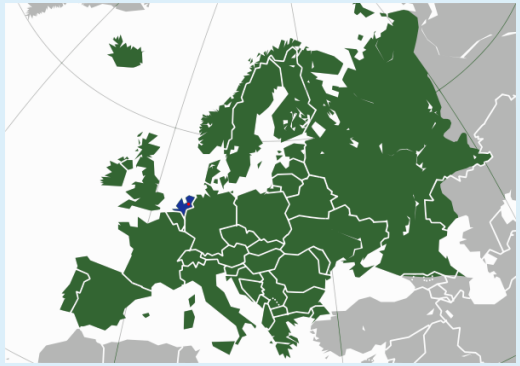
ASCEE
www.ascee.nl
info@ascee.nl
+31 6 189 71 622

Duct Silencer Modeling With COMSOL Multiphysics®

COMSOL Conference Online Event



October 14 – 15, 2020

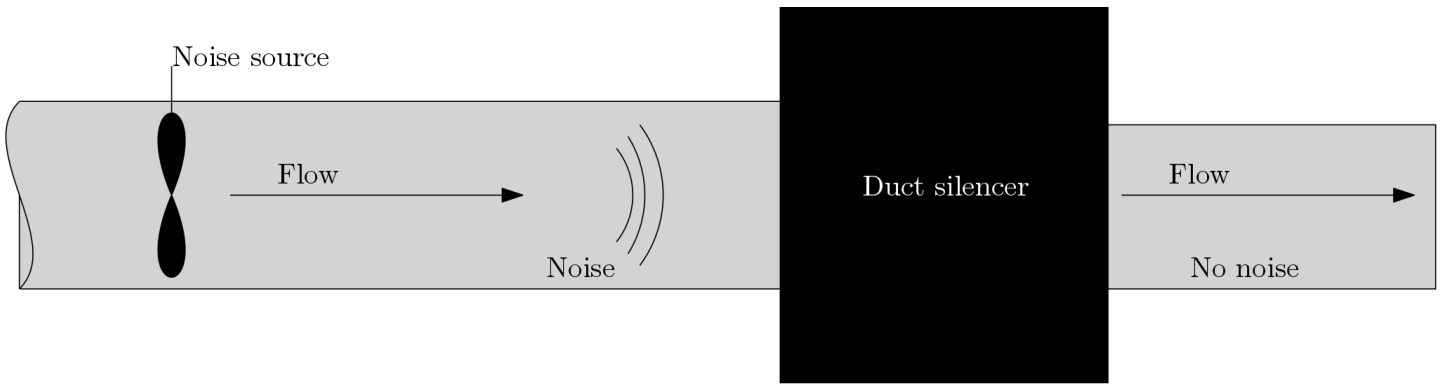
Dr.ir. Anne de Jong

COMSOL Certified Consultant

acoustics | software | consultancy | engineering | education

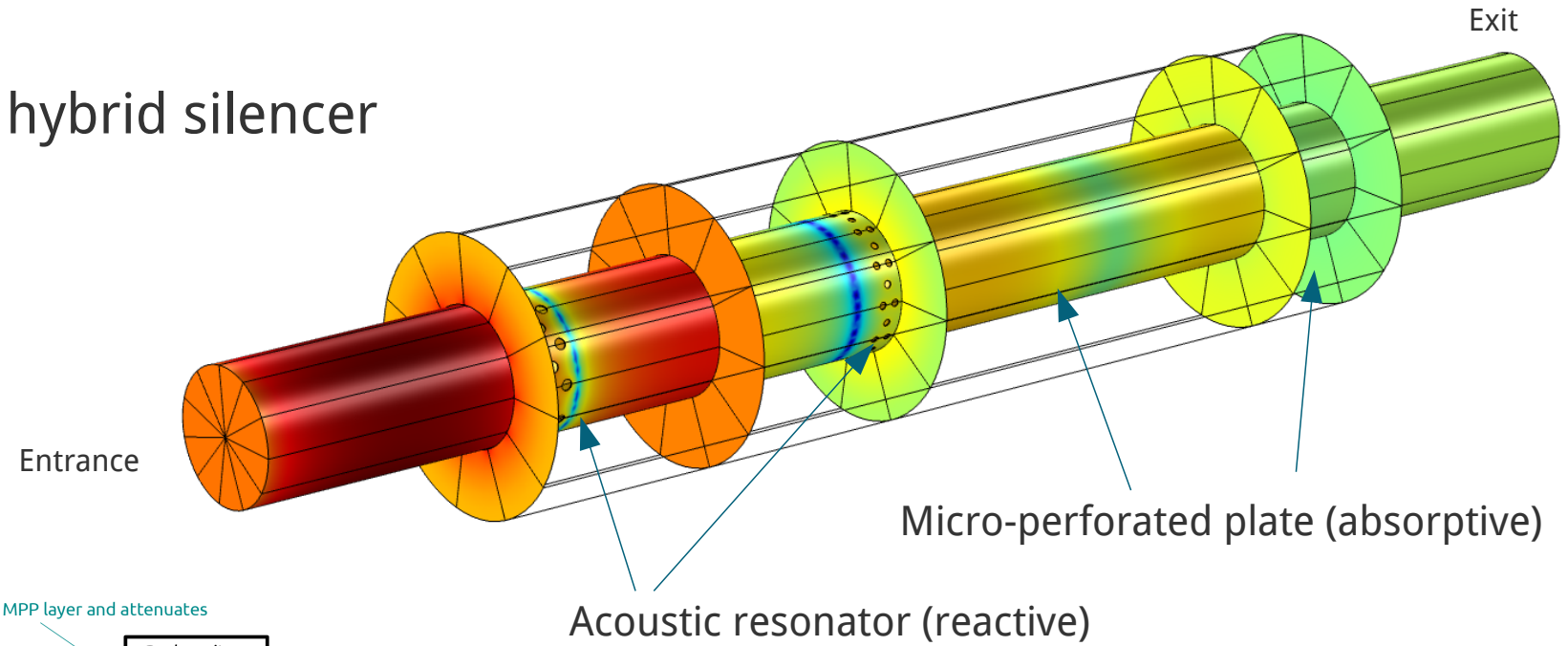
Introduction

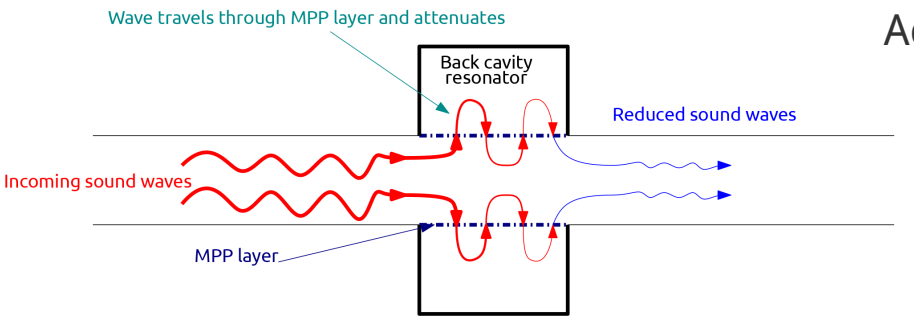
- Duct acoustic silencing
  - Applications:
    - Exhaust gas streams
    - Heating, Ventilation, Air Conditioning



Duct silencer internals

Example: hybrid silencer



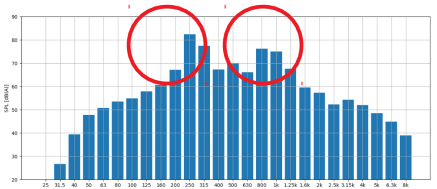


- Reactive part: low frequencies
- Absorptive: mid-bands to high frequencies

The approach of ASCEE

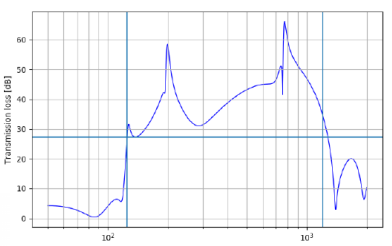
- We design custom silencers
- Benefits:
  - Optimized result by tuning duct silencer to source
  - Free flow-through, no flow head losses (pressure drop)
  - Smallest silencer for a required noise reduction

Source spectrum (noise problem)



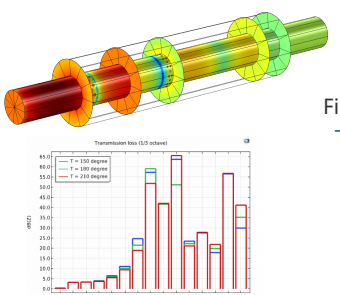
Required reduction (15 dB(A))

1D optimizer (Transfer matrix method + genetic algorithm)



Chamber volumes, Resonance frequencies, Lengths, etc

COMSOL Modeling



Final dimensions

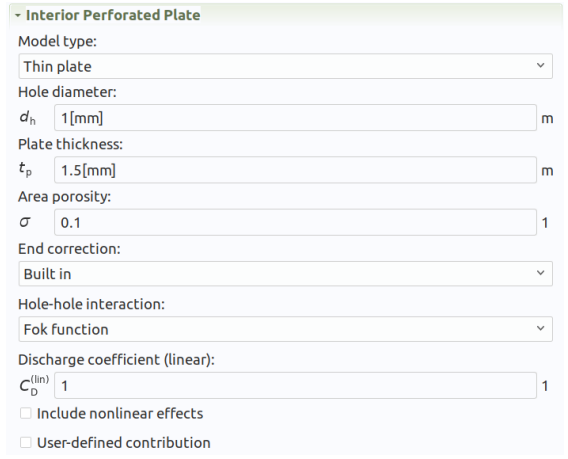
Design & Construction

Limitations of transfer matrix method

- Local near fields of resonators interact with each other (evanescent wave coupling)
- Only valid for plane waves (below cut-on frequency only):

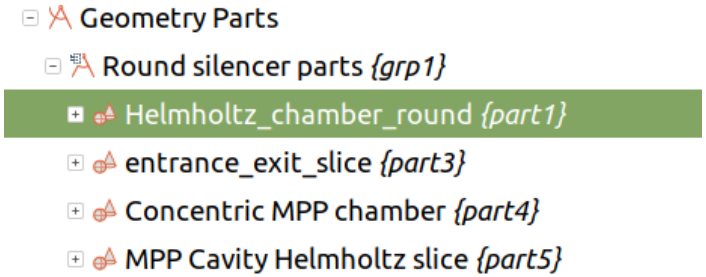
$$f \ll f_c = \frac{c_0}{1.7D}$$

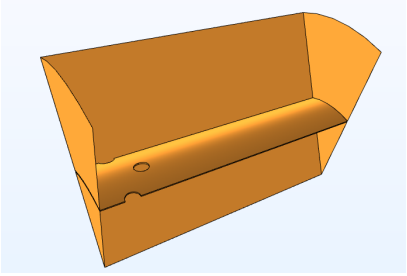
- Resonator hole dimension fine-tuning
  - First step: hole models (often in axisymmetric case)
  - Second step: actual holes

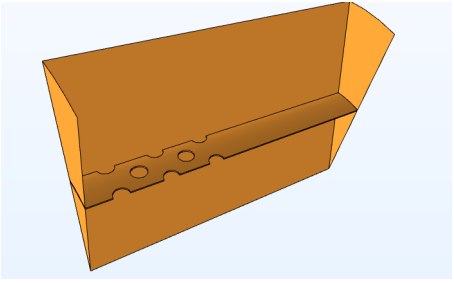


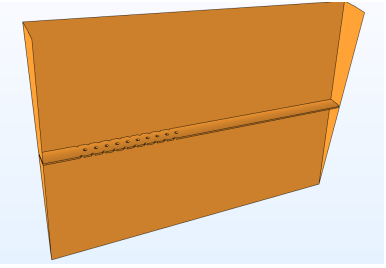
COMSOL Steps (1): Resonator fine-tuning

- Real-hole geometry (no perforate modeling)
  - Comsol parts library, parametrized resonator chamber





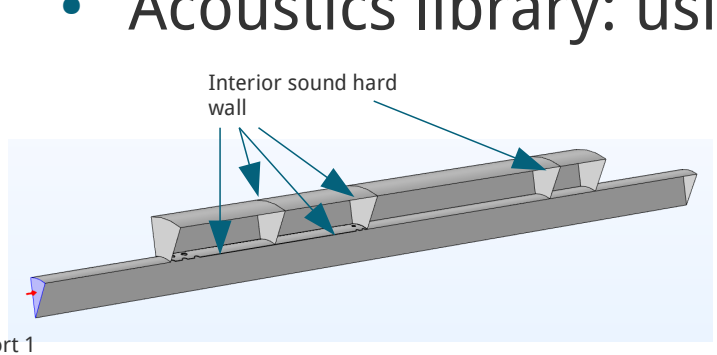


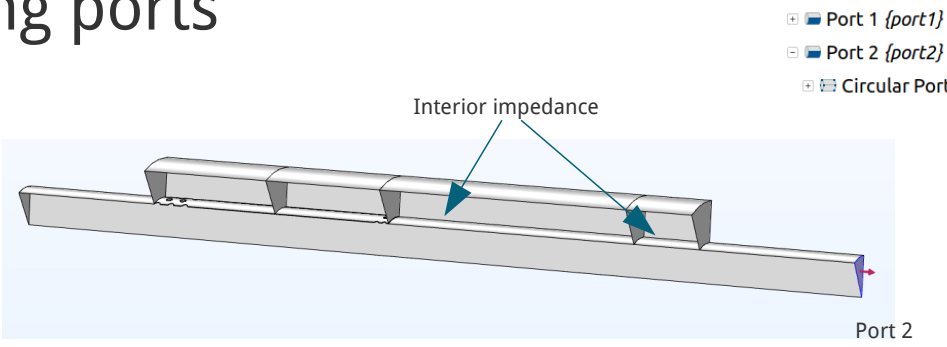


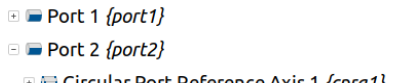
- These resonator chambers all come from the same library part
- Selections are used for more easy application of boundary conditions
- Axi-symmetric slice size is automatically computed

Computation of transmission loss

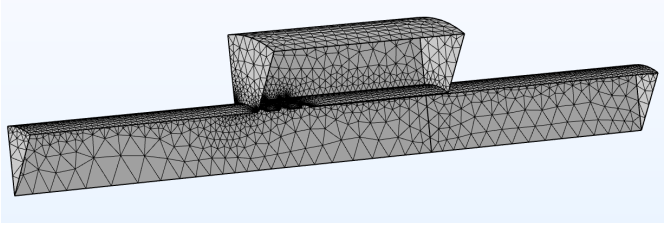
- Acoustics library: using ports

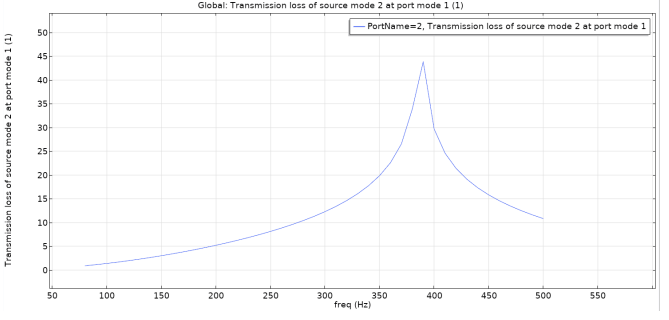






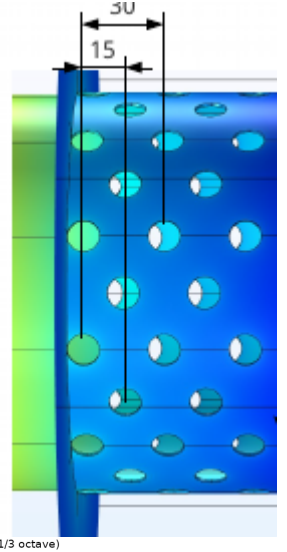
- Tune individual chambers first
  - Holes: reactance is already in Helmholtz equation. Viscous resistance term added to holes from global equations, using an interior impedance boundary condition

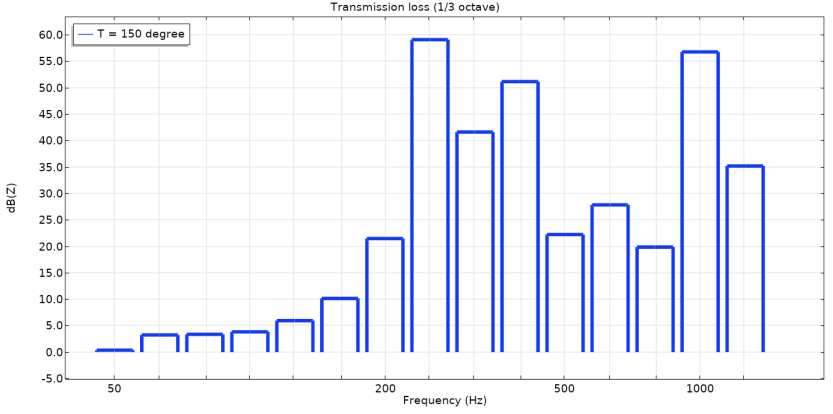




Assembling all together

- Note: transmission loss (TL) is a silencer property, while the final result the client is often interested in, is the insertion loss (IL).
  - TL: The ratio between the sound power of the incoming wave and the sound power of the transmitted wave without any reflections from the downstream end of the silencer.
  - IL: the difference in level prior to insertion of the silencer minus the level after inserting a silencer
- IL is hard to compute, as it depends on the exact installation, pipe lengths, exit radiation and source impedance.
  - **This analysis is done by exporting the derived acoustic transfer matrix back into the transfer matrix 1D code.**
- However, a high TL mostly results in high IL (there are exceptions)





Conclusions

- We built a streamlined silencer design methodology for duct acoustic problems, involving
  - Source spectra tuning
  - 1D Optimal (reactive / hybrid) silencer design, without fiber-containing materials)
  - Further tuning in COMSOL for final design

- We have become quite effective and successful with this technology and methodology

- I am looking forward to answering your boiling questions!