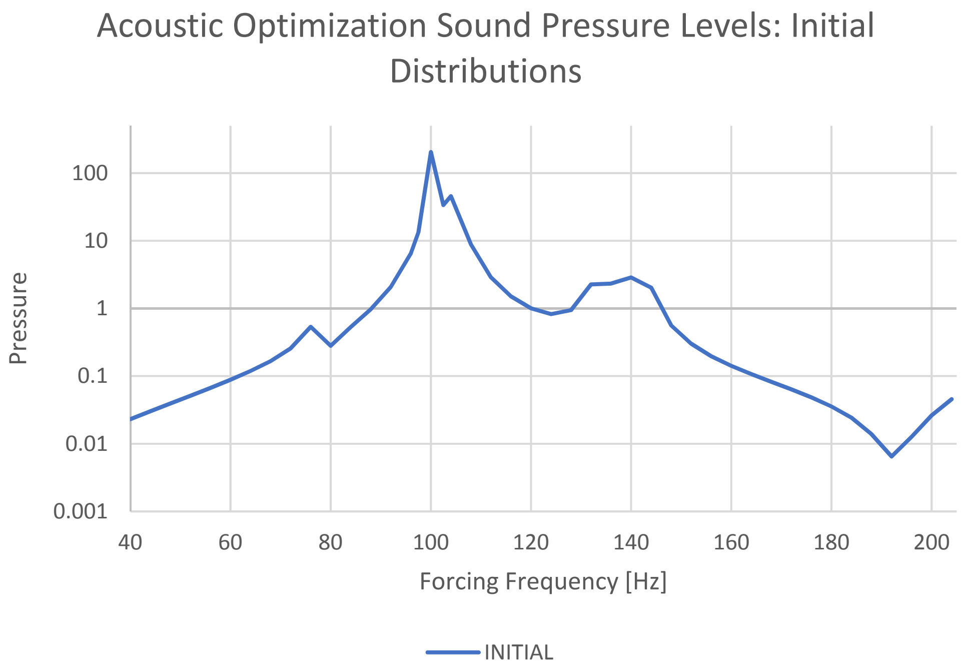
Acoustic Optimization, Beta Method

PRESENTED BY CHRISTIAN APARICIO

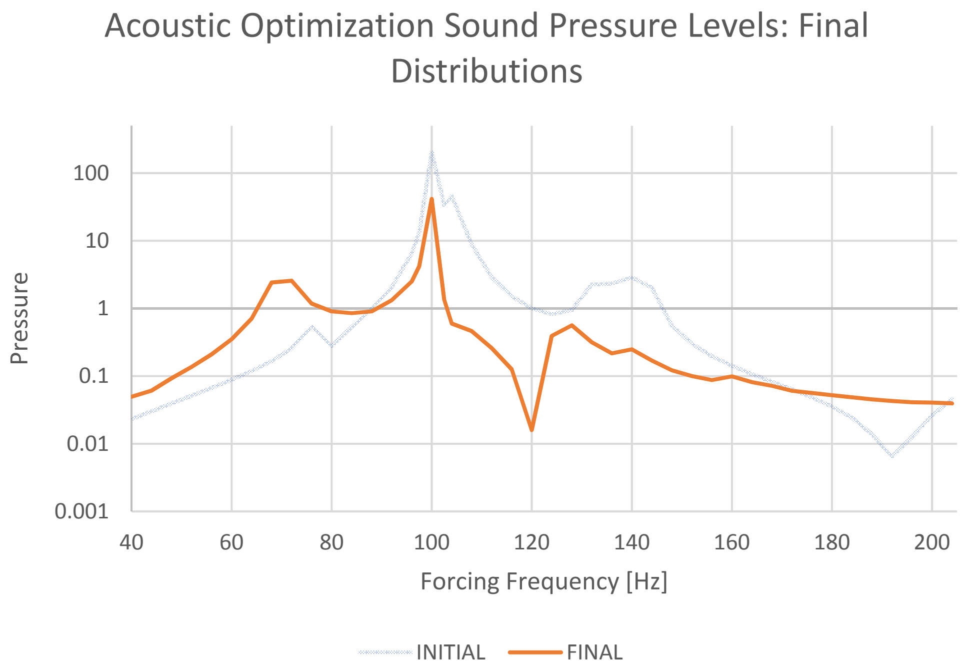
Goal: Use Nastran SOL 200 Optimization

Minimize peak acoustic pressure without increasing the weight of the box

BEFORE OPTIMIZATION



AFTER OPTIMIZATION



MSC Nastran Design Sensitivity and Optimization User's Guide
Chapter 8 - Example Problems - Dynamic Response Optimization

Agenda

Details of the structural model

Optimization Problem Statement

Steps to use Nastran SOL 200 (Optimization)

- Convert a .bdf file to SOL 200
- Create:
  - Design Variables
  - Design Objective
  - Design Constraints
- Perform optimization with Nastran SOL 200

View optimization results

- Online Plotter
- Structural Results

Update the original structural model with optimized parameters

Contact me

- Nastran SOL 200 training
- Nastran SOL 200 questions
- Structural or mechanical optimization questions
- Access to the SOL 200 Web App

christian@ the-engineering-lab.com

Details of the structural model

Acoustic Optimization

Acoustic Optimization uses acoustic pressures as a design response. These are computed from a solution of the coupled fluid-structure interaction problem. An optimal design can thus be found based not only on a consideration of acoustic pressures, but structural responses as well.

This example considers a closed box with fluid elements on the interior. An acoustic source is located at one end of the box, with a transducer located at the opposite end. The design goal is to modify the thicknesses of the box walls such that the peak acoustic pressure at the transducer is minimized without increasing the weight of the box.

The box geometry and property groups of thicknesses to be modified are shown in Figure 8-29. Six design variables are to be related to six of these property groups (the third property group in Figure 8-29 remains fixed.) The model consists of 1000 structural elements and 2000 fluid elements.

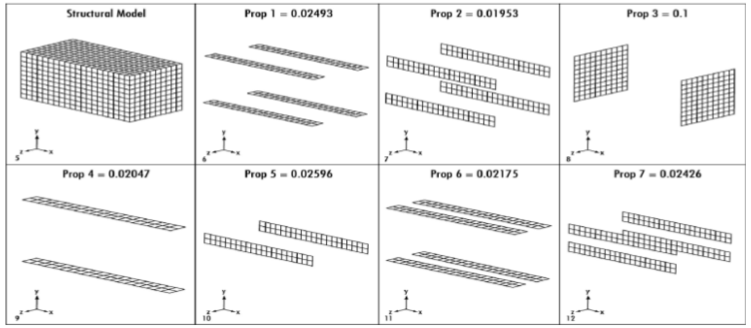
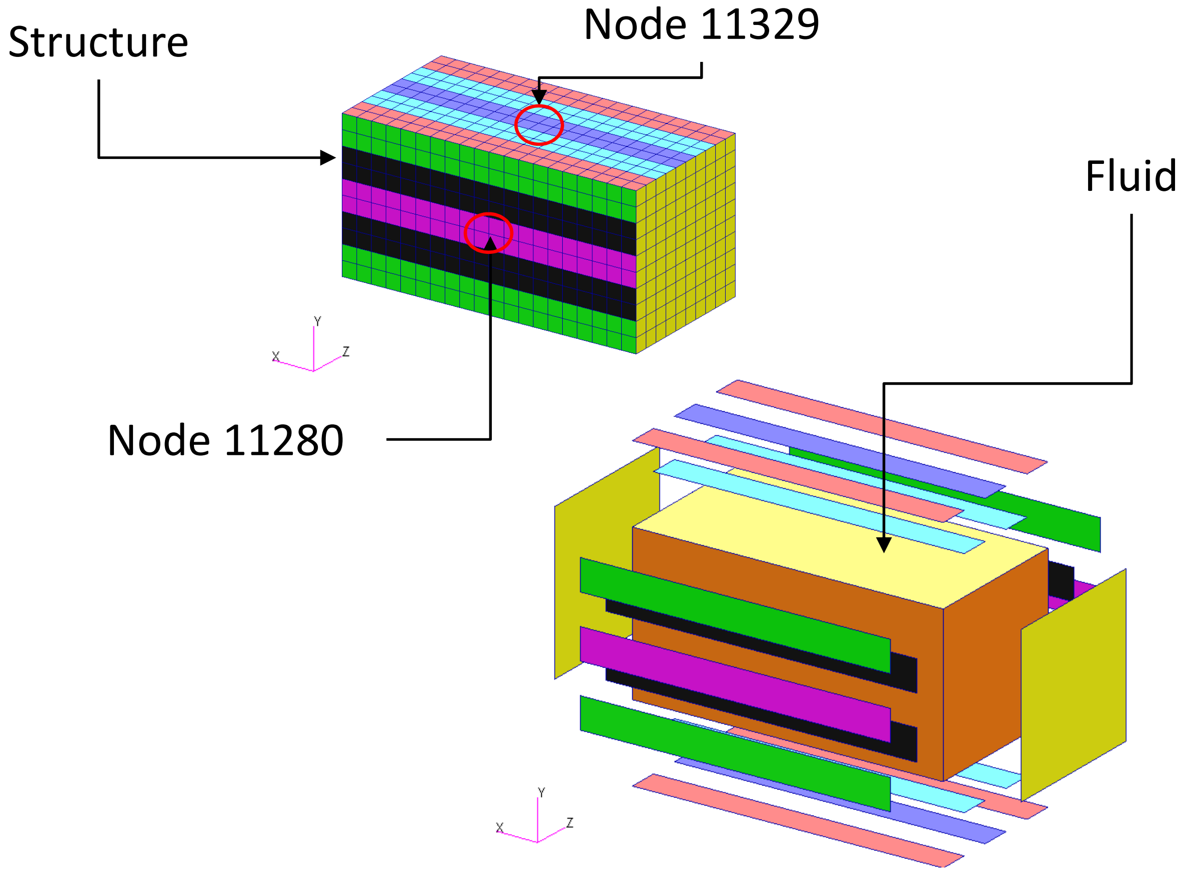


Figure 8-29 Acoustic Box Showing Portions Designed by Each Design Variable (Prop 3 is Fixed)

MSC Nastran Design Sensitivity and Optimization User's Guide
Chapter 8 - Example Problems - Acoustic Optimization



Derivation of the Optimization Problem Statement for the Beta Method

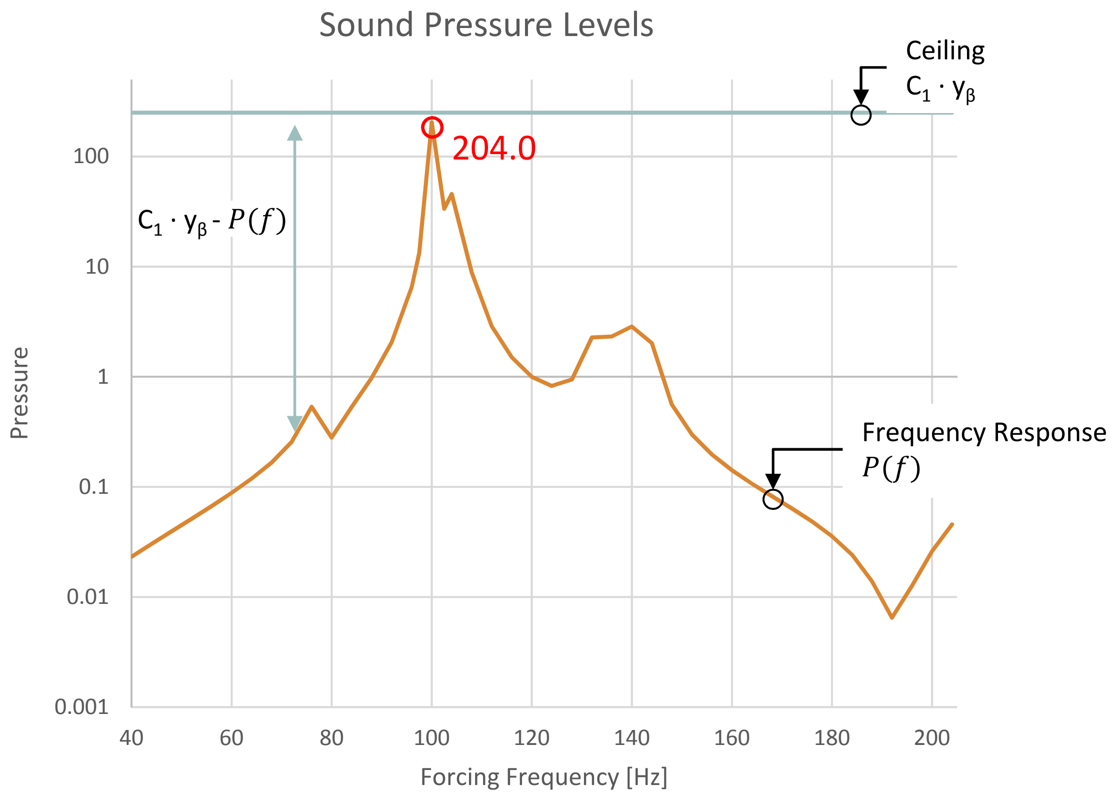
Prerequisites:

- The initial value of variable y_β is 1.0
- $P(f)$ represents the frequency response (For example, the response is Pressure vs. Frequency)

Derivation:

1. The ceiling ($C1 \cdot y_\beta$) should always be taller than the response $P(f)$ and is expressed via this inequality
   $P(f) < C1 \cdot y_\beta$
2. The expression is re-organized as:
   $0.0 < C1 \cdot y_\beta - P(f)$
3. The bound is 0.0, and optimizers do not like using 0.0 for the bounds, so an offset of 1000.0 is used. The expression is now
   $\underline{1000.0 < C1 \cdot y_\beta - P(f) + 1000.0}$

- **How is C1 determined?**
  - Find the max peak of the response (Pressure vs Frequency)
  - Add a small delta to the max peak and this is your C1
  - For example, if your max peak is 204.0, then C1 can be 205, 206, 207, …. For example, C1=210 is chosen.

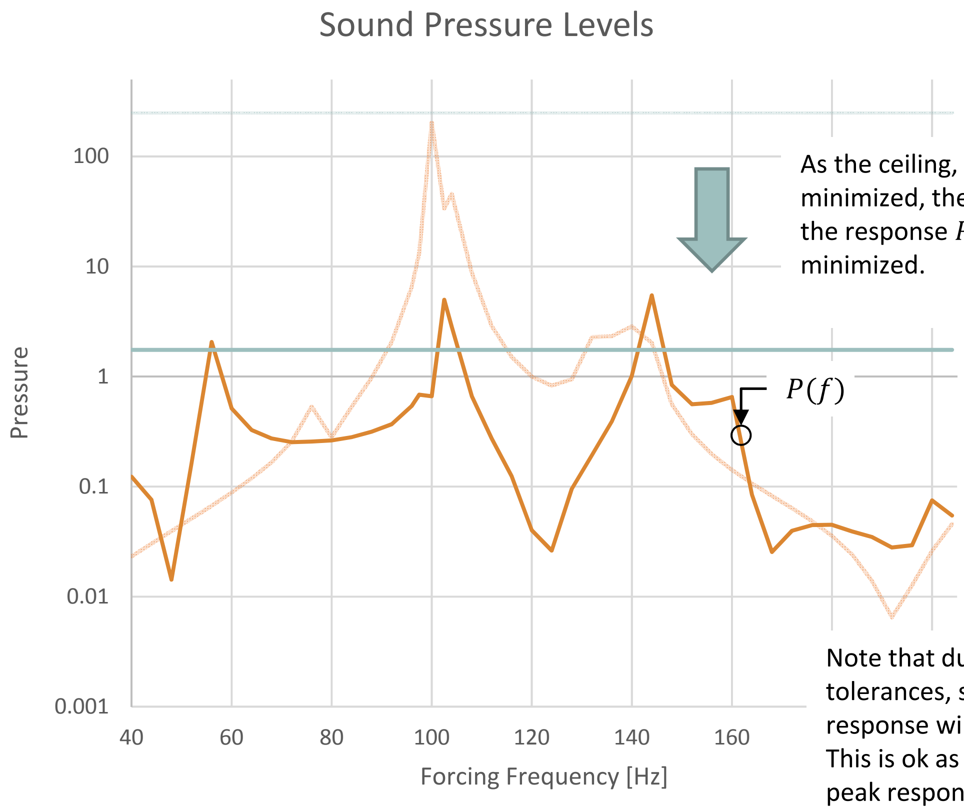


Optimization Problem Statement for the Beta Method

The optimization problem statement is now as follows:

- Variable:
  - y_β : The initial value is 1.0. The bound can be .0001 < y_β
- Objective:
  - Minimize C1 · y_β
  - i.e. minimize the ceiling
- Constraints:
  - 1000.0 < C1 · y_β - $P(f)$ + 1000.0
    - $P(f)$ represents the frequency response (For example, the response is Pressure vs. Frequency)
  - i.e. as the ceiling is minimized, require the response $P(f)$ to be under the ceiling

This optimization method can be seen as a moving ceiling scenario. The goal is to minimize the ceiling (blue line), while ensuring the response curve (orange) remains under the ceiling.



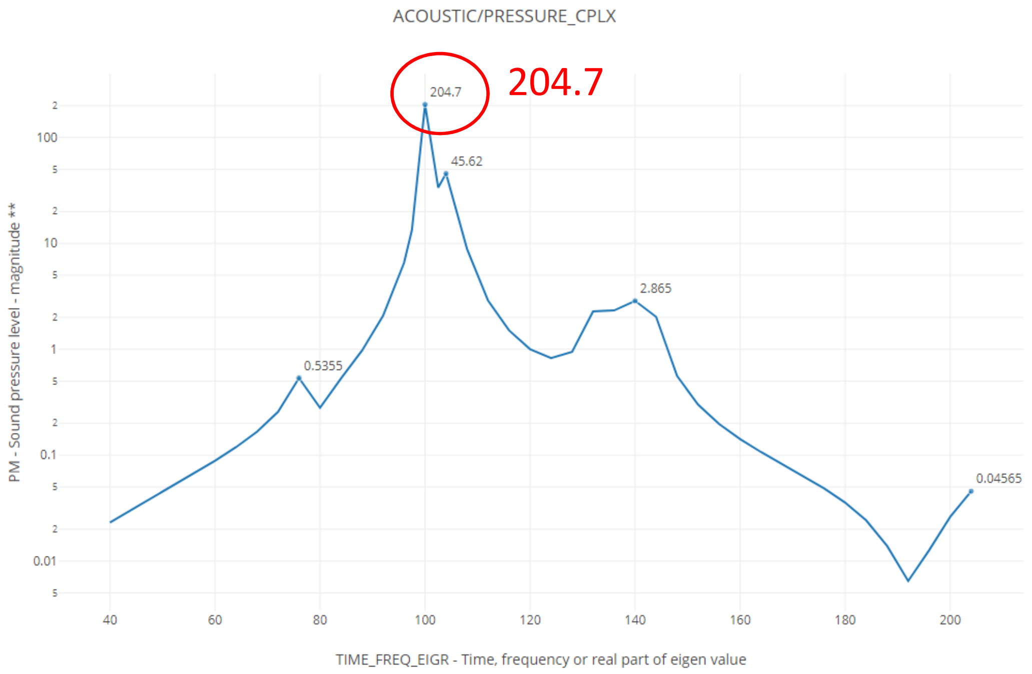
As the ceiling, $C_1 \cdot y_\beta$, is minimized, the constraint forces the response $P(f)$ to also be minimized.

Note that due to optimizer tolerances, some peaks of the response will breach the ceiling. This is ok as long as the max peak response is minimized.

Example of Beta Method with Multiple Responses and Subcases

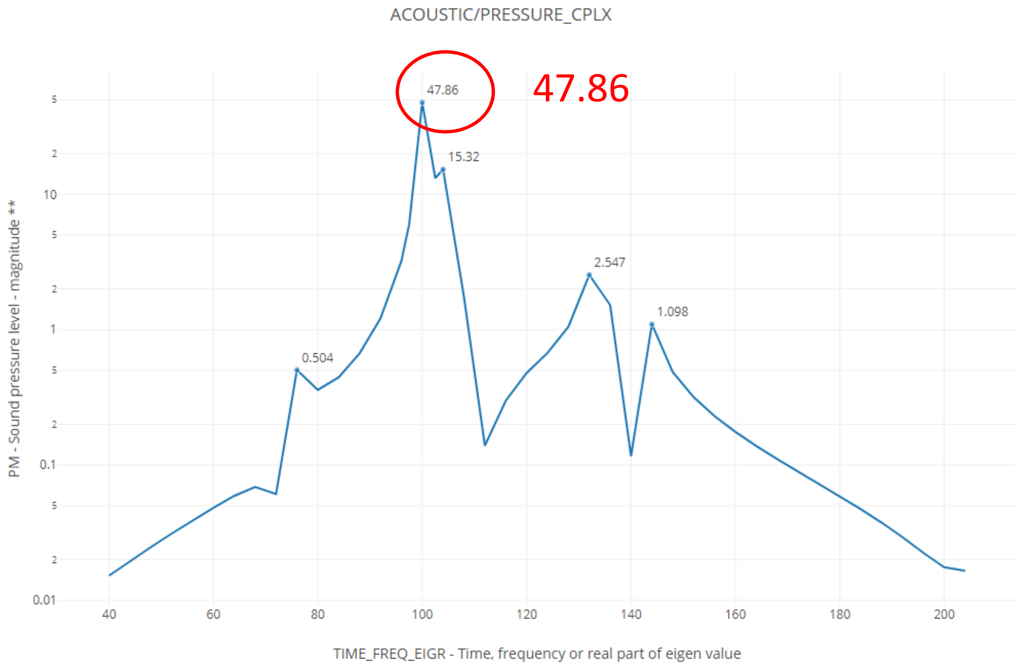
SUBCASE 1 – NODE 11280

THE MAX PEAK IS 204.7, SO C1 SHOULD BE GREATER. YOU CAN USE 205, 206, … FOR MY EXAMPLE, I PICK **C1=210.**



SUBCASE 2 – NODE 11329

THE MAX PEAK IS 47.86, SO C1 SHOULD BE GREATER. YOU CAN USE 50, 51, 52, … FOR MY EXAMPLE, I PICK **C1=50.**

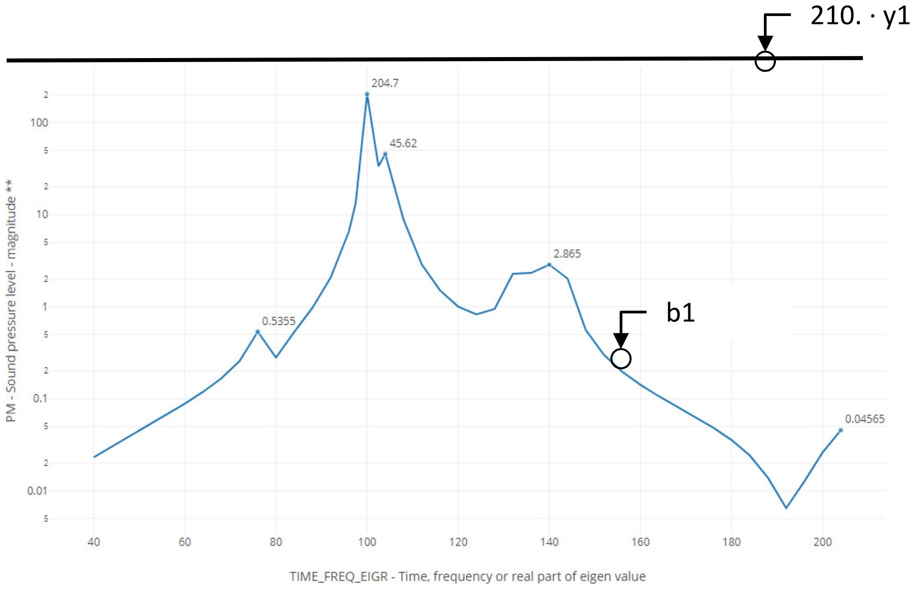


Example of Beta Method with Multiple Responses and Subcases, Continued - Constraints

SUBCASE 1 – NODE 11280

R1: 1000.0 < **210.** · y1 – b1 + *1000.0*

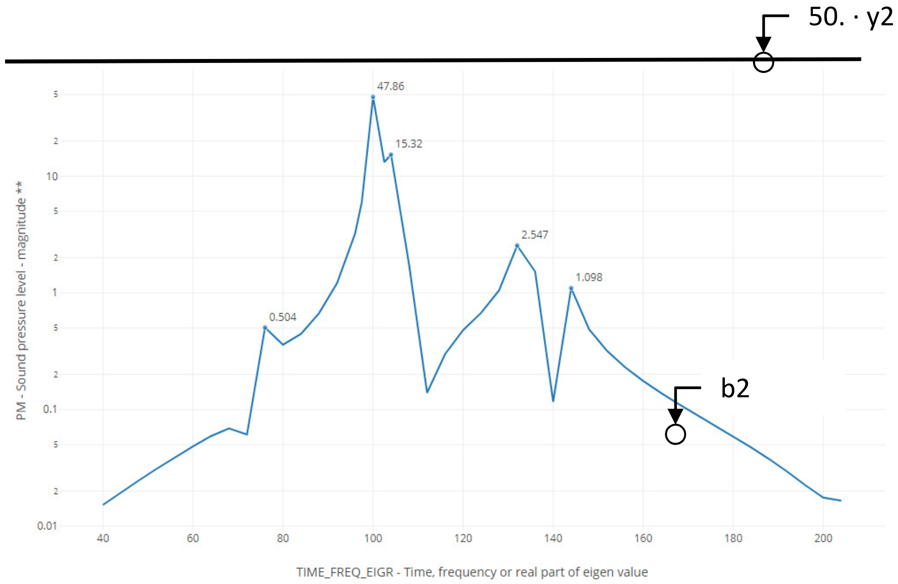
b1: The response (Pressures vs. Frequency) of node 11280, subcase 1



SUBCASE 2 – NODE 11329

R2: 1000.0 < **50.** · y2 – b2 + *1000.0*

b2: The response (Pressures vs. Frequency) of node 11329, subcase 2



Example of Beta Method with Multiple Responses and Subcases, Continued - Final Optimization Problem Statement and Subcase Configuration

The combined problem statement is

Variable:

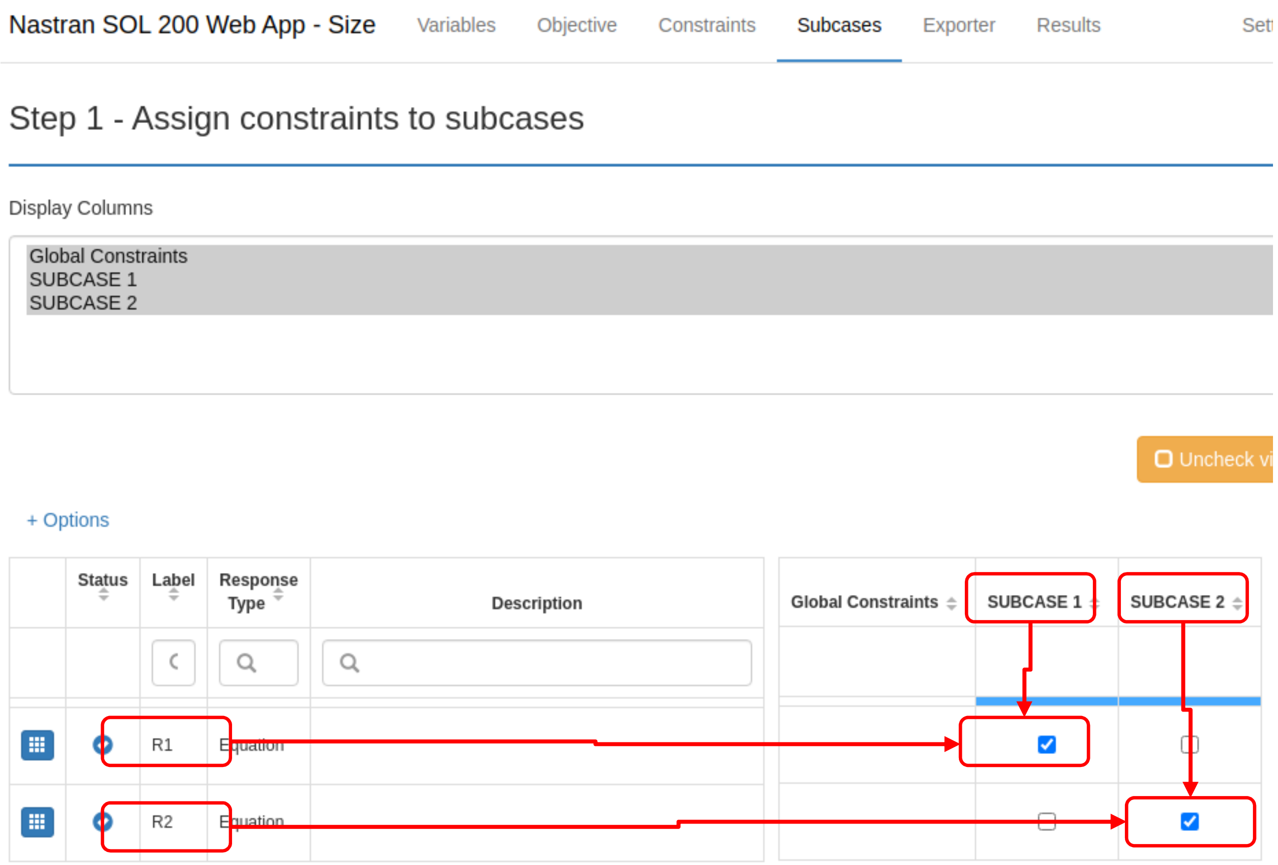
- y1: The initial value is 1.0. The bound can be .0001 < y1
- y2: The initial value is 1.0. The bound can be .0001 < y2

Objective:

- Minimize: $210. \cdot y1 + 80. \cdot y2$

Constraints:

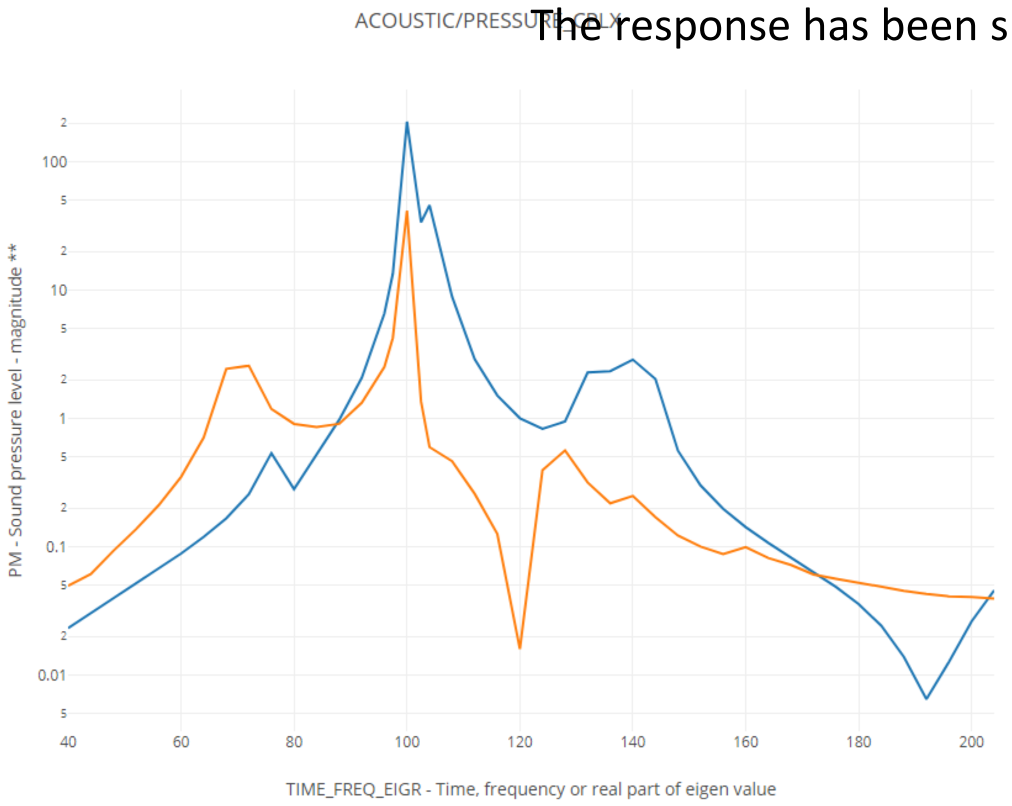
- R1: $1000.0 < 210. \cdot y1 - b1 + 1000.0$
- R2: $1000.0 < 50. \cdot y2 - b2 + 1000.0$
- R1 and R2 are assigned to SUBCASE 1 and 2, respectively
- The web app is used to assign constraint, see the image to the right.



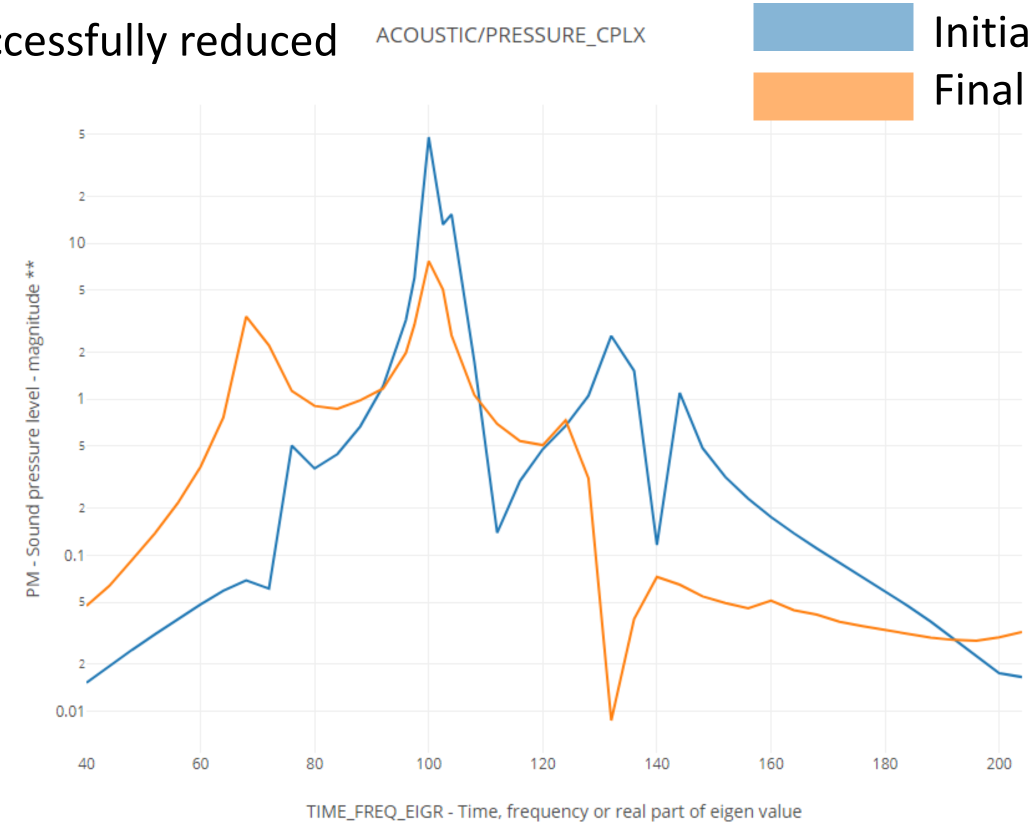
Example of Beta Method with Multiple Responses and Subcases, Continued - Responses After Optimization

The response has been successfully reduced

Initial
Final



Node 11280, Subcase 1



Node 11329, Subcase 2

Optimization Problem Statement

Design Variables

x1: T of PSHELL 1
x2: T of PSHELL 2

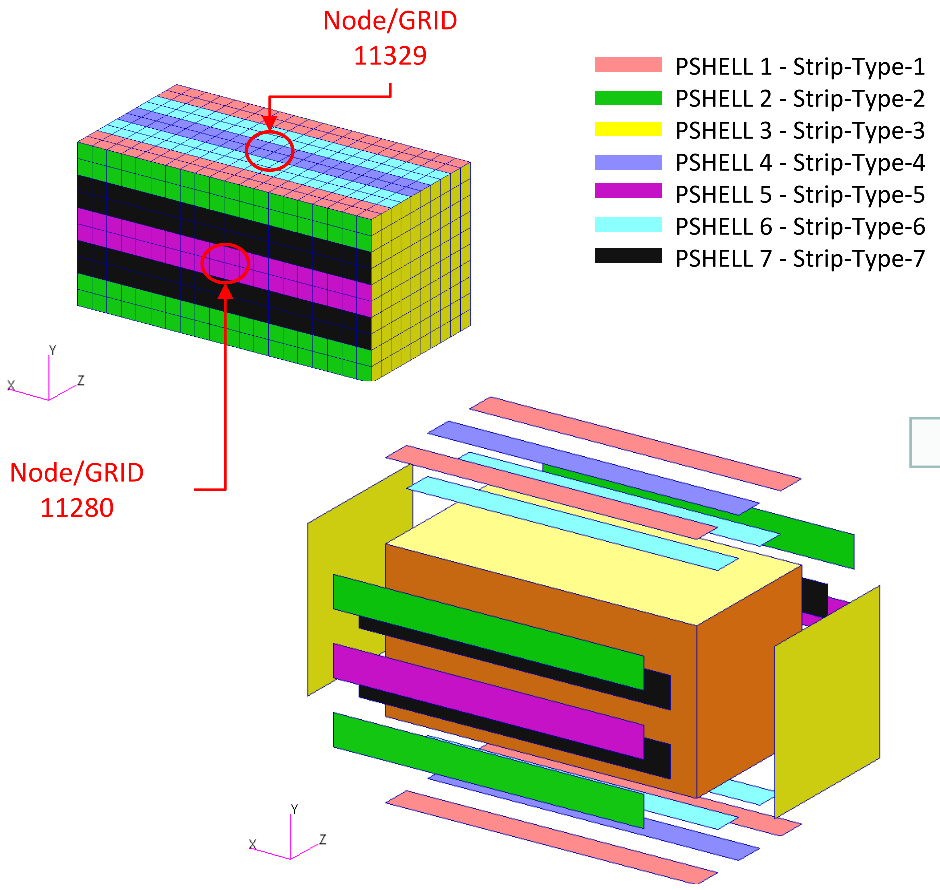
x4: T of PSHELL 4
x5: T of PSHELL 5
x6: T of PSHELL 6
x7: T of PSHELL 7

$.001 < x_i < 1.0$

y1: 1st variable of BETA method
y2: 2nd variable of BETA method

y1_initial = 1.0
y2_initial = 1.0

$.001 < y1$
$.001 < y2$



Design Objective, Equation

R0: Minimize
210. * y1 + 50. * y2

Design Constraints

r1: Weight
2890. < r1 < 2910.

Design Constraints, Equation

R1: 210. * y1 - b1 + 1000
R1: 50. * y2 – b2 + 1000
1000 < R1 SUBCASE 1
1000 < R2 SUBCASE 2

Other Responses

b1: Pressure, x-component, at node 11280 across all forcing frequencies
b2: Pressure, x-component, at node 11329 across all forcing frequencies

Steps to use Nastran SOL 200 (Optimization)

1. Start with a .bdf or .dat file
2. Use the SOL 200 Web App to:
   - Convert the .bdf file to SOL 200
     - Design Variables
     - Design Objective
     - Design Constraints
   - Perform optimization with Nastran SOL 200
3. Review optimization results
   - Online Plotter
   - Optimized structural results
4. Update the original model with optimized parameters

SOL 200 Web App Capabilities

The Post-processor Web App and HDF5 Explorer are free to MSC Nastran users.

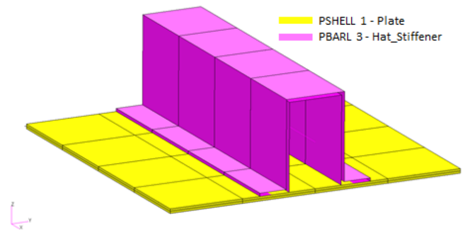
Compatibility

- Google Chrome, Mozilla Firefox or Microsoft Edge
- Windows and Red Hat Linux
- Installable on a company laptop, workstation or server. All data remains within your company.

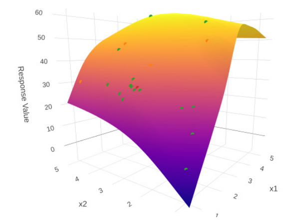
Benefits

- REAL TIME error detection. 200+ error validations.
- REALT TIME creation of bulk data entries.
- Web browser accessible
- Free Post-processor web apps
- +80 tutorials

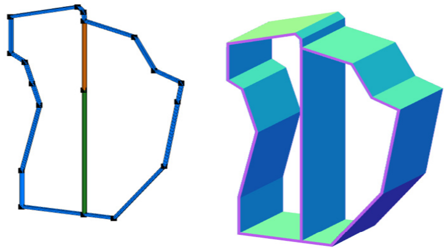
Web Apps



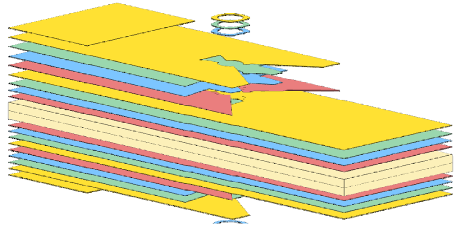
Web Apps for MSC Nastran SOL 200
Pre/post for MSC Nastran SOL 200. Support for size, topology, topometry, topography, multi-model optimization.



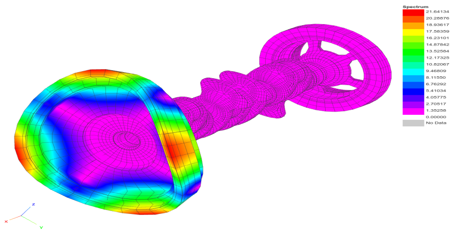
Machine Learning Web App
Bayesian Optimization for nonlinear response optimization (SOL 400)



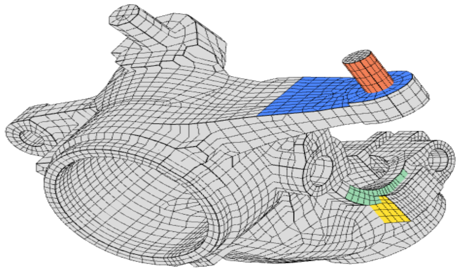
PBMSECT Web App
Generate PBMSECT and PBRSECT entries graphically



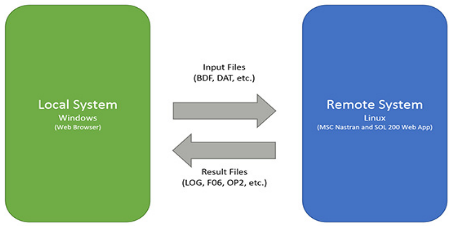
Ply Shape Optimization Web App
Optimize composite ply drop-off locations, and generate new PCOMPG entries



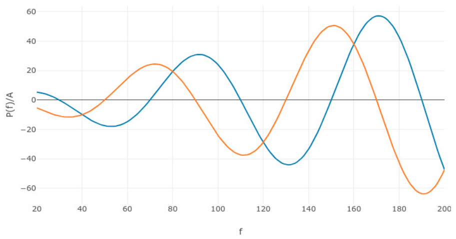
Post-processor Web App
View MSC Nastran results in a web browser on Windows and Linux



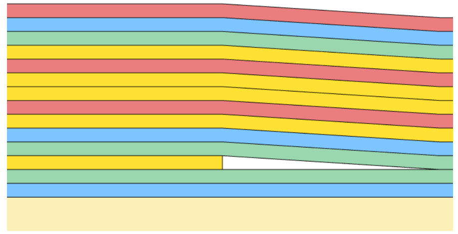
Shape Optimization Web App
Use a web application to configure and perform shape optimization.



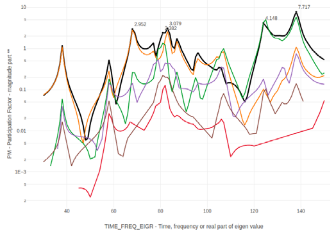
Remote Execution Web App
Run MSC Nastran jobs on remote Linux or Windows systems available on the local network



Dynamic Loads Web App
Generate RLOAD1, RLOAD2 and DLOAD entries graphically



Stacking Sequence Web App
Optimize the stacking sequence of composite laminate plies

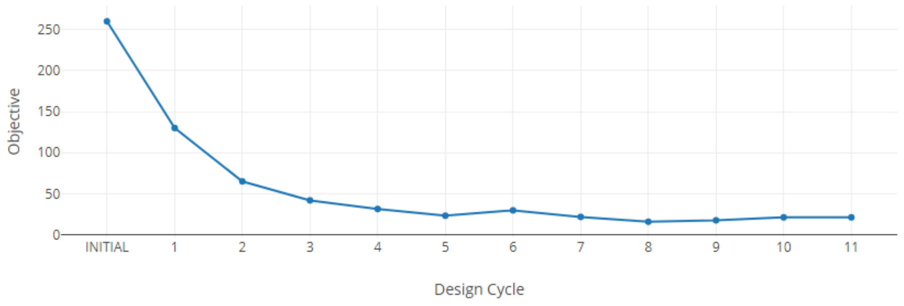


HDF5 Explorer Web App
Create graphs (XY plots) using data from the H5 file

View Optimization Results

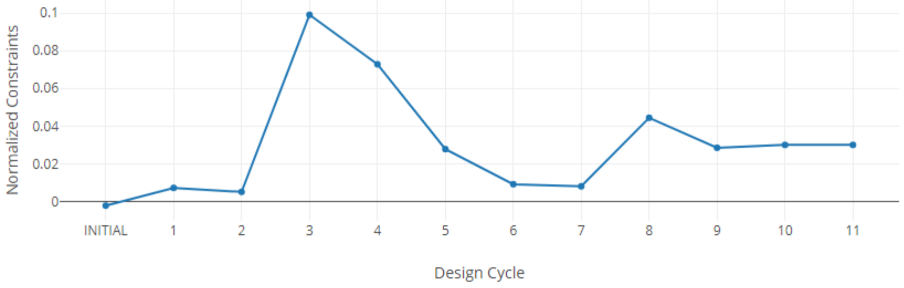
Online Plotter

Objective

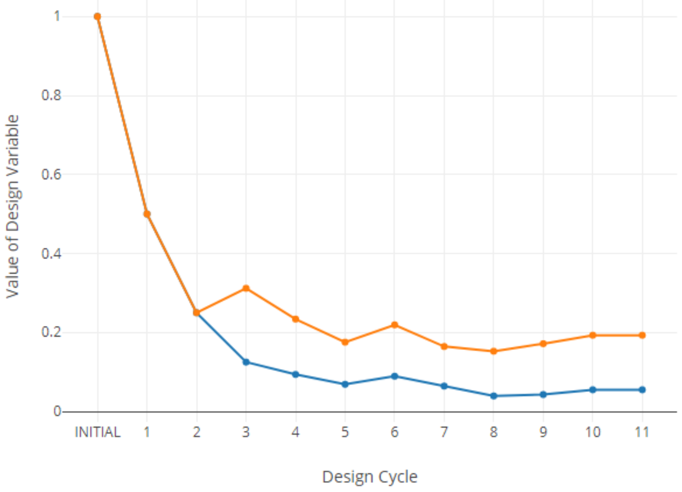


Normalized Constraints

+ Info



Design Variables



Display None | Display All

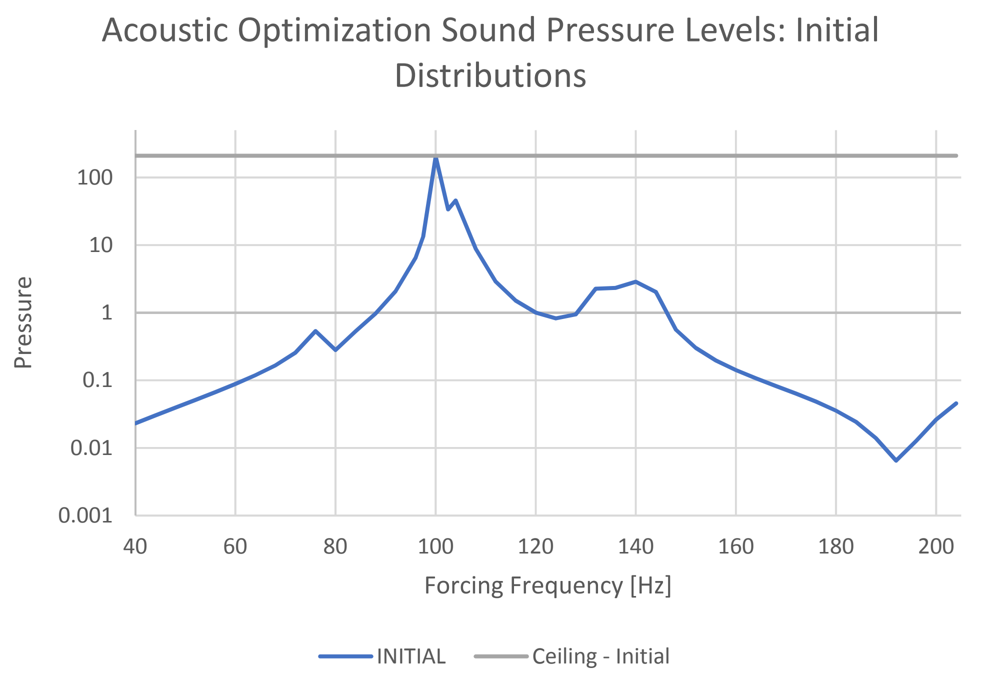
Display	Color	Label	Label Comments
☐		x1	T, Thickness, of PSHELL 1 (Strip-Type-1)
☐		x2	T, Thickness, of PSHELL 2 (Strip-Type-2)
☐		x4	T, Thickness, of PSHELL 4 (Strip-Type-4)
☐		x5	T, Thickness, of PSHELL 5 (Strip-Type-5)
☐		x6	T, Thickness, of PSHELL 6 (Strip-Type-6)
☐		x7	T, Thickness, of PSHELL 7 (Strip-Type-7)
☑	blue	y1	Beta 1
☑	orange	y2	Beta 2

Results

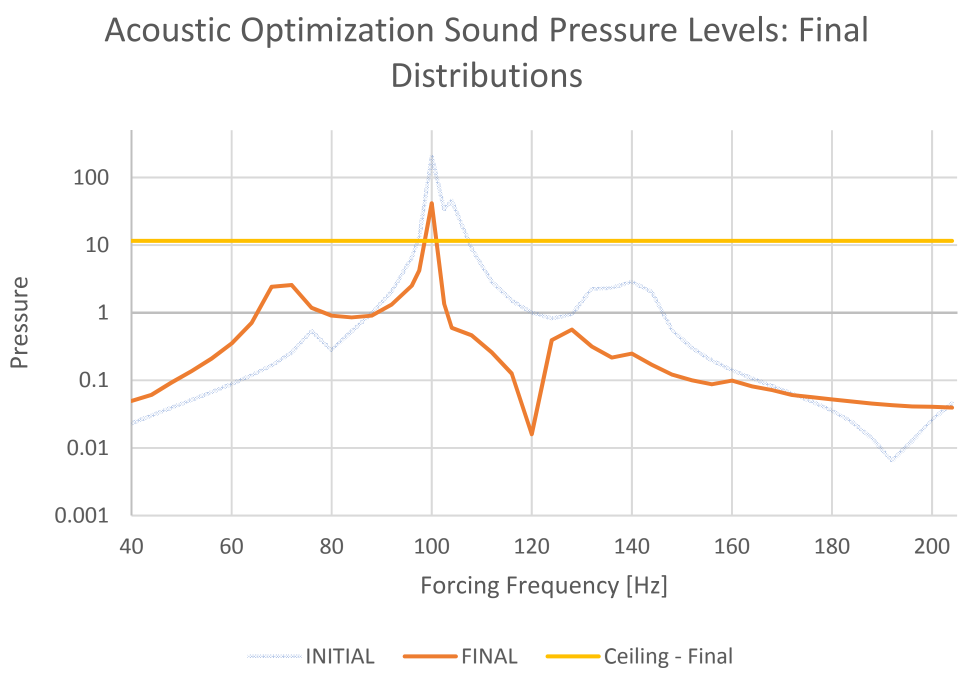
Response at node 11280, subcase1

Minimize peak acoustic pressure without increasing the weight of the box

BEFORE OPTIMIZATION



AFTER OPTIMIZATION

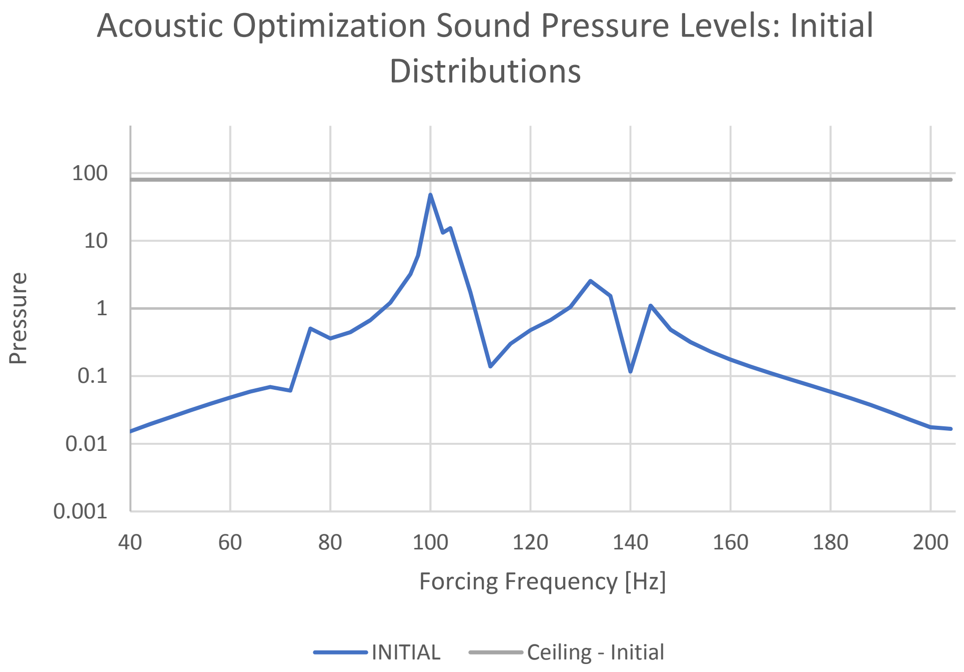


MSC Nastran Design Sensitivity and Optimization User's Guide
Chapter 8 - Example Problems - Dynamic Response Optimization

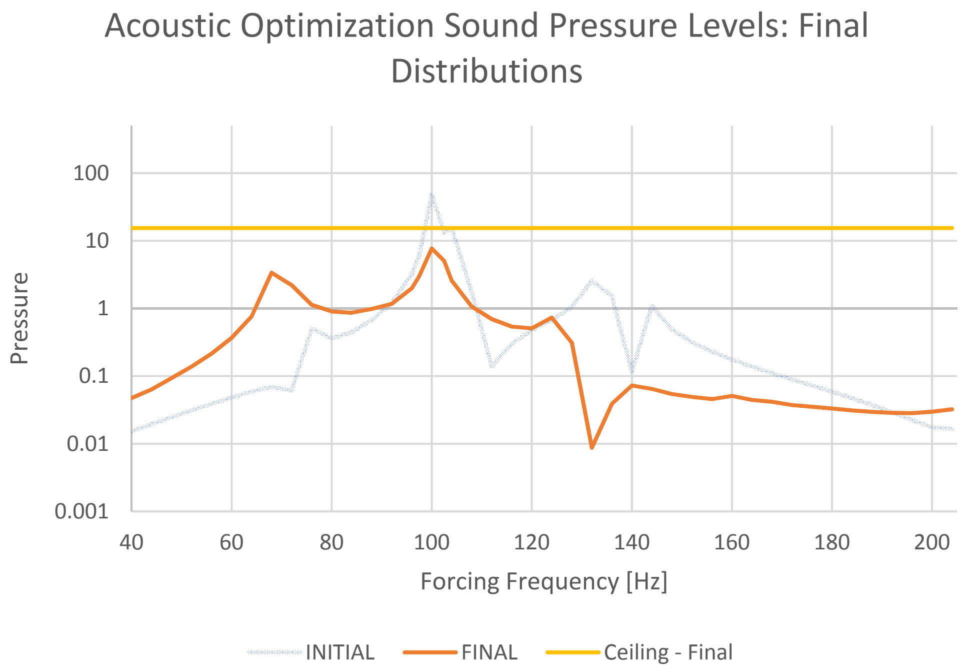
Results
Response at node 11329, subcase 2

Minimize peak acoustic pressure without increasing the weight of the box

BEFORE OPTIMIZATION



AFTER OPTIMIZATION



MSC Nastran Design Sensitivity and Optimization User's Guide
Chapter 8 - Example Problems - Dynamic Response Optimization

Update the original structural model with optimized parameters

Use the .pch file

Contact me

- Nastran SOL 200 training
- Nastran SOL 200 questions
- Structural or mechanical optimization questions
- Access to the SOL 200 Web App

christian@ the-engineering-lab.com