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The Constructive Functional Optimization of the Speaker Dust Cap

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Abstract: ***This paper aims to determine the optimal shape of the part, with the lowest stresses and minimal material and labor consumption, by means of a dimensional analysis using the computer aided design software Catia, ProEngineering and Ansys.***

Keywords: car speaker dust cap, three-dimensional modeling, optimization

1. Introduction

The car speaker dust cap is part of a loudspeaker used for sound reproduction. It is made of an easily deformable metallic material that fits into a fairly general shape.

Figure 1: Car speaker dust cap

This part will be analyzed by taking into account both the weight of the cap, the other components that the system consists of, and, of course, the sound produced by the entire system.

1.1 The Constructive Functional Optimization of the Products

Optimization is the action of studying a problem and finding a solution for it, which is the best, the most appropriate, the most indicated out of all other possible solutions, and which will help making a technical economic decision in accordance.
The steps to be taken in order to achieve an optimization are the following:

- Gathering information regarding the analyzed technological process;
- Developing the mathematical model (creating the model, establishing the equations of the mathematical model);
- Verifying the mathematical model;
- Determining the optimal solution.

CAE - Computer Aided Engineering is the subsystem designed for the optimization and the engineering calculations using electronic computing means. CAE deals with the analysis and evaluation of the projects using computer-aided techniques to calculate the operational, functional and manufacturing parameters of the product.

1.2 The Mathematical Model of Optimizing the Mechanical Structures using the Finite Element Method

The mathematical model of the optimization has been approached in four subchapters, highlighting the following issues:

- The structural optimization of the mechanical systems is done by choosing the best design alternatives, ensuring the continuous improvement of the specified parameters;
- The FEM optimization procedure leads to the conclusion that the structural optimization algorithm implies defining three types of variables specific to the process: the design variable (quantities which do not depend on the optimization process and are limited by values), the state variable (response quantities that are dependent on the design variable) and the objective function (dependant on the design variable);
- The topological optimization is a way of optimizing the configuration of the mechanical structure, aiming at the optimal use of the material in making a part subjected to certain forces;
- The finite element method is one of the three main methods that employ differential equations and partial derivatives, the other methods being the finite difference method and the boundary element method.

1.3 Methods and Means of Constructive Functional Optimization

The methods and means of the functional and constructive optimization are discussed in terms of the computer-aided constructive design, which must be viewed together with the other components of the CIM concept. The main modules of the Catia v5 assisted design software are highlighted and exemplified on a given model.

Figure 2: Example of a computer-aided design model

The constructive functional optimization using the finite elements in the Catia v5 computer aided design software is further presented as a way of working for any given element, and the example on a real model shows how the FEM of the Catia v5 computer aided design software is used.

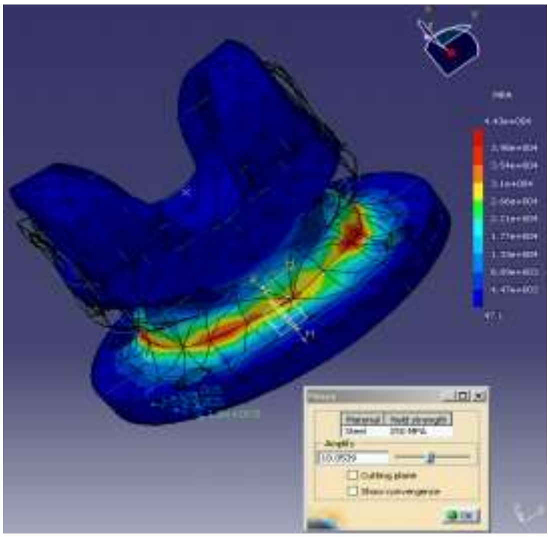

Figure 3: Example of constructive functional optimization

Modeling and Optimization of the Speaker Dust Cap Part

1) The research methodology

- The geometric modeling of the part: car speaker dust cap with CAD software (ProENGINEER, CATIA);
- The static and dynamic analysis by the finite element method using the ANSYS software;
- The structural and topological optimization of the car speaker dust cap part.

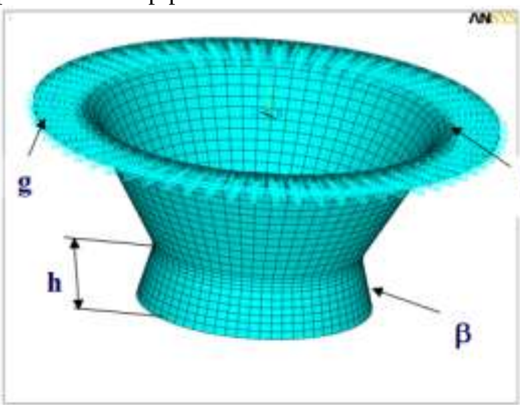

Figure 4: Modeling the car loudspeaker dust cap

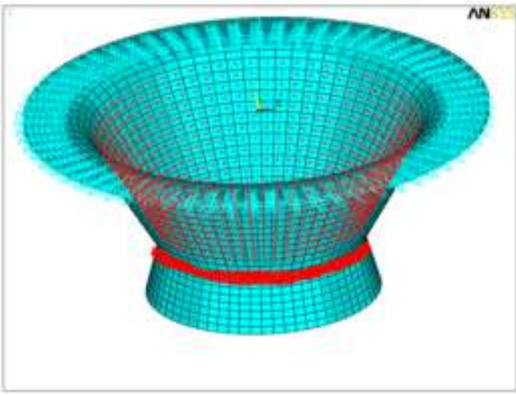

Figure 5: Loads and constraints imposed on the model

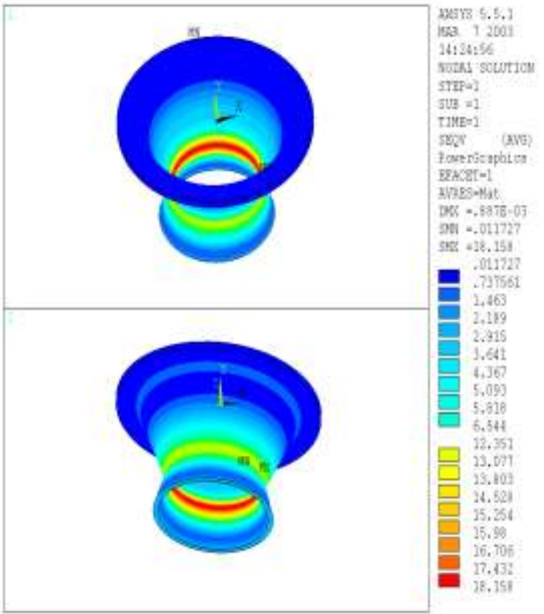

Figure 6: Distribution of von Mises stresses on the initial model

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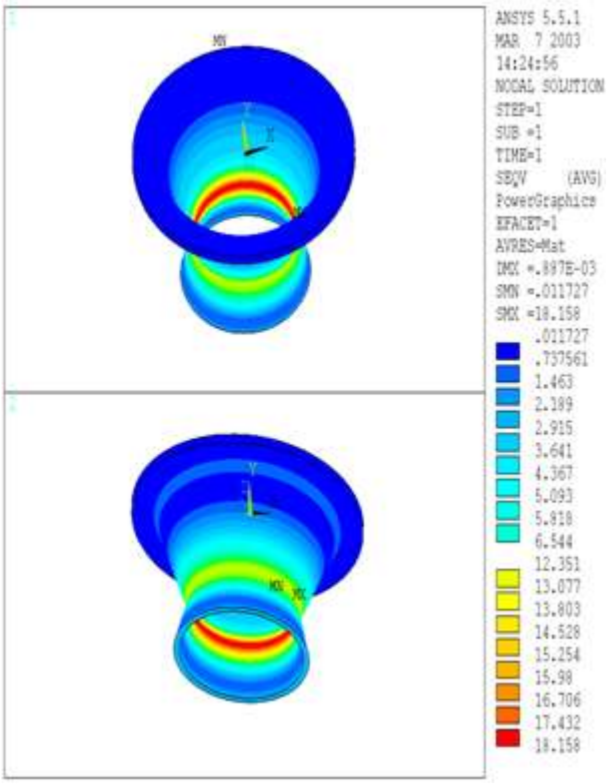

Figure 7: Distribution of von Mises stresses on the initial model

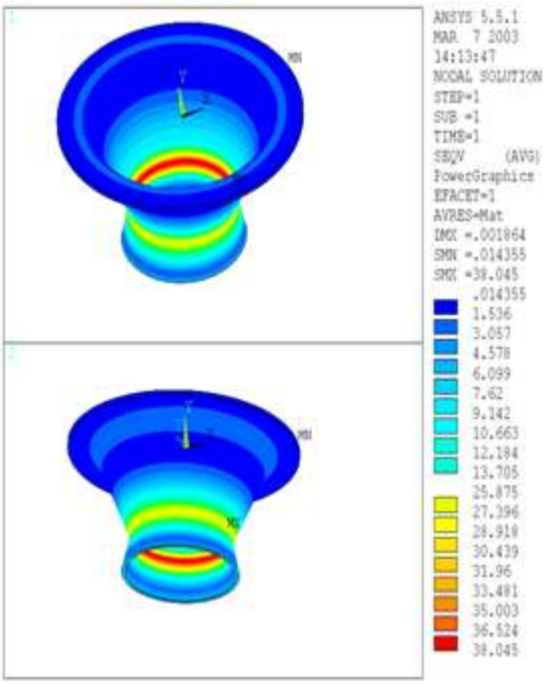

Figure 8: Distribution of von Mises stresses on the optimized model

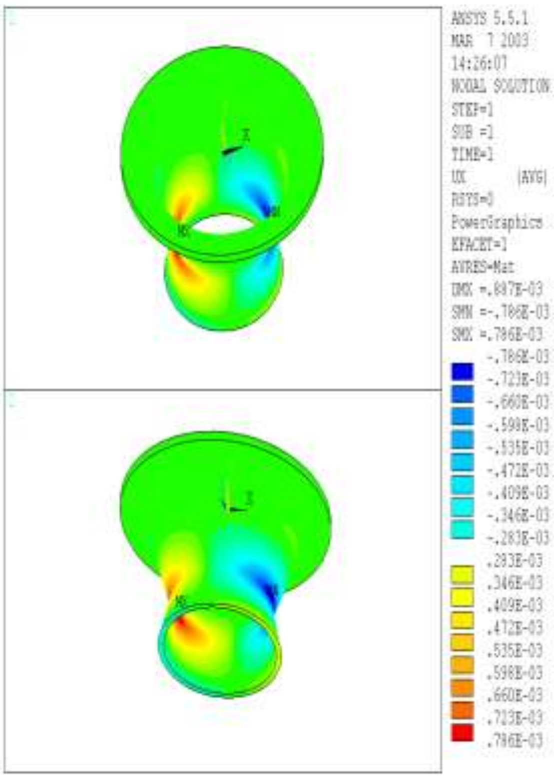

Figure 9: Distribution of ux nodal displacements on the initial model

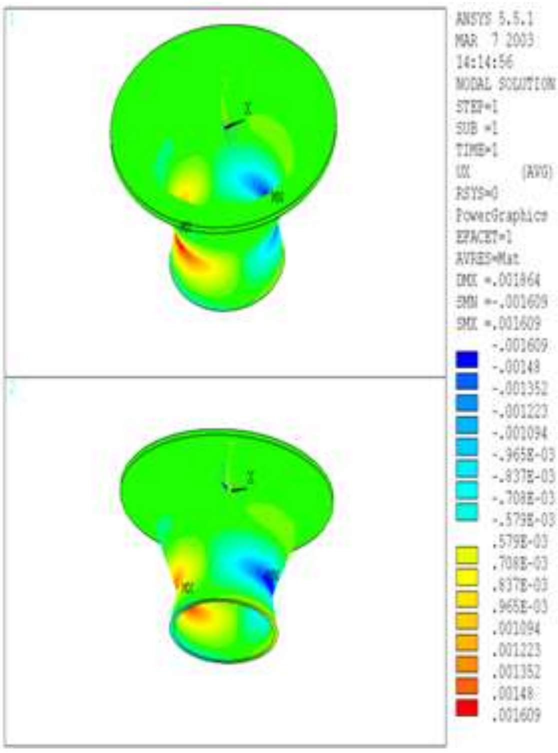

Figure 10: Distribution of ux nodal displacements on the optimized model

2) The static optimization of the part by the finite element method

The geometric model of the part is identical to the one shown in the static analysis, the optimization parameters being the following:

h - the outside length of the cap;

g - the thickness of the cap;

r_1 – the junction radius;
β - the angle of inclination of the back collar, these resulting from the requirement of the minimum volume of material.

The objective function of the optimization is the minimum volume for the analyzed part.

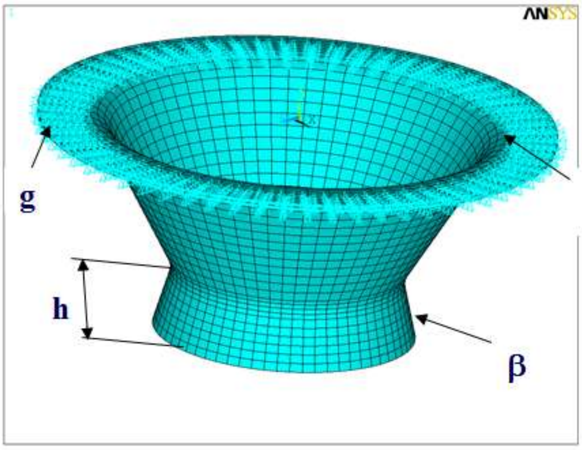

Figure 11: Modeling the loudspeaker dust cap part

List Optimization Sets from set 12 to set 12 and show only Optimization Parameters

SET 12	(FEASIBLE)
S (SV)	38.045
DUY (SV)	0.91364E-03
G (DV)	1.0042
BETA (DV)	30.205
R1 (DV)	2.9903
H1 (DV)	7.0429
VOL (OBJ)	3863.6

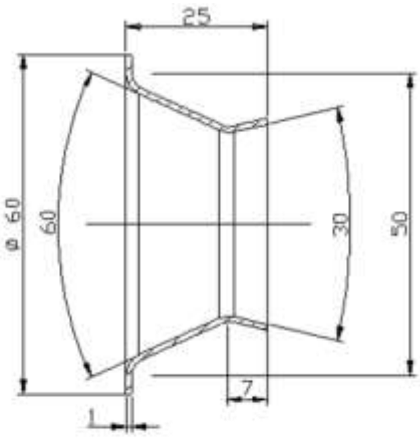

Figure12: The optimal part resulted from the analysis [mm]

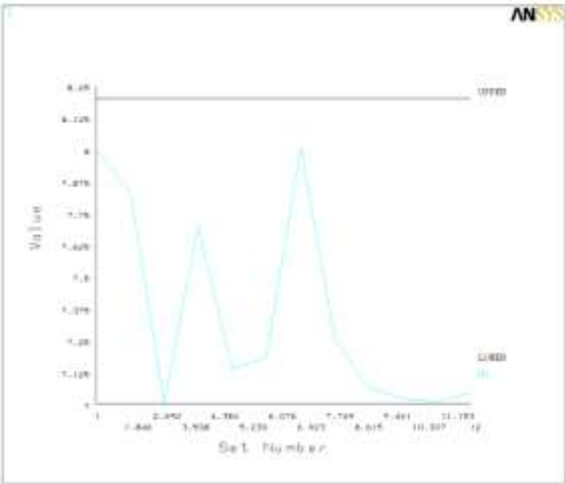

Figure 13: The variation of the height of the collar h_1 throughout the 12 sets

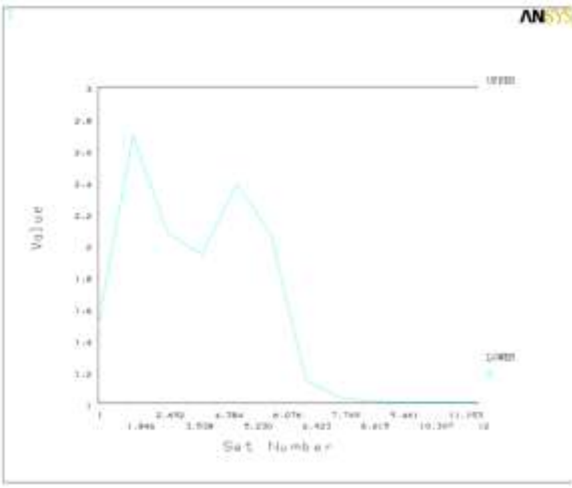

Figure 14: The variation of the thickness of the material g throughout the 12 sets

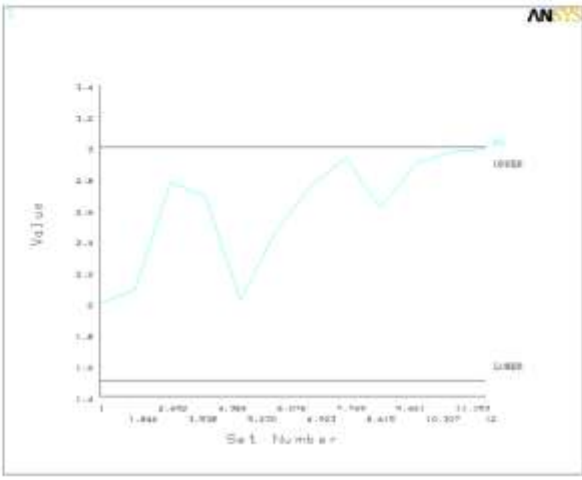

Figure 15: The variation of the radius r_1 throughout the 12 sets

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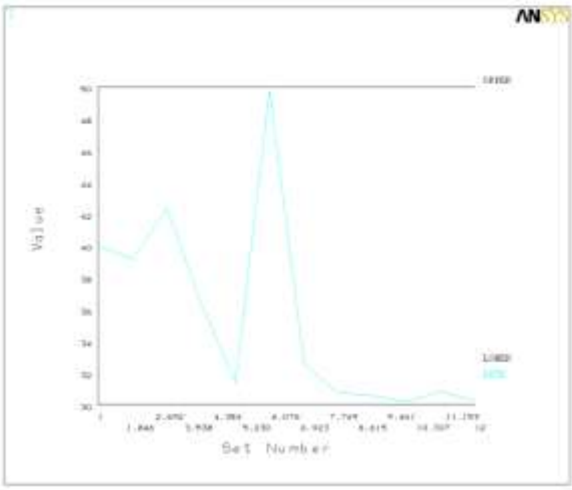

Figure 16: The variation of the angle of the collar β of the part throughout the 12 sets

2. Conclusions

The purpose of this research is to determine the first own frequencies of the structure, to highlight certain of its weaknesses as well as to determine the tendencies to deform in the dynamic field influencing the processing precision.

The modal analysis was performed using the ANSYS 5.5 software, the spatial structure of the part being modeled with SOLID 45 type finite elements.

The normalization of the vibration modes is done in relation to the mass matrix so that it can be possible to continue the analysis with the response to a harmonic excitation.

In the modal analysis, the first six eigenmodes were extracted, covering the range of the working frequencies.

Index of Data Sets on Results File

SET	TIME/FREQ	Load Step	Substep	Cumulative
1	16129	1	1	1
2	16131	1	2	2
3	17669	1	3	3
4	17669	1	4	4
5	22658	1	5	5
6	22658	1	6	6

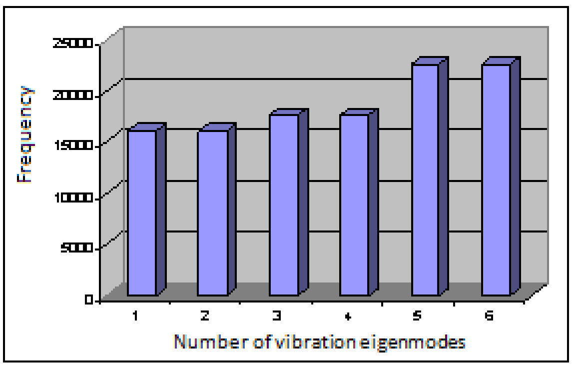

Figure 17: Representation of the eigen frequencies obtained after the analysis

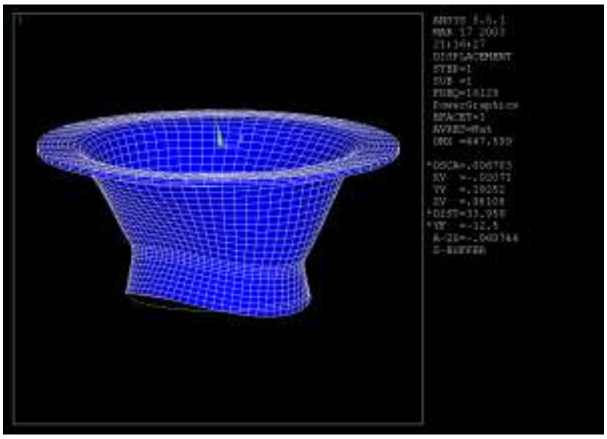

Figure 18: Running the analysis of the model of the car speaker dust cap to determine the optimal dimensions in terms of the volume of materials

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