SmartAnswer - Investigation of turbulence-surface interaction noise mechanisms and their reduction using porous materials

R. Zamponi[1], C. Schram[2], D. Ragni[3], F. Scarano[4]

[1]PhD Candidate, [2]Professor, EA Department, von Karman Institute for Fluid Dynamics
[3]Assistant professor, [4]Professor, Aerodynamics, Wind-Energy, Flight Performance and Propulsion, TU Delft

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

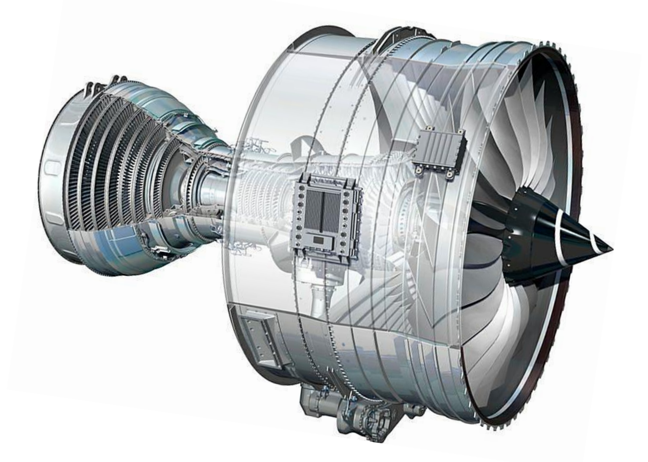
Host institution von KARMAN INSTITUTE FOR FLUID DYNAMICS

Partnership TU Delft Delft University of Technology

Motivation

Turbulence-interaction noise contributes to the broadband noise radiated by fans, turbomachines and high-lift devices.

HVAC systems for automotive



Aeronautical propulsion systems

In many instances the turbulent field is inherent to **installation elements** and cannot be directly controlled.

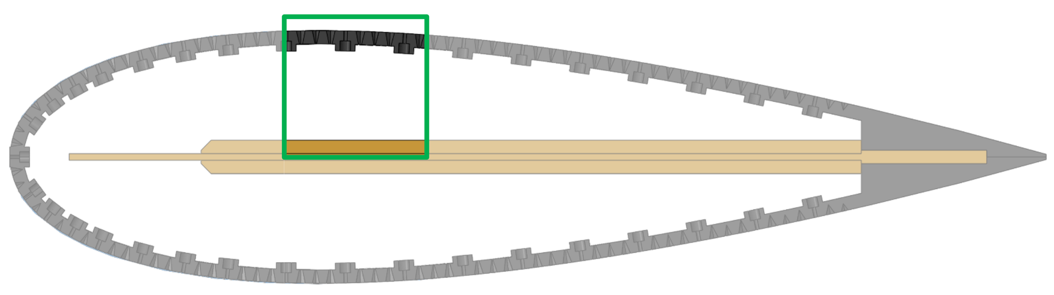
Acting on the airfoil to make it less sensitive to turbulence in terms of acoustic response is a promising strategy.

Main objectives

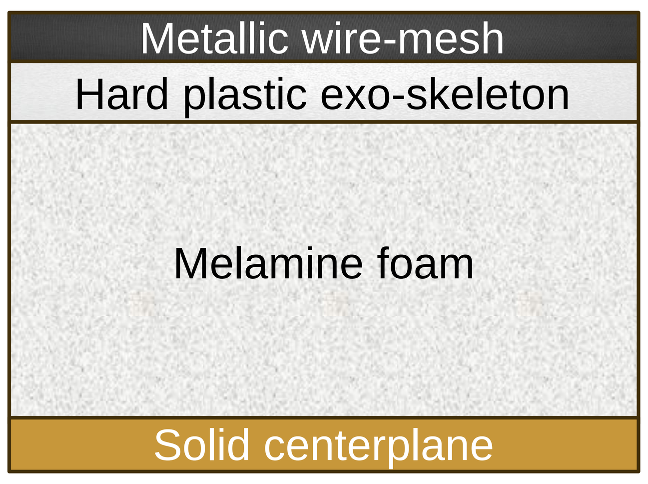
- To improve the understanding of the turbulence behavior in the interaction with the airfoil
- To evaluate the effectiveness of **porous materials** as turbulence-interaction noise mitigation technique

Design of the porous airfoil

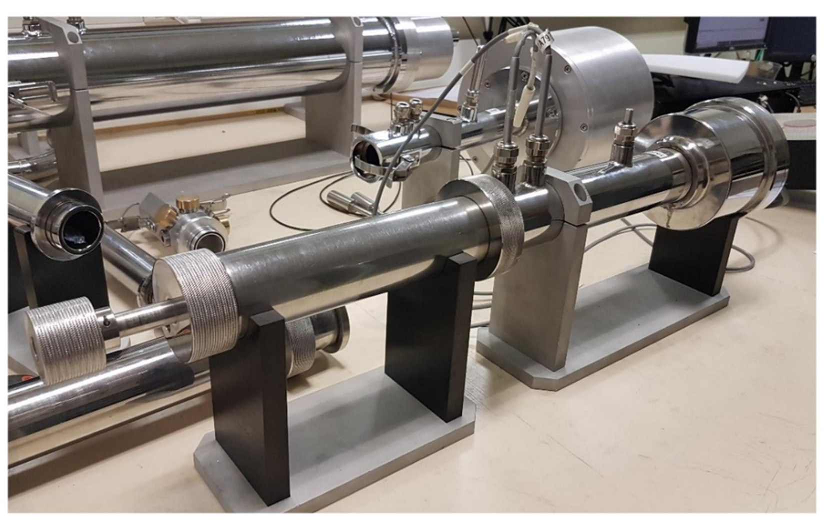
A **solid** and a **porous** airfoil are manufactured at **VKI** and tested in a **rod-airfoil configuration** [1].

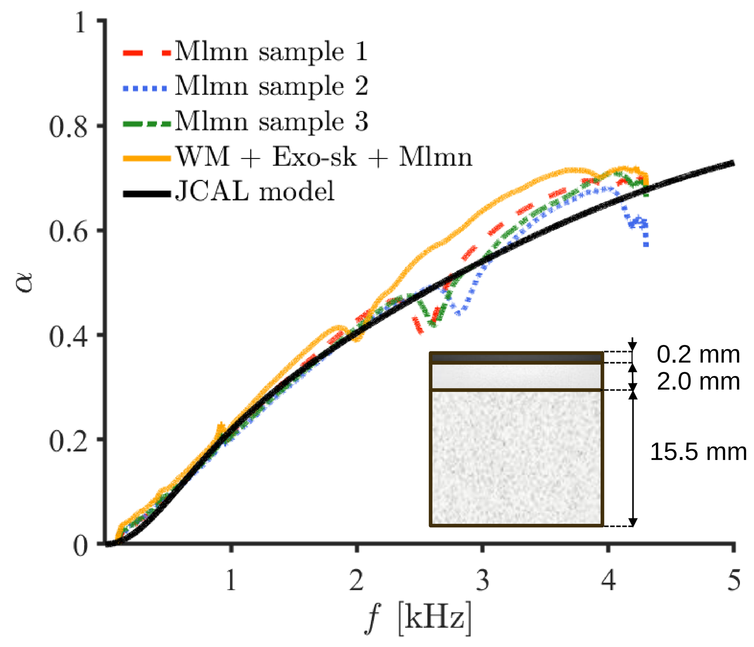


Design and composition of the VKI porous NACA-0024 profile



The melamine foam is characterized to analyze the **parameters** and the **sound absorbing behavior** of the porous medium [2].

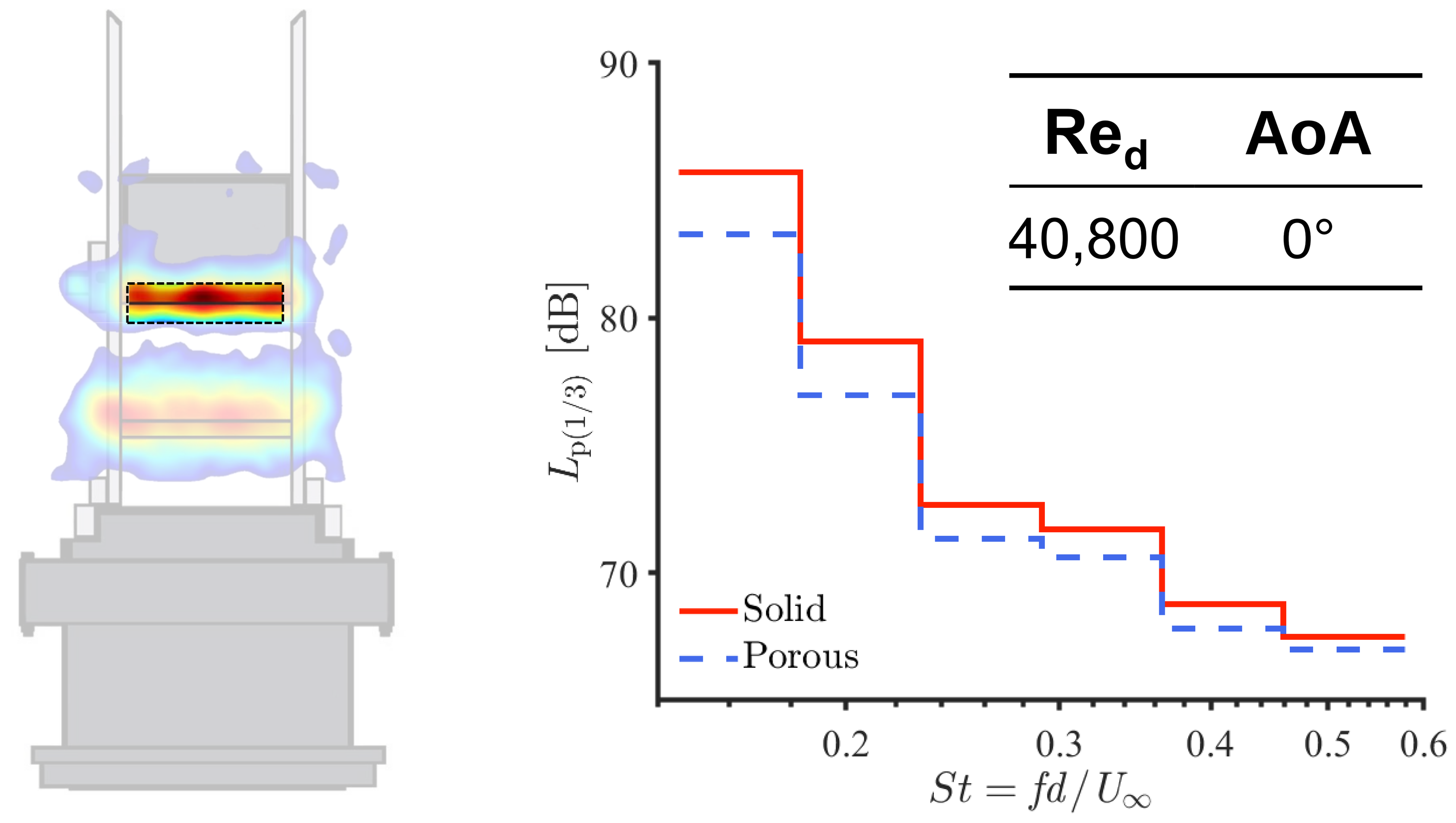




Absorption coefficient for different samples of melamine foam studied with the impedance tube and compared with JCAL model

Far-field acoustic measurements

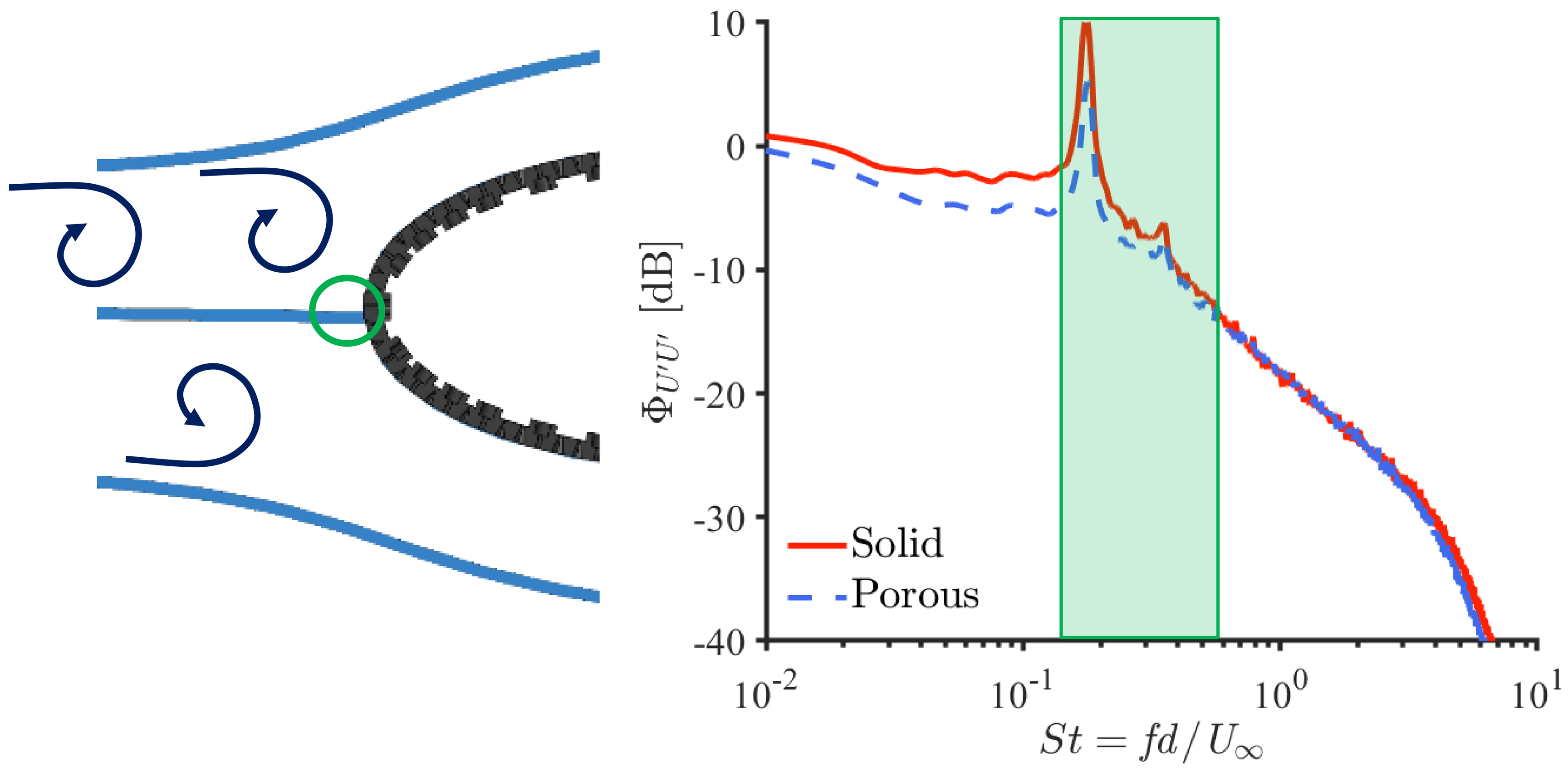
GIBF [3] is used to evaluate the far-field **noise reduction** due to the **porous treatment** of the airfoil.



GIBF integrated one-third octave band spectra for solid and porous airfoil

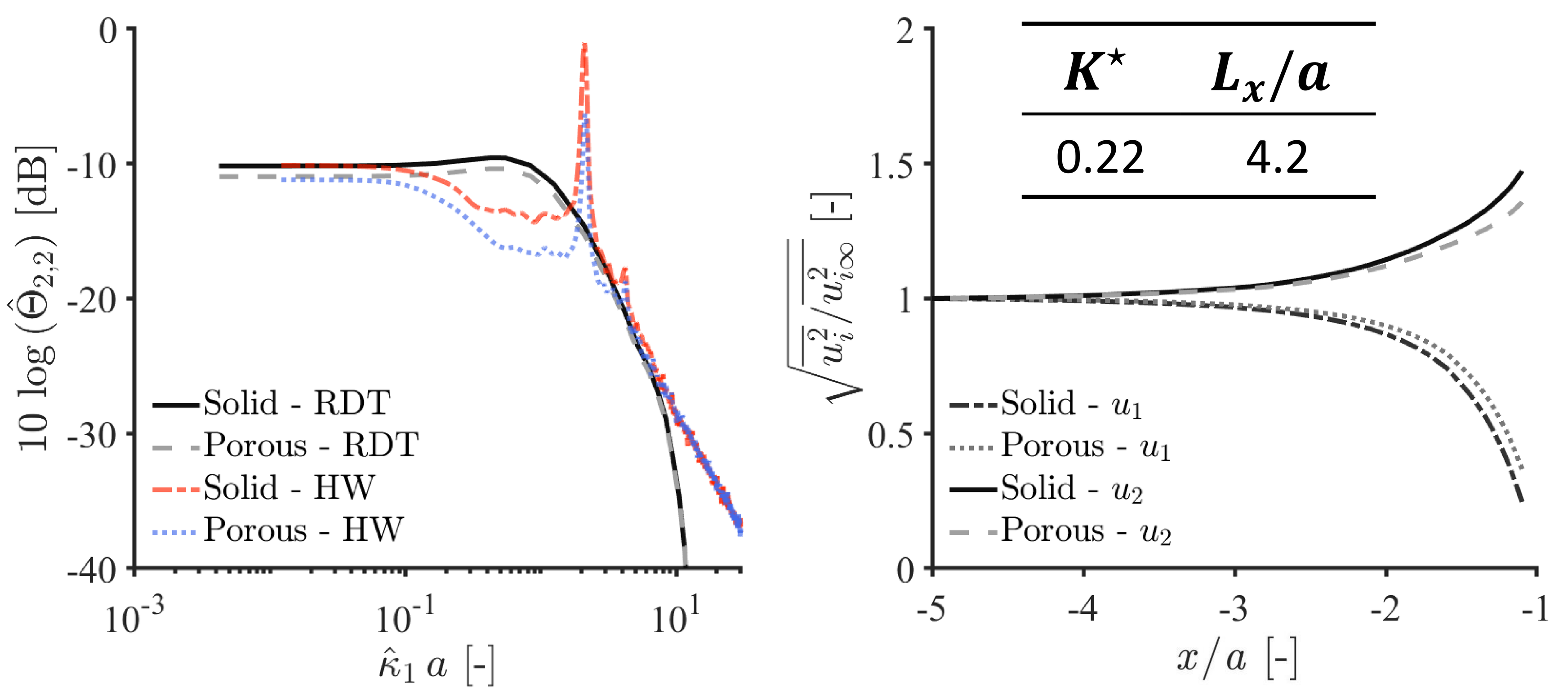
Turbulence distortion investigation

Hot-wire measurements are performed to characterize the **distortion** of **turbulence** interacting with the **leading edge**.



Spectra of the incident turbulent velocity for solid and porous airfoil near the leading edge, with the green area denoting the St-range of the acoustic spectra

An analytical **model** based on the **RDT** [4] is developed to predict the turbulence-distortion **attenuation** by porosity.



Comparison between the spectra of the upwash turbulent velocity for solid and porous airfoil computed by the RDT and measured by the hot-wire (on the left) and normalized variances along the stagnation streamline (on the right)

References

[1] Zamponi *et al.*, "On the role of turbulence distortion on leading-edge noise reduction by means of porosity", *JSV*, 2020

[2] Satcunathan *et al.*, "Validation of a model for acoustic absorption in porous media", INTER-NOISE, 2019

[3] Zamponi *et al.*, "Benchmark Assessment of an Improved Regularization Technique for Generalized Inverse Beamforming", *24th AIAA/CEAS*, 2018

[4] Hunt, "A theory of turbulent flow round two-dimensional bluff bodies", *JFM*, 1973

MARIE CURIE ACTIONS

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