ANSA and μETA for Nastran Solution 200

Introduction

ANSA and μETA, the pre- and post-processing package of BETA CAE Systems, has become an essential part of the optimization processes. Their extensive usage in a variety of industries and across many disciplines has transformed ANSA and μETA into standard tools for setting up an optimization. In this framework ANSA supports all the necessary keywords for all possible Nastran Solution 200 optimization types. Sizing, shape, topology, topography and topometry optimization cases can be defined within ANSA in an automated way. In this document a shape and a sizing optimization case are presented.

Shape optimization of a piston rod

Problem description and goal

A solid model of a piston rod is subjected to a static loadcase. A distributed pressure with a total resultant force of 7975 [N], is applied to the connecting rod small eye bushing, while the nodes movement of the big bushing that is attached to the crankshaft is constrained. The goal is to find a shape for the piston rod, that minimizes the rods volume, while keeps the maximum developed stresses bellow a specified limit (42.5 [MN/m^2]).

Manual Grid Variation Method

ANSA supports the Manual Grid Variation method for shape optimization with solution 200. This means that the user must define a displacement vector for every grid of the design space. These vectors prescribe the movement of the grids through the optimization. For each grid of the design space, a DVGRID keyword must be defined which contains the information of the displacement vector. The DVGRID keyword is connected to a design variable which drives the grid movement and defines its boundaries. The definition of the DVGRID keywords can be automated through the Morphing Tool.

DVGRIDS automated definition and Morphing Tool

The shape of the model is parameterized in three different ways. One parameter controls the middle curvature of the rod, another one

controls the pocket depth and a third one controls the taper. The shaping of the model is achieved by the use of ANSA morphing tool.
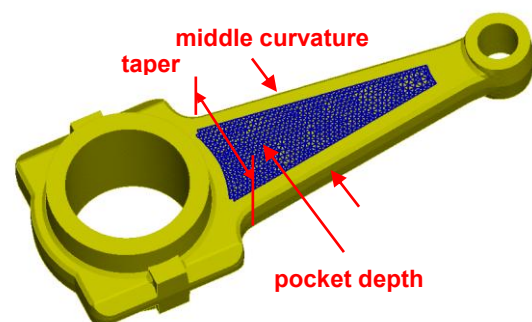
Two groups of boxes are created. One that controls the middle curvature and the taper parameters, and one that controls the pocket depth. The piston rod is symmetric and so, linked boxes are used, assuring identical shaping to both sides of the model, and reducing by half the time needed for boxes creation.
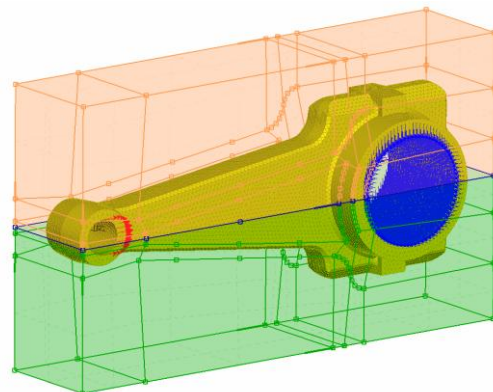
The shaping can be performed parametrically using morphing parameters. From these parameters, history states can be created. Each state corresponds to a specific shape of the model. A DVGRID is defined as the displacement vector of a grid between two different history states. The DVGRIDs are automatically assigned to a design variable while the whole process is a matter of minutes.
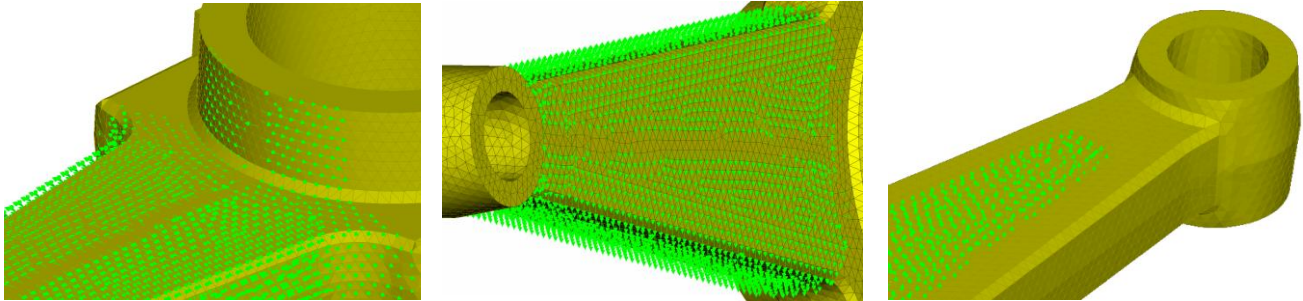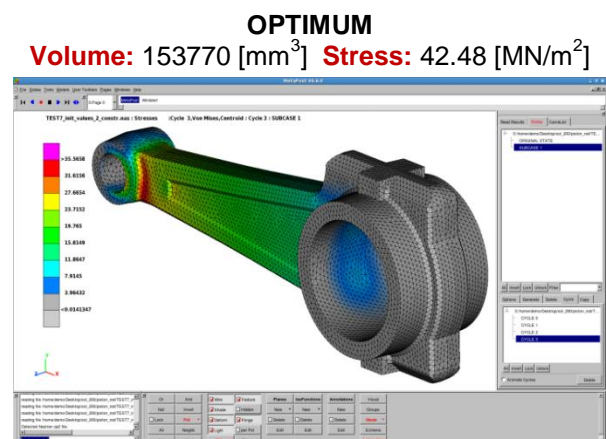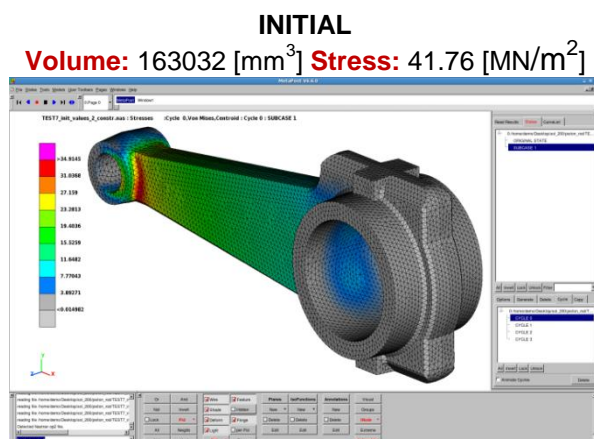

Simulation of the design space

An important step of the process is to check the validity of the model for different values of design variables, meaning the different shapes that the model can take during the optimization. This is possible by using the Simulate tool. Many experiments can be created and animated within ANSA, giving a preview of the design space, quality criteria violation, self-intersection etc. while the animation can be recorded and saved as a video file.
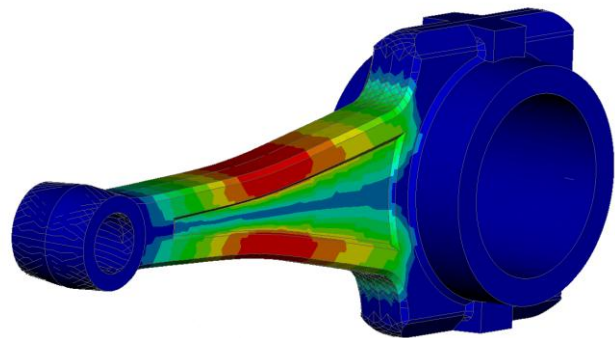
The design responses can be defined using the corresponding keywords. In this case one response is the rods total volume that is specified as the design objective in Nastran header and another is the maximum Von Mises stress on the rods most critical area. The maximum stress is defined as a design constraint. All the Solution 200 related keywords are listed in the database browser of ANSA, under the respective tab and can be easily edited and previewed.

Results on μETA

Nastran converged to an optimum solution within 4 cycles. The results are presented in μETA. The user can move through the optimization cycles and view the results of each cycle, including shape change. μETA offers a variety of capabilities for 3d-results handling and along with its automation and reporting capabilities comprise a complete post processing package

INITIAL
Volume: 163032 [mm^3] **Stress:** 41.76 [MN/m^2]

OPTIMUM
Volume: 153770 [mm^3] **Stress:** 42.48 [MN/m^2]

2d-plot capabilities

μETA offers powerfull options for 2d-results handling and viewing through its enhanced 2d-plot capabilities. There is an option specifically designed for solution 200 results handling. Through this option a 2d-plot is automatically created, containing the design variable and responses values in respect to the optimization cycles.
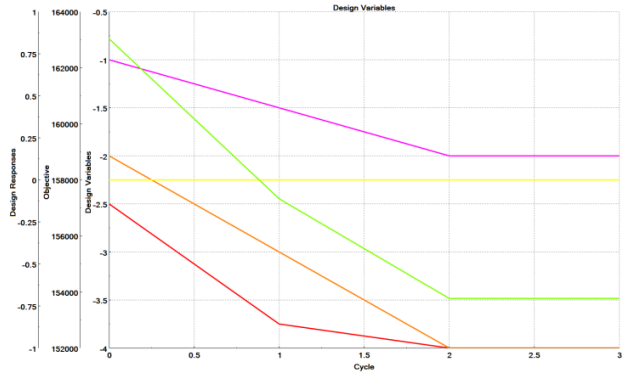
Property Thickness optimization

Problem description and goal

In this case the model is constrained at the section of the pillars and is subjected to a normal modes analysis. The target is to find the optimum thickness of the sheet metal parts in order to minimize the weight of the structure, while at the same time constraining the 5th eigenfrequency of the roof inside the desired limits (75- 120 [Hz])


Massive Design Variables definition

One of the most tedious tasks when setting up a sizing optimization, such as this, is the design variables definition. The problem becomes much more intense if the number of attributes to be used is big. ANSA offers an elegant solution to this problem, since the user can massively define at once all the design variables. The user selects the properties, materials, or elements which he will use from the database browser and a list with all the supported attributes opens for selection. The Design Variables are automatically created and connected to the selected attributes while the DVPREL/DVMREL/DVCREL keywords are also automatically defined. In this case four design variables are used each one connected with the thickness of a sheet metal part of the roof. Two design responses are created, one of type 'WEIGHT' which is specified as objective in Nastran Header, and one of type 'FREQ' which is used as a design constraint.

INITIAL
**Mass:** 52.83 [kg] **5th Eigenfrequency:** 100.8 [Hz]
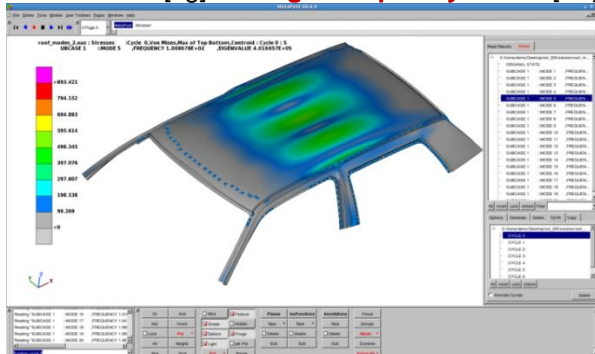
OPTIMUM
Mass: 14.9 [kg] **5th Eigenfrequency:** 74.8 [Hz]
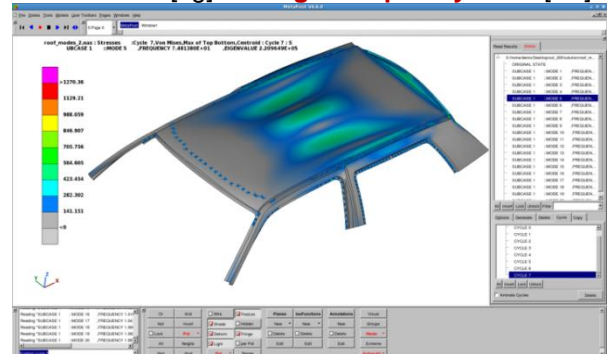
Results on μETA

Nastran converged to an optimum solution within 7 cycles. The evolution of the thicknesses and weight values can be presented in an automatically created 2d-plot. μETA offers an animation toolbar on the bottom of the screen that can be used for an easy navigation through the states of the model, which in this case are the first 20 modes of the roof. The user can be navigated also through the seven optimization cycles for each state in order to have an overview of the 3d-results evolution during the optimization. Moreover using the harmonic animation mode an eigenvector can be animated in a harmonic way between the deformed and the undeformed state.
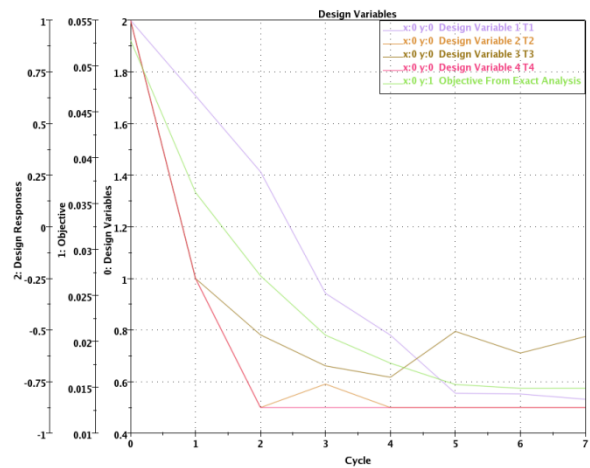
For more information contact
BETA CAE Systems S.A.
Email: ansa@beta-cae.gr