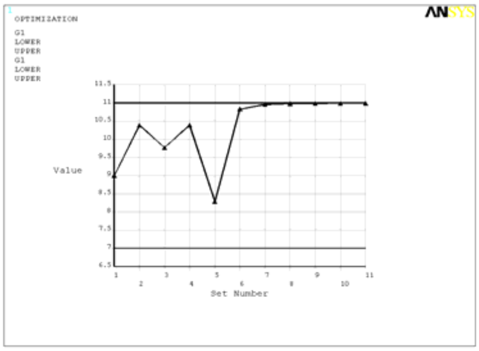

Fig.5 Variation of thickness of the ring during optimization

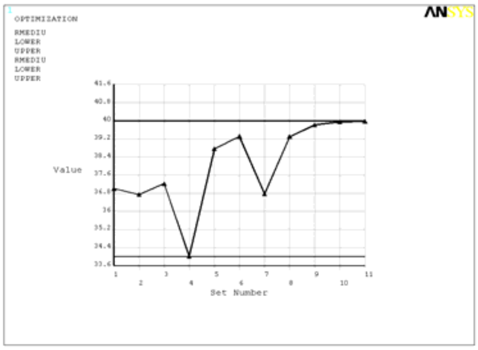

Fig.6 Variation of medium radius (*Rmedium)* during optimization

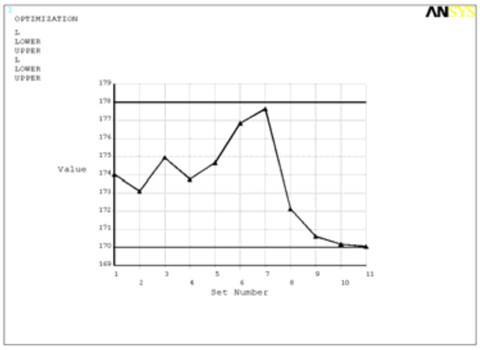

Fig.7 Variation of total length of the ring (*L)* during optimization

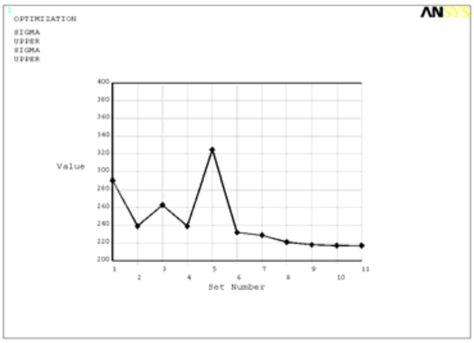

Fig.8 Variation of von Mises equivalent stresses during optimization

Map of distribution of specific deformations on Oy direction for the initial set is presented in fig. 9 and for the optimum set is presented in fig. 10.

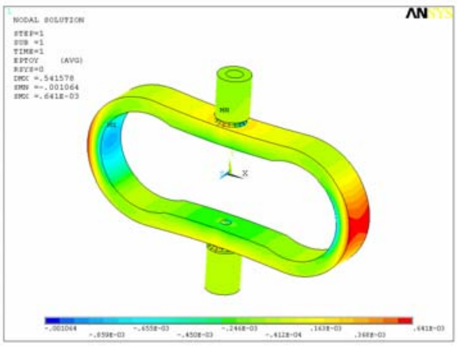

Fig.9 Map of distribution of specific deformations for the initial set

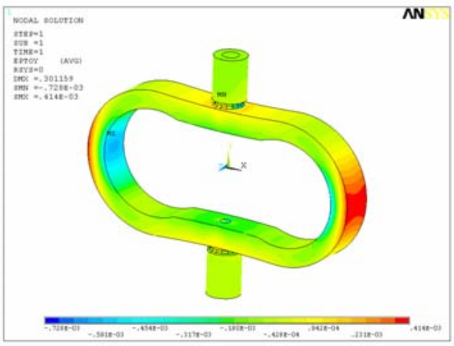

Fig.10 Map of distribution of specific deformations for the optimum set

Map of distribution of nodal displacement on Oy direction for the initial set is presented in fig. 11 and for the optimum set is presented in fig. 12.

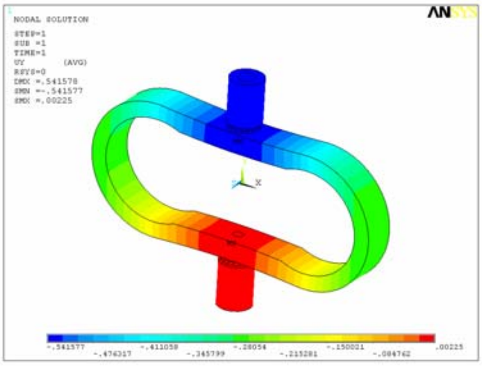

Fig.11 Map of distribution nodal displacement on Oy direction for the initial set

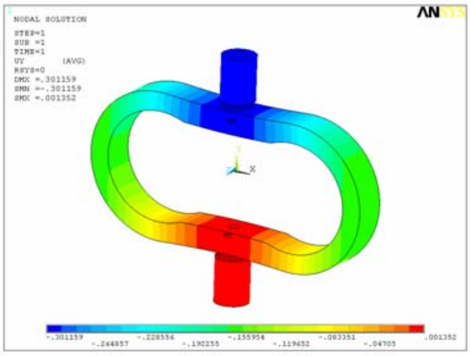

Fig.12 Map of distribution nodal displacement on Oy direction for the optimum set

Map of distribution of von Mises equivalent stresses for the initial set is presented in fig. 13 and for the optimum set is presented in fig. 14.

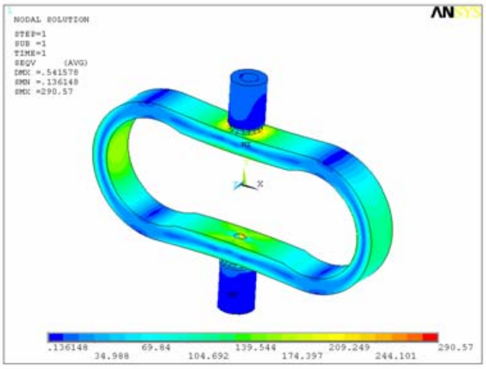

Fig.13 Map of distribution of von Mises equivalent stresses for the initial set

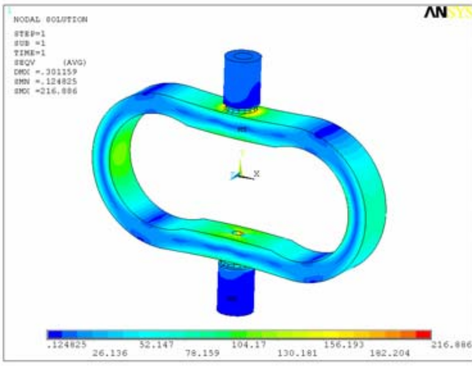

Fig.14 Map of distribution of von Mises equivalent stresses for the optimum set

3. CONCLUSIONS

As a follow up to the static optimization of the elastic ring by FEM using the ANSYS software, it can be observed an increase of the sensibility of the elastic ring by reducing the difference between the values of specific deformations on the outer and inner surface with approximately 36%. This could be possible by increasing the thickness from 9 mm to 10.992 mm, the increase of the medium radius from 37 mm to 39.978 mm and by reducing the length from 174 mm to 170.05 mm.

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