SmartAnswer – Development of Intelligent Material Solutions for Vibro-acoustic transmissions problems.

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Smart Mitigation of flow-induced Acoustic Radiation and Transmission for reduced Aircraft, surface traNSport, Workplaces and wind enERgy noise

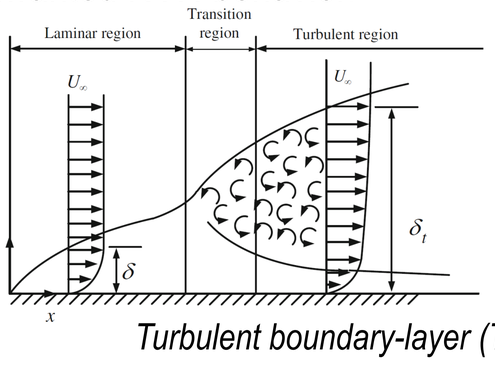
Host institution

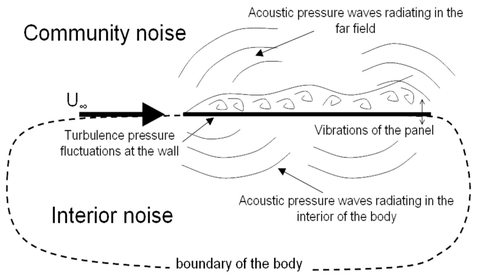
KU LEUVEN

Partnership

Motivation

- Enhancement of noise and vibration harshness (NVH) behavior is crucial due to increasing customer expectations and stricter regulations regarding human exposure to noise and vibrations.
- Aerodynamic excitation of flexible and lightweight structures leads to unwanted NVH behavior.





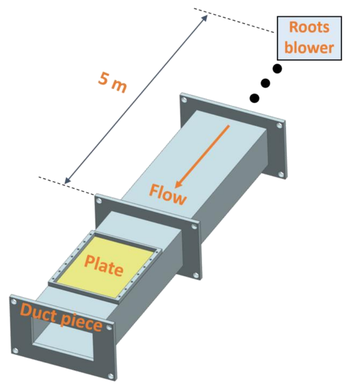
Turbulent boundary-layer (TBL) flow past a flat plate [1] [2].

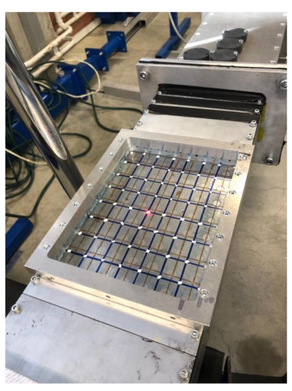
Main Objective

Investigate the potential of locally resonant metamaterials to reduce flow-induced noise and vibrations.

Test case

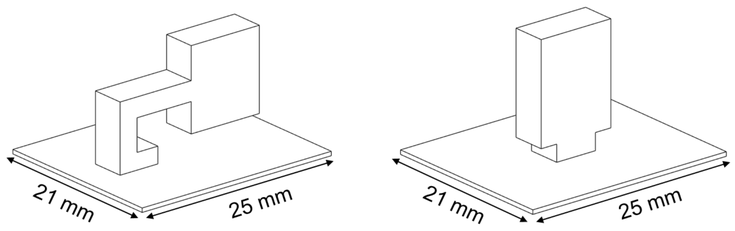
- Steel flat plate with dimensions 150 x 200 x 0.5 mm:
  - mounted flush as a side wall of a duct,
  - boundary conditions: clamped along its boundaries,
  - excited by roots blower in a small wind tunnel 5m upstream,
  - V_∞ = 19 m/s; Re = 19614; Mach = 0.05.





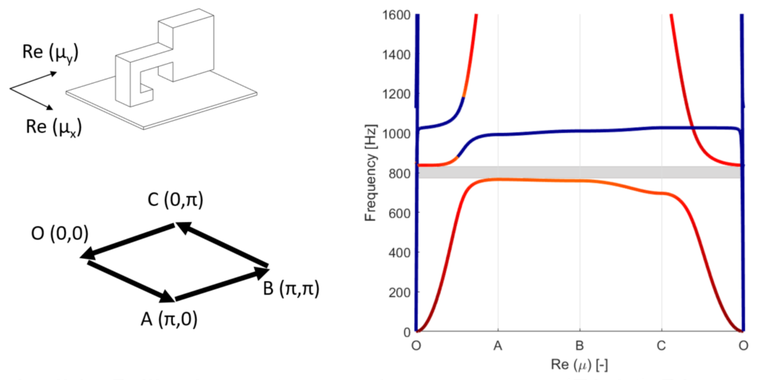
Steel flat plate attached to the duct piece (Left) Idealized (Right) Realized.

- Addition of resonant structures on a subwavelength scale to create stop band behavior and equivalent mass structures as benchmark.



Unit cell (UC) with (Left) Resonant structure (Right) Non-resonant equivalent mass structure.

- Resonant structures tuned frequency: 800 Hz.
- 56 UCs on the finite plate: 27% mass addition.
- Stop band opens for bending waves between 766.2 Hz and 837 Hz.

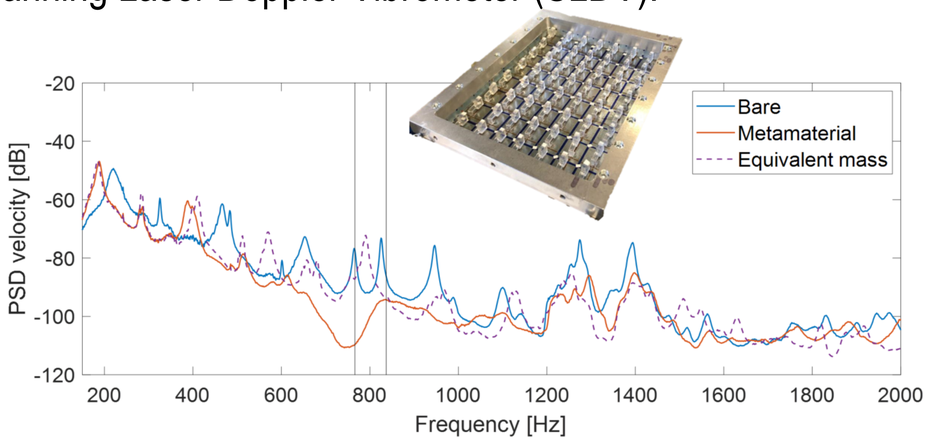


(Left) Irreducible Brillouin contour and wave space (Right) Dispersion diagram.

Experimental results

Vibrations

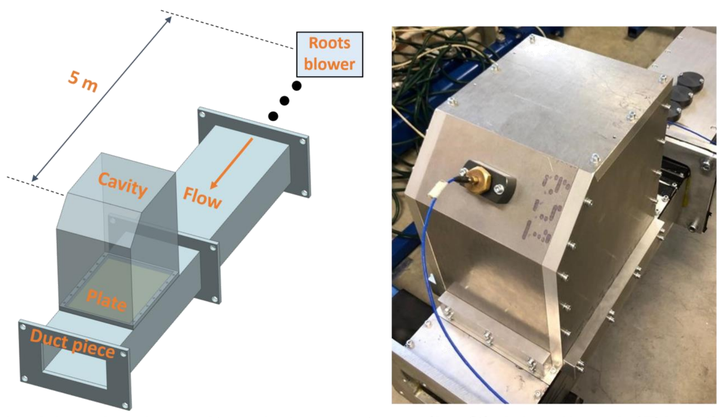
- Vibrations due to TBL excitation measured in 72 points by Scanning Laser Doppler Vibrometer (SLDV).



PSD velocity response of the flat plate with and without metamaterials.

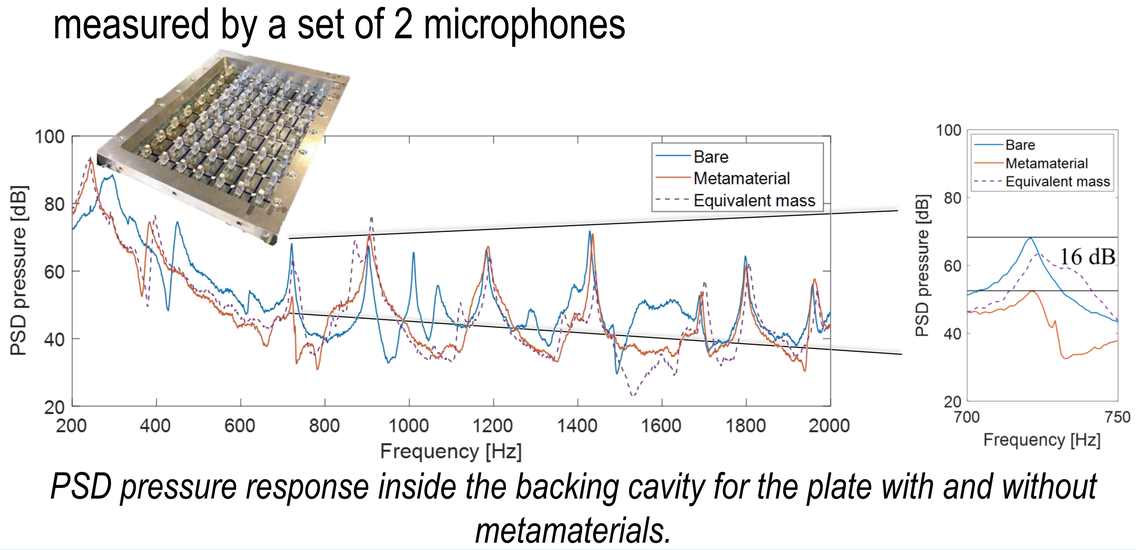
Noise radiation

- Hard-walled backing-cavity mounted over the TBL-excited flat plate.



Coupled backed-cavity plate system (Left) Idealized (Right) Realized.

- Noise radiation due to the plate's vibrations into the backing cavity measured by a set of 2 microphones



PSD pressure response inside the backing cavity for the plate with and without metamaterials.

Conclusions

- Locally resonant metamaterials show a strong potential to improve flow-induced noise and vibrations on targeted frequency ranges in a mass efficient manner.
- Outperforms the equivalent mass case:
  - additional 22 dB vibration reduction,
  - additional 11 dB noise reduction.

References

[1] Dewan, Anupam. Tackling turbulent flows in engineering. Springer Science & Business Media, 2010.

[2] Camussi, Roberto, ed. Noise sources in turbulent shear flows: fundamentals and applications. Vol. 545. Springer Science & Business Media, 2013.

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