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# Acoustical Performance Design of Automotive Muffler

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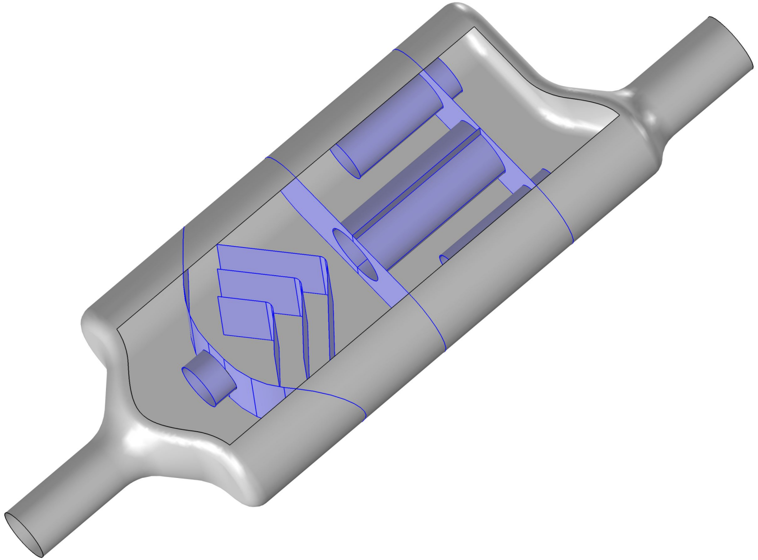
# Automotive Muffler

- The muffler is acoustically engineered as an soundproofing device designed to reduce the loudness of the sound pressure generated from the engine by help  of acoustic quieting.
- Types of Mufflers
  - Dissipative (absorptive) muffler
  - Reactive Muffler
  - Hybrid Muffler
- Reactive Muffler :- Sound is attenuated by reflection and cancellation of sound waves.

# Model Definition

Inlet diameter = 40 mm
Outlet diameter = 34 mm
Chamber length = 300 mm
Chamber width = 160 mm
Chamber depth = 60 mm
Resonating chambers = 5
Total Length = 510 mm



# Meshing Process

Wavelength $\lambda = \frac{c}{f}$

$$= \frac{343}{2000} = 0.1715\ m$$

Maximum Element Length

$$\frac{Wavelength}{4} = \frac{0.1715}{4} = 0.042875\ \text{m}$$

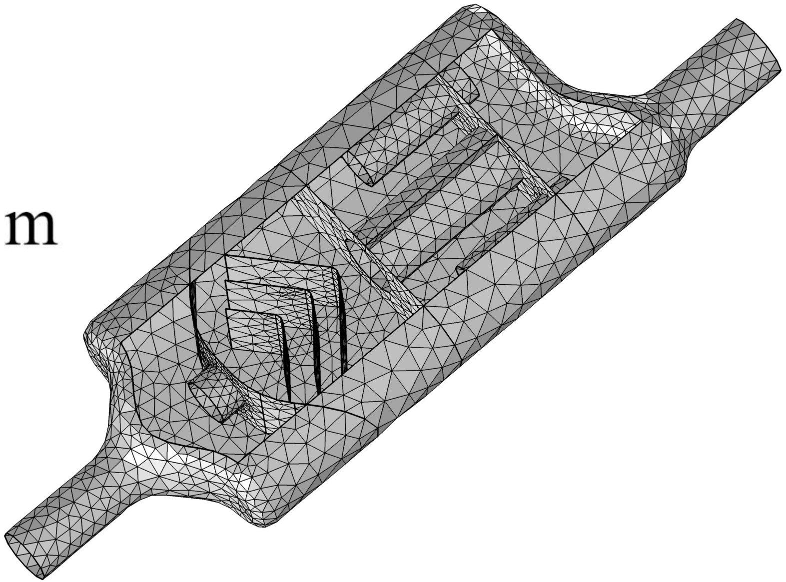
Tetrahedral Elements = 20542

Triangular Elements = 5101

Edge Elements = 626

Vertex Elements = 90

Mesh Volume = 2965000 mm$^3$



# Physics & Study Environments

- **Physics Interface**
  - Pressure Acoustics, Frequency Domain
- **Boundary Conditions**
  - Sound Hard (Wall)
  - Incident pressure field
  - Radiation pressure field
- **Study Environment**
  - Frequency Domain
  - Frequency range (100 Hz to 2000 Hz)
- **Solver Configuration**
  - Linear
  - Direct Solver

# Governing Equation

Domain equation

$$\nabla . \left( - \frac{\nabla p}{\rho} \right) - \frac{\omega^2 p}{c^2 \rho} = 0$$

Where

$\rho$ = Density

$\omega$ = Angular Frequency

c = Speed of Sound

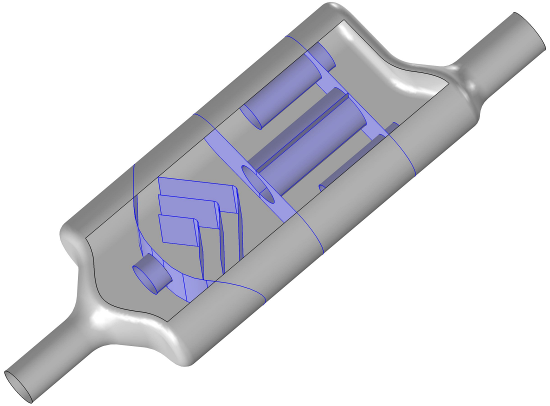
*p* = Acoustic Pressure

# Boundary Conditions

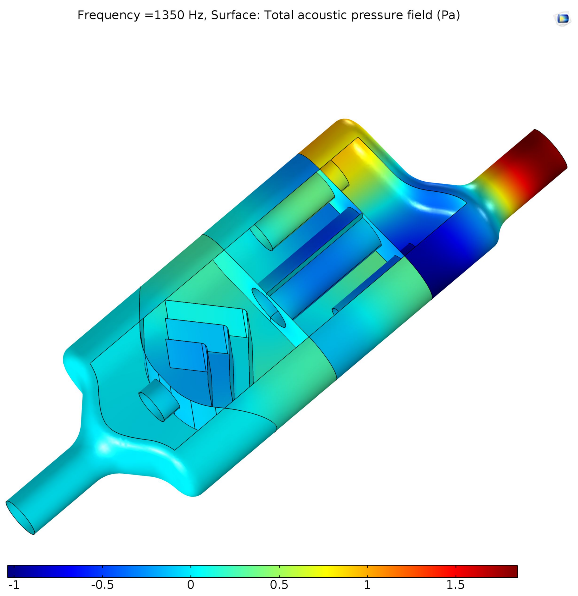
Sound hard $\left(-\frac{\nabla p}{\rho}\right).n = 0$

Incident $\left(-\frac{\nabla p}{\rho}\right).n = \frac{i\omega}{\rho c}p - \frac{2i\omega}{\rho c}p_0 \ .\mathrm{n}$

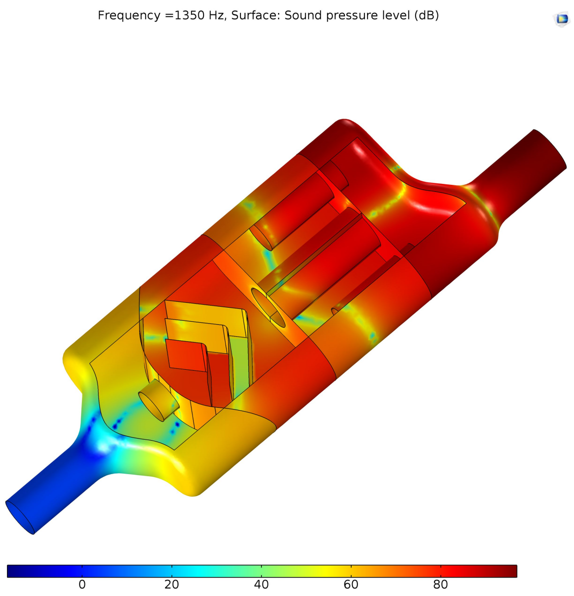
Transmitted $\left(-\frac{\nabla p}{\rho}\right).n = \frac{i\omega}{\rho c}p$



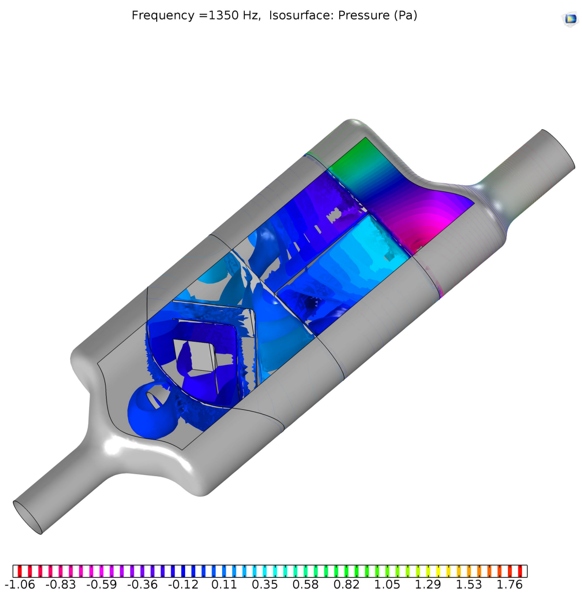
# Results and Discussion




Acoustic Pressure Field (Pa)




Sound Pressure Level (dB)




Isosurface Pressure Field (Pa

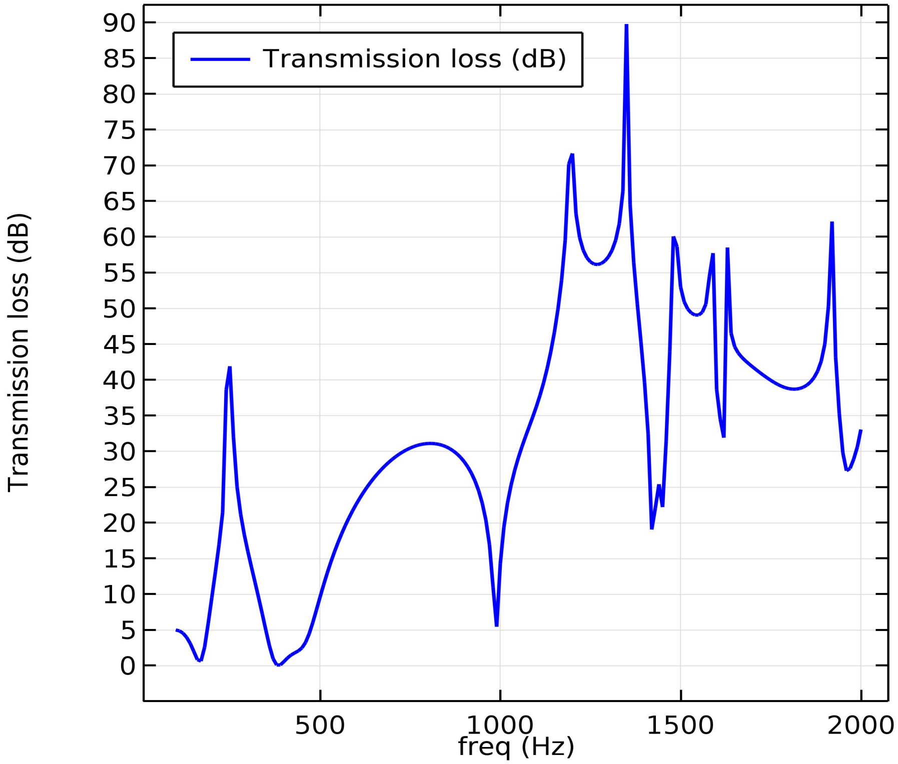
# Transmission Loss

$$TL = 10log\left(\frac{P\,in}{P\,out}\right)$$

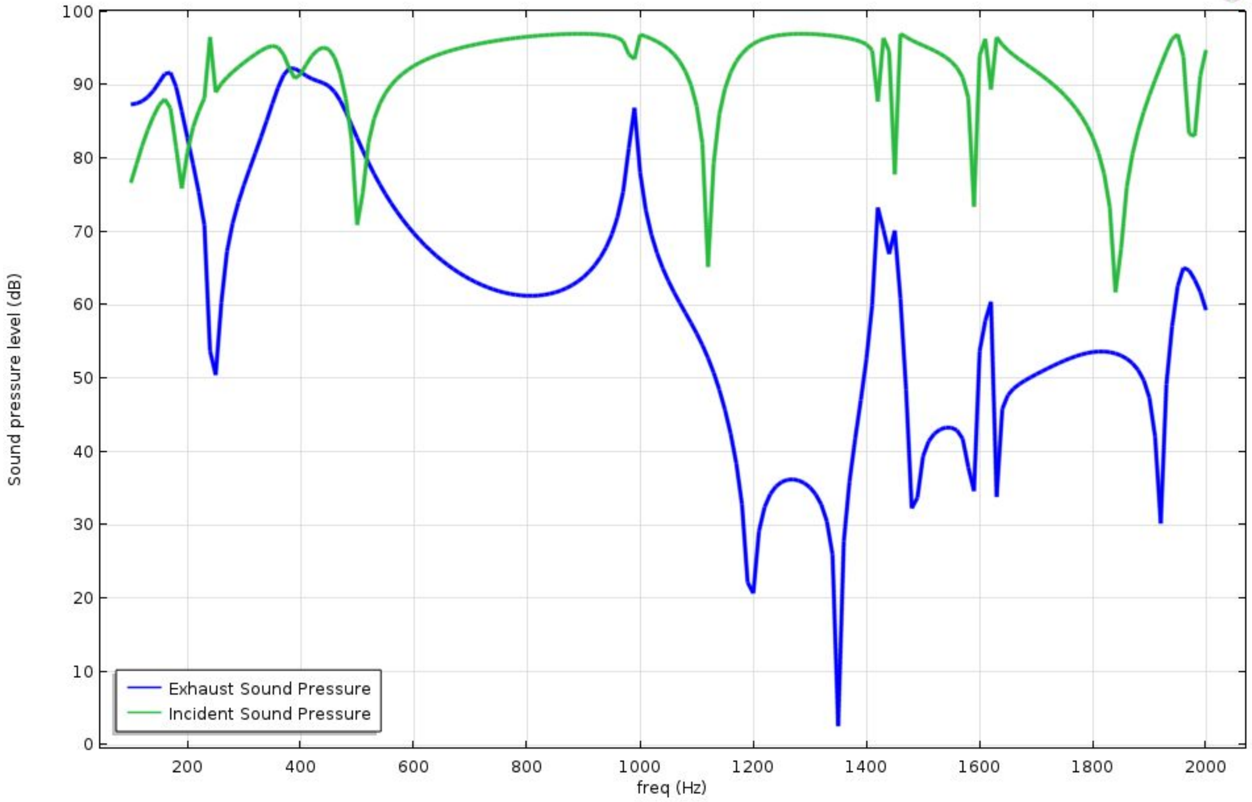
$$P_{in} = \int_{\partial\Omega} \frac{(P_0)^2}{2\rho c} dA$$

$$P_{out} = \int_{\partial\Omega} \frac{|P_c|^2}{2\rho c} dA$$

Here $P_{in}$, $P_{out}$ denotes the acoustic effects at inlet and outlet of the muffler respectively



# Sound Pressure comparison



# Conclusion & Future Works

- Acoustical analysis and Muffler performance prediction by numerical methodologies shows potential to increase productivity of Automotive manufacturers, reduces production time and cost respectively.
- Future work:- Multiphysics design optimization will be performed for superior sound cancellation in Automotive Muffler.

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