Vibration and acoustic behavior investigation of millimeter-sized porous mesh samples

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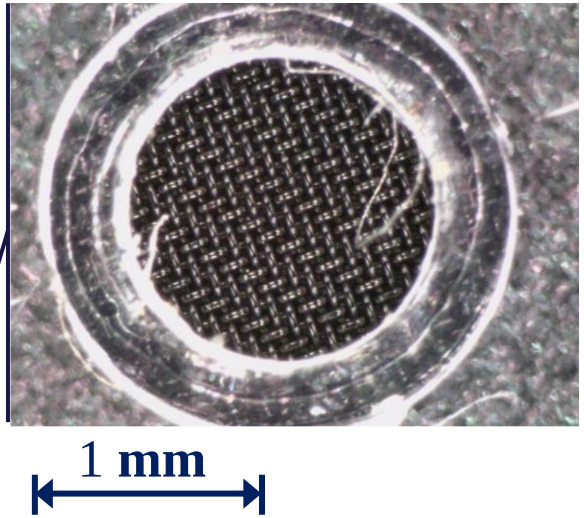
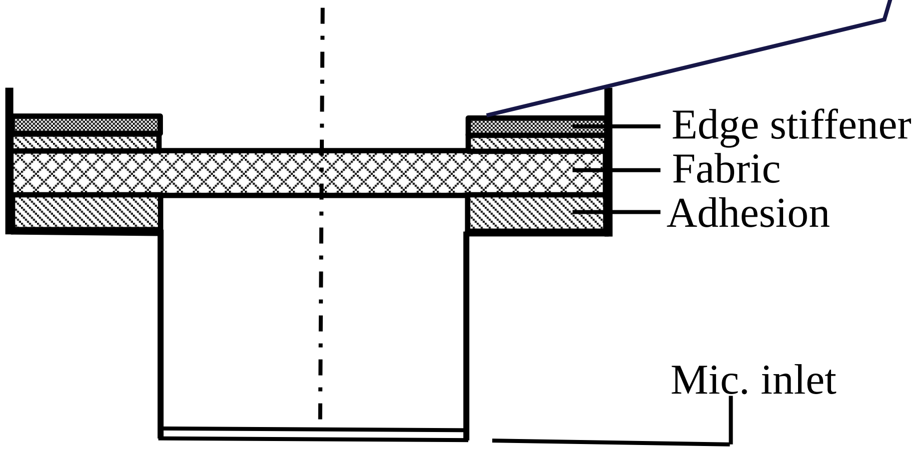
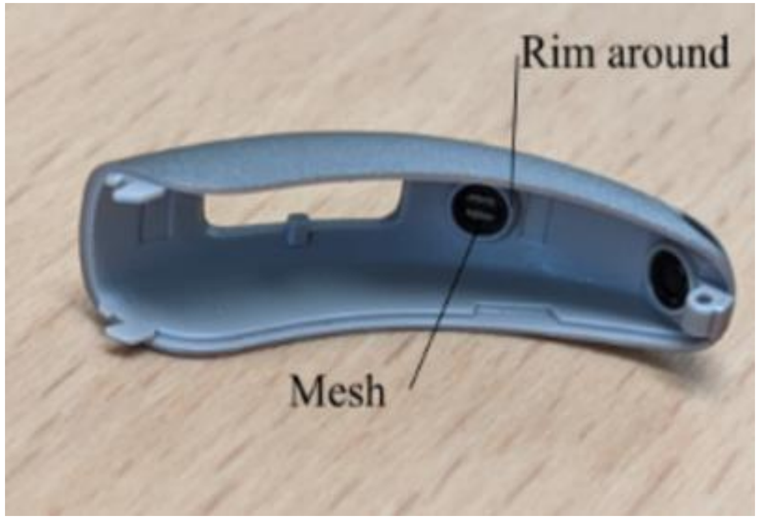
Motivation and background

- Porous mesh structure refers to the woven fabric
- Widely used in sound control, ingress protection
- Component of the loudspeaker, microphone





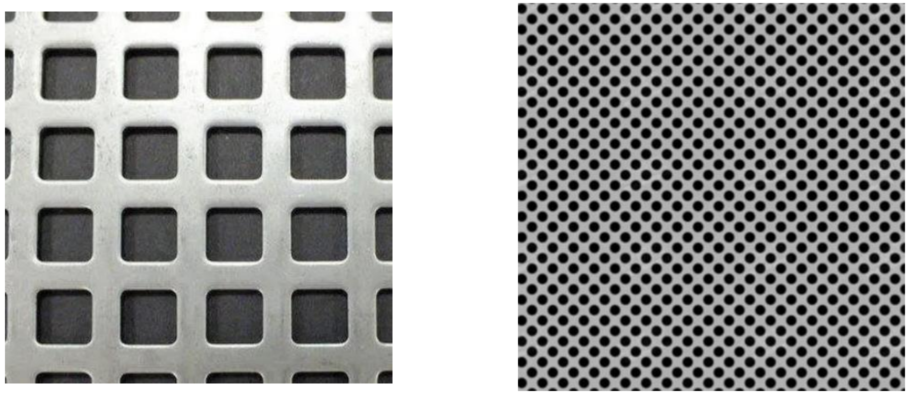
- ➤ Previous studies treat it as a homogeneous material, assuming the structure is motionless.



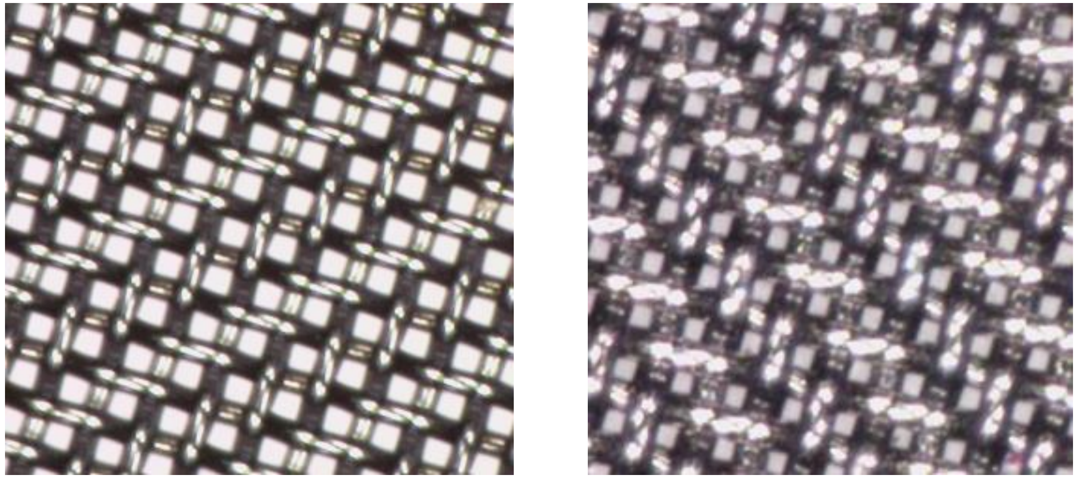
- ➤ How does the porous mesh structure influence the acoustic performance?

Motivation and background

- Additional absorption peak caused by the MPP's vibration
- MPP's eigenfrequency has a significant influence on sound absorption



(Micro-) perforated plate (MPP)



Porous mesh samples under the microscope

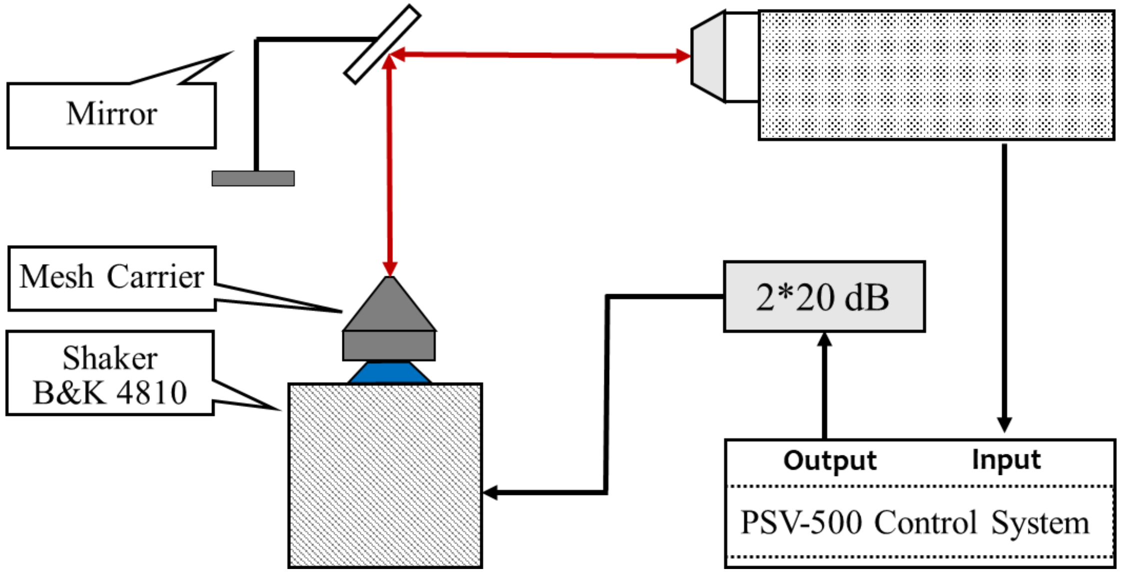
- ➢ Does the vibration of the porous mesh structure influence the acoustic performance?
- ➢ Could we use the perforated plate to mimic the motion of the mesh structure?

Vibration of porous mesh samples *(Direct measurement)*

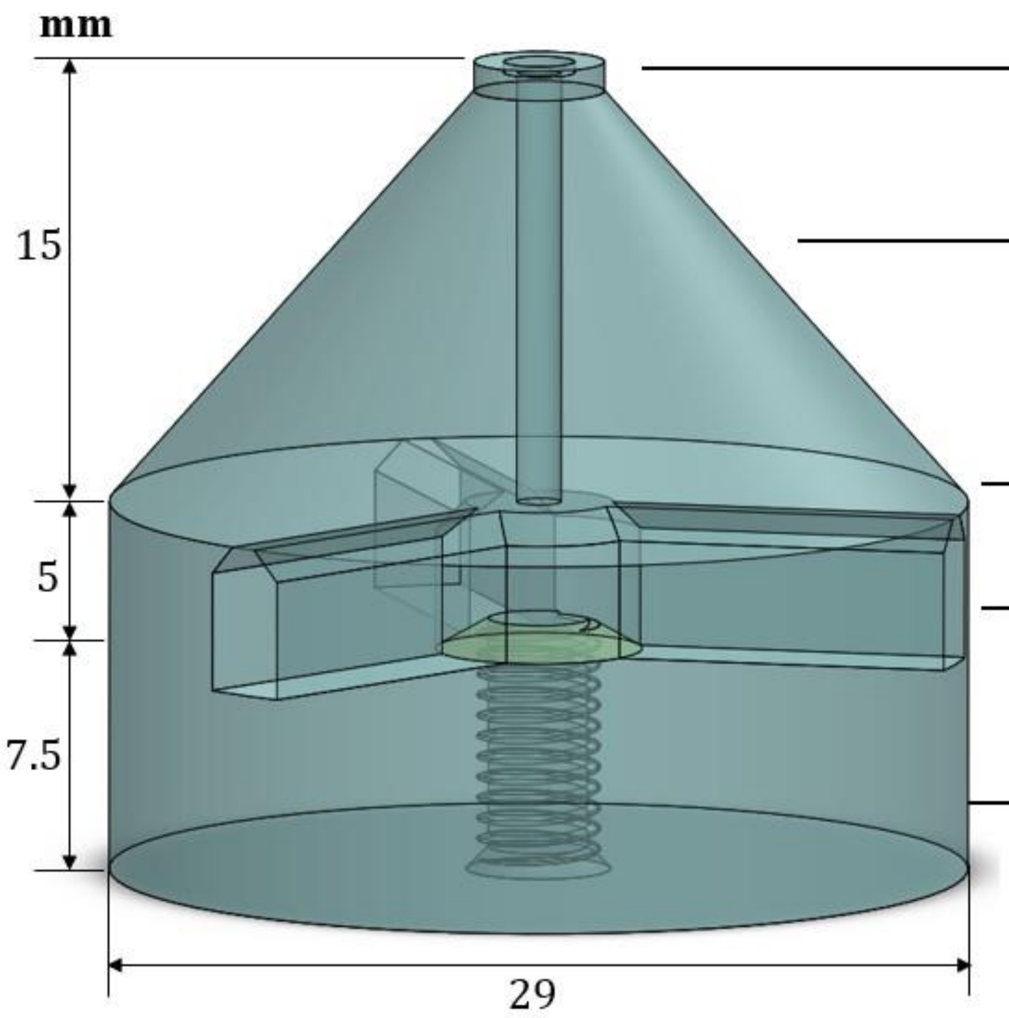
Feature of mesh: Small (d<2 mm); thin (t<0.1 mm)

No-contact measurement: laser vibrometer (PSV-500)

Excitation carrier: hold the mesh, provide controlled and stable excitation



Vibration of porous mesh samples *(Direct measurement)*



Same size as the HA's rim design

Cone-shaped structure to reduce resonance issues

Chamfers inside the air vent avoid potential 3D printing failure

Three air vents to alleviate the influence of FSI

The thread helps install the carrier on the shaker

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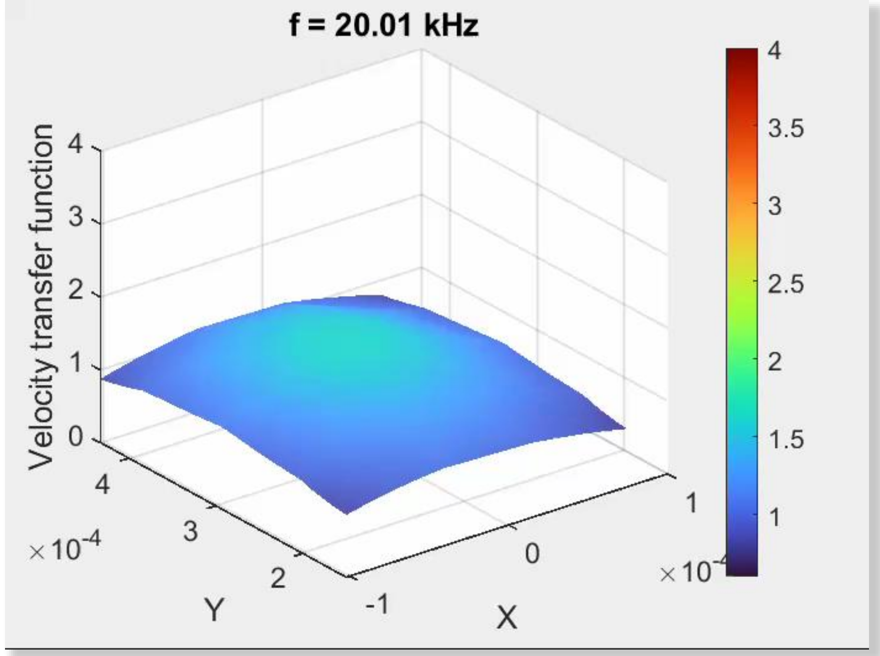
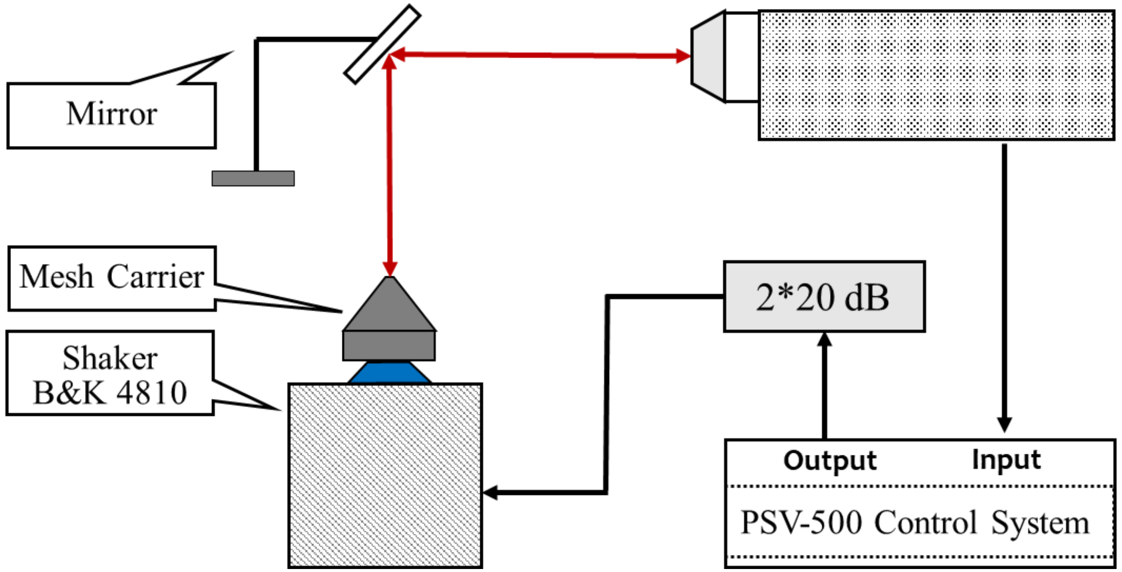
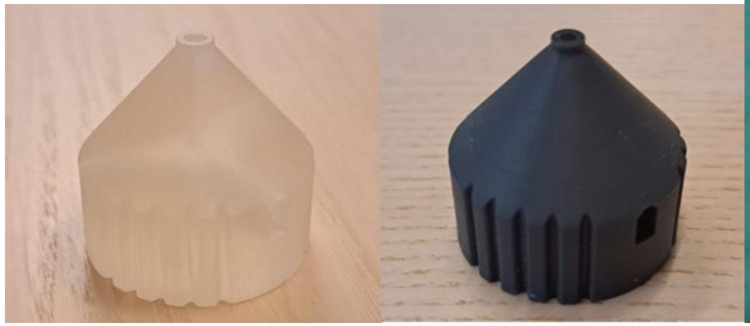
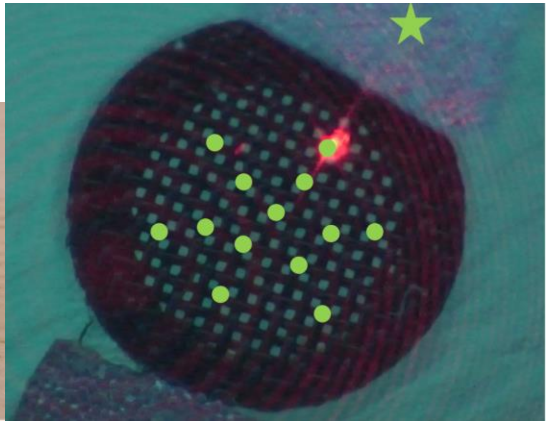




TF = Central point / Rim point

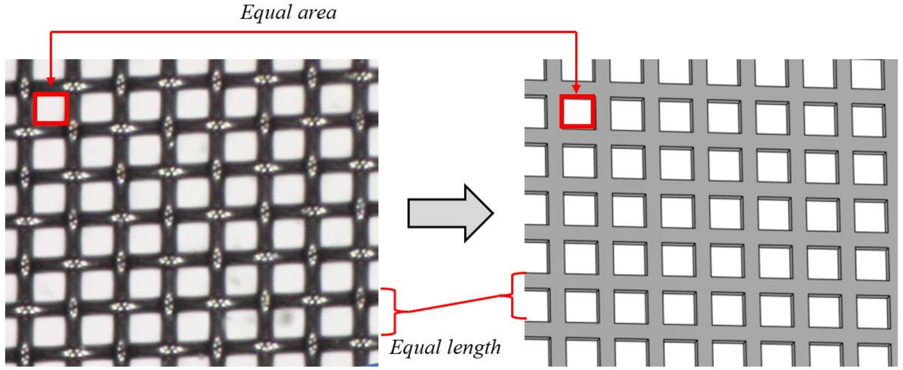




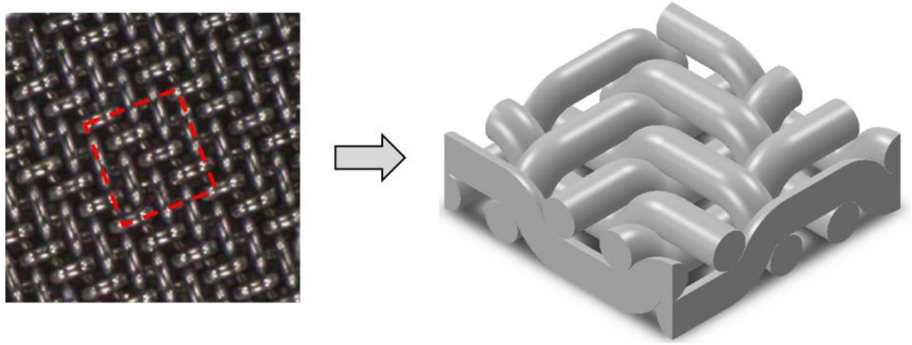
(Numerical and Lumped model approaches)

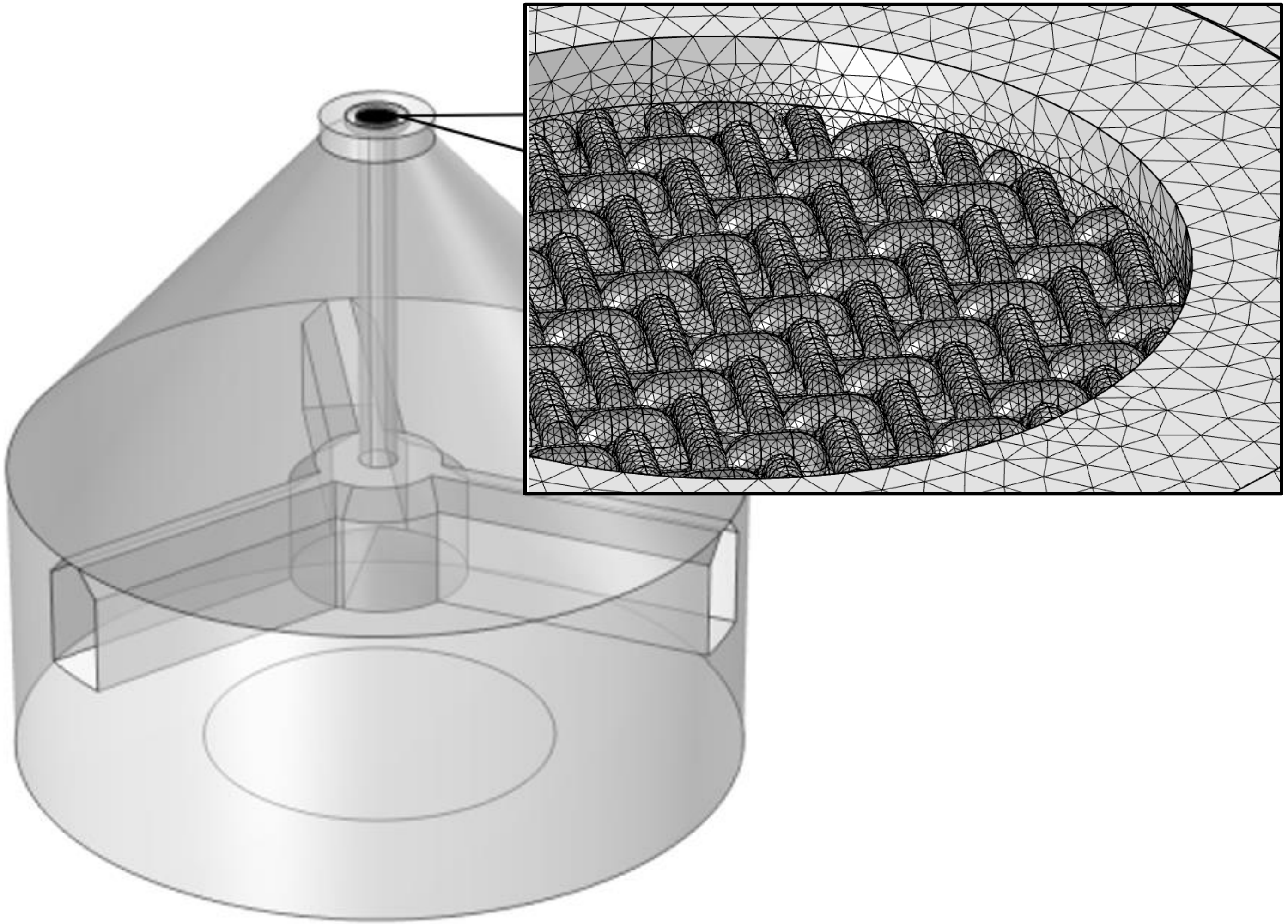
Numerical:

Baseline - *S*ame-mass perforated plate



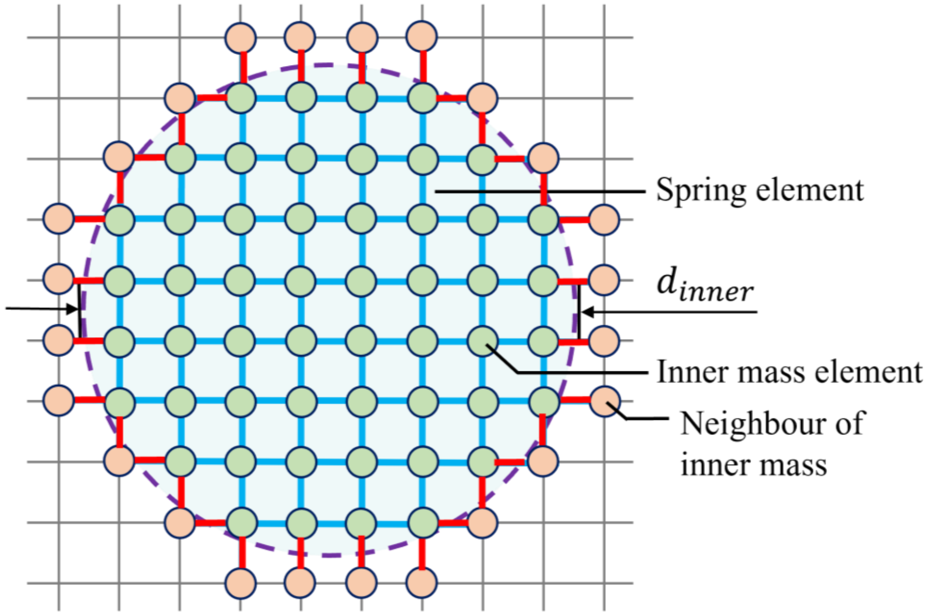
Structure improved model

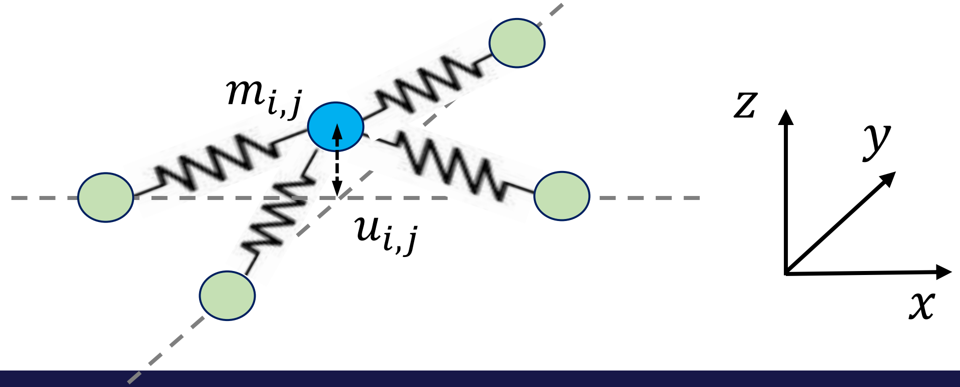




(Numerical and Lumped model approaches)

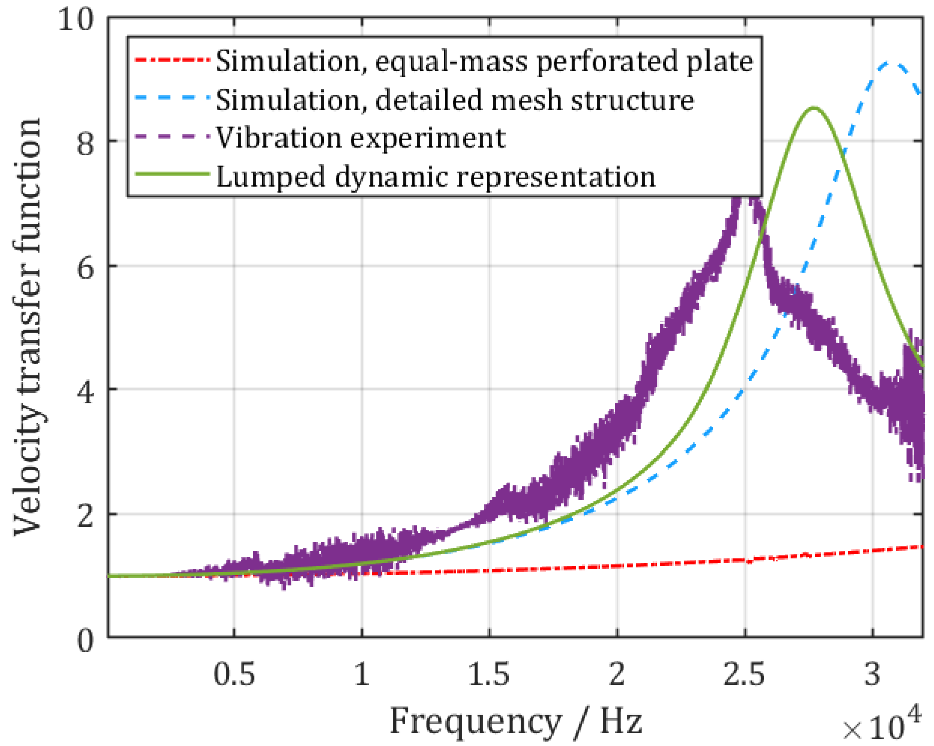
Lumped dynamic model:

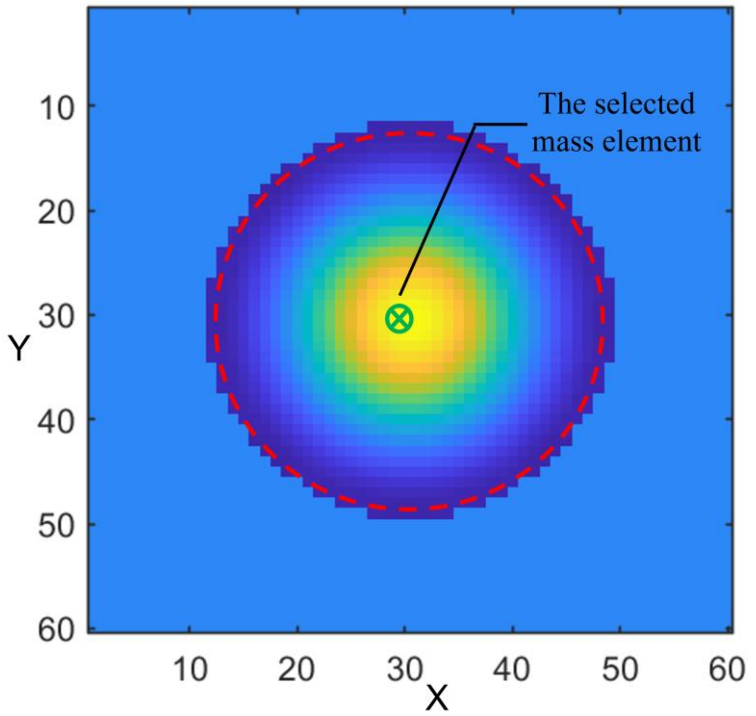




- Assuming the mass only moves along the z-axis
- Assuming the spring is pre-stretched; the motion of the mass is linear when the mesh's deformation is small
- Utilizing $\mathbf{M}\ddot{\mathbf{u}} + \mathbf{C}\dot{\mathbf{u}} + \mathbf{K}\mathbf{u} = \mathbf{f}$ to represent the dynamic system
- Excite the system at the boundary (red circulars in the figure)

Vibration of porous mesh samples



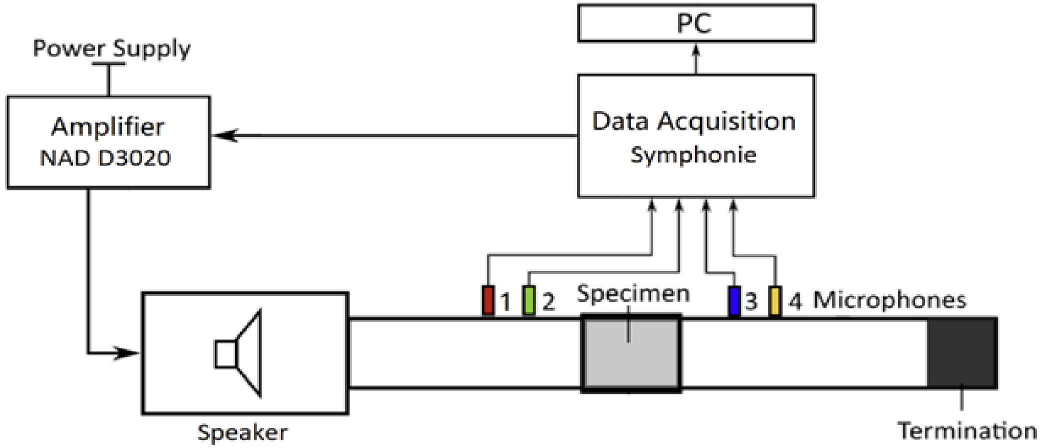


- Perforated plate performs worst;
- Detailed mesh structure have difficulty in predicting the resonance frequency;

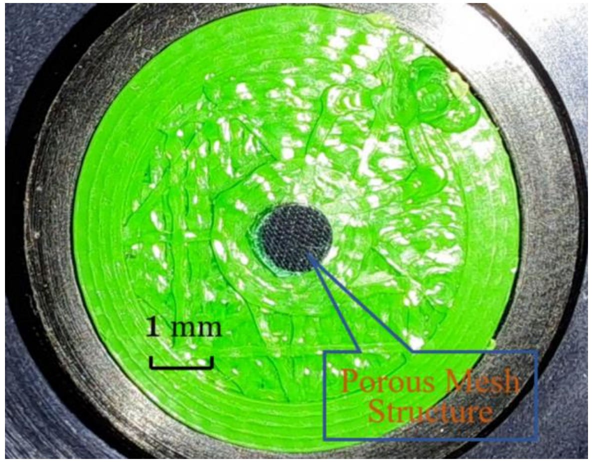
➢ Lumped model gives a much easier way to predict the first resonance frequency;

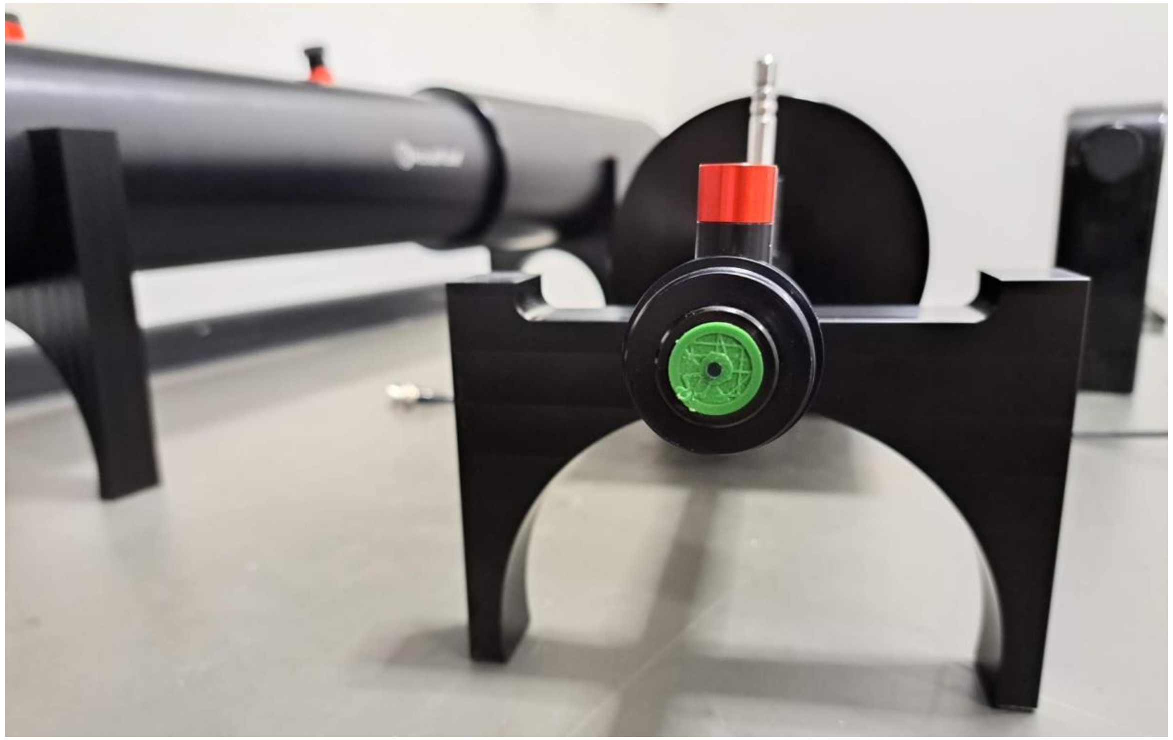
➢ It is limited by the pre-estimation of the residual tension in the mesh.

Transmission loss investigation

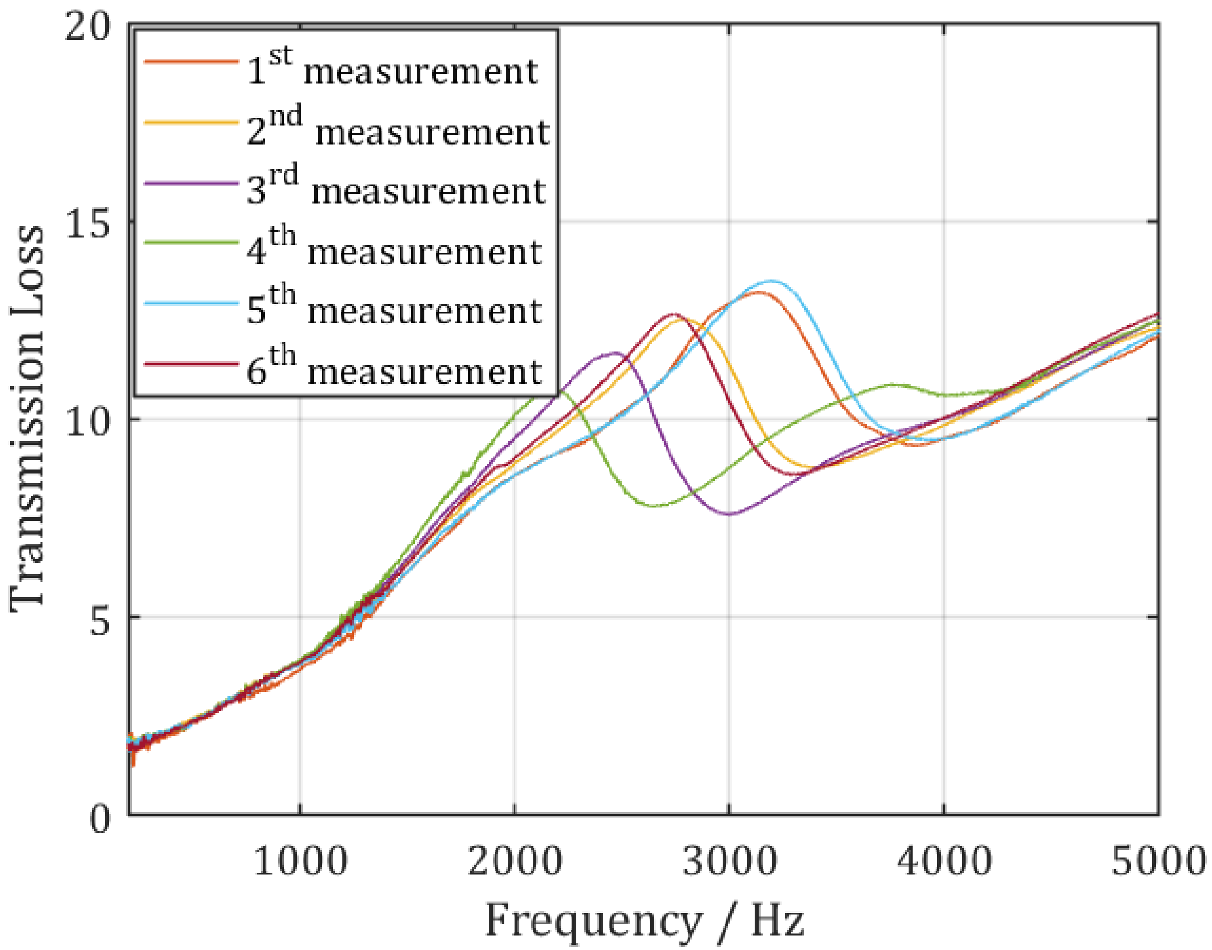


Four-microphone measurement of TL

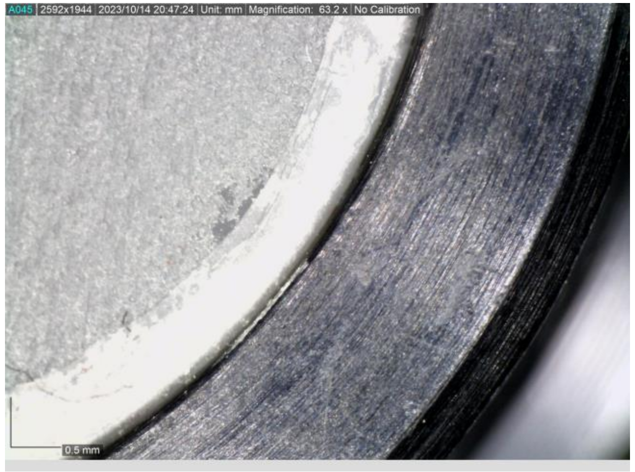




Transmission loss investigation

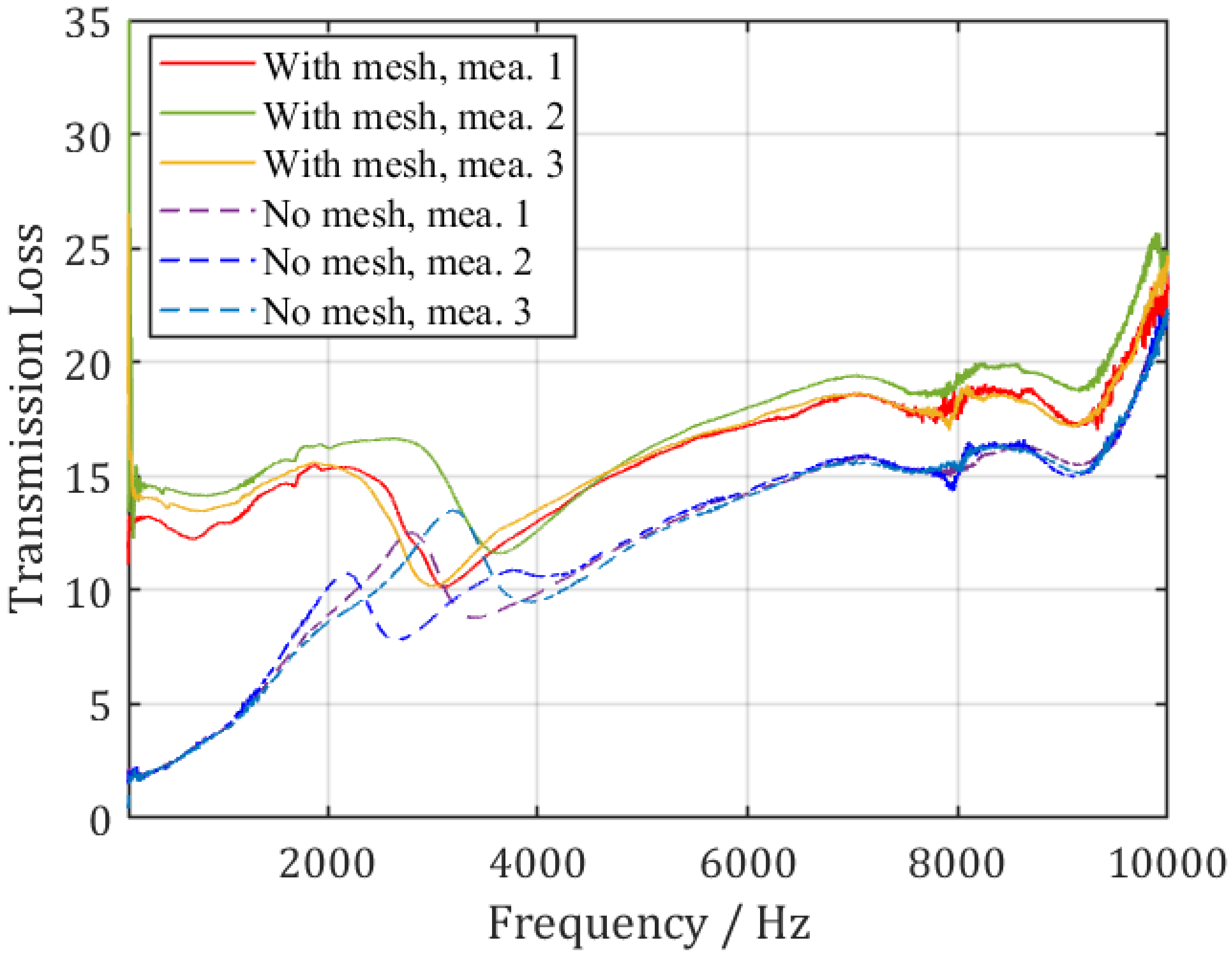


Good seal



Bad seal

Transmission loss investigation



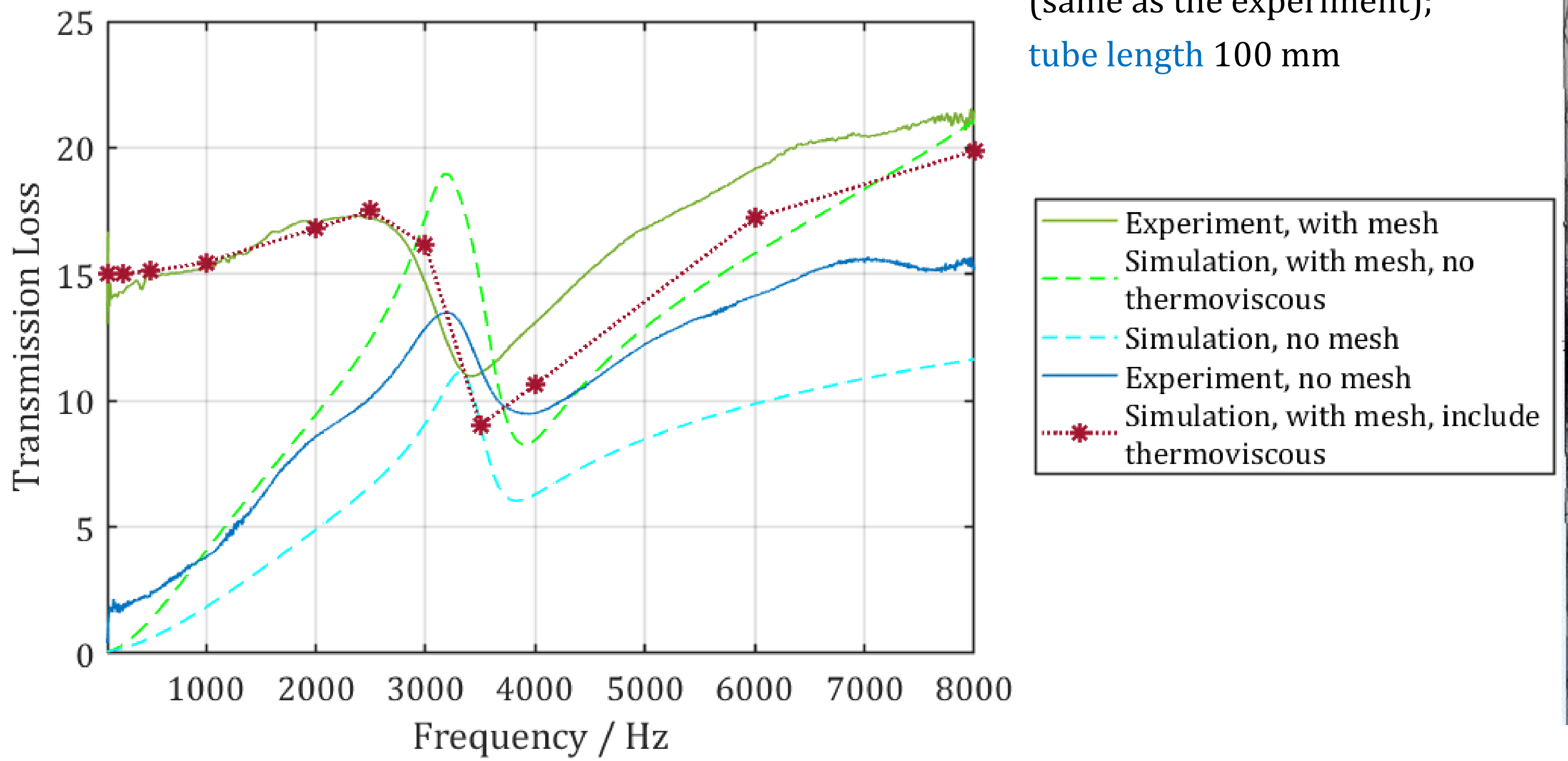
- ➢ Apparent difference when freq.<3000 Hz

With mesh condition has much higher transmission loss;

- ➢ 3.5 dB TL gap from 4 kHz to 8 kHz (close to the reliable measurement range in the impedance tube)

- ➢ Unable to directly measure the influence of the mesh's vibration

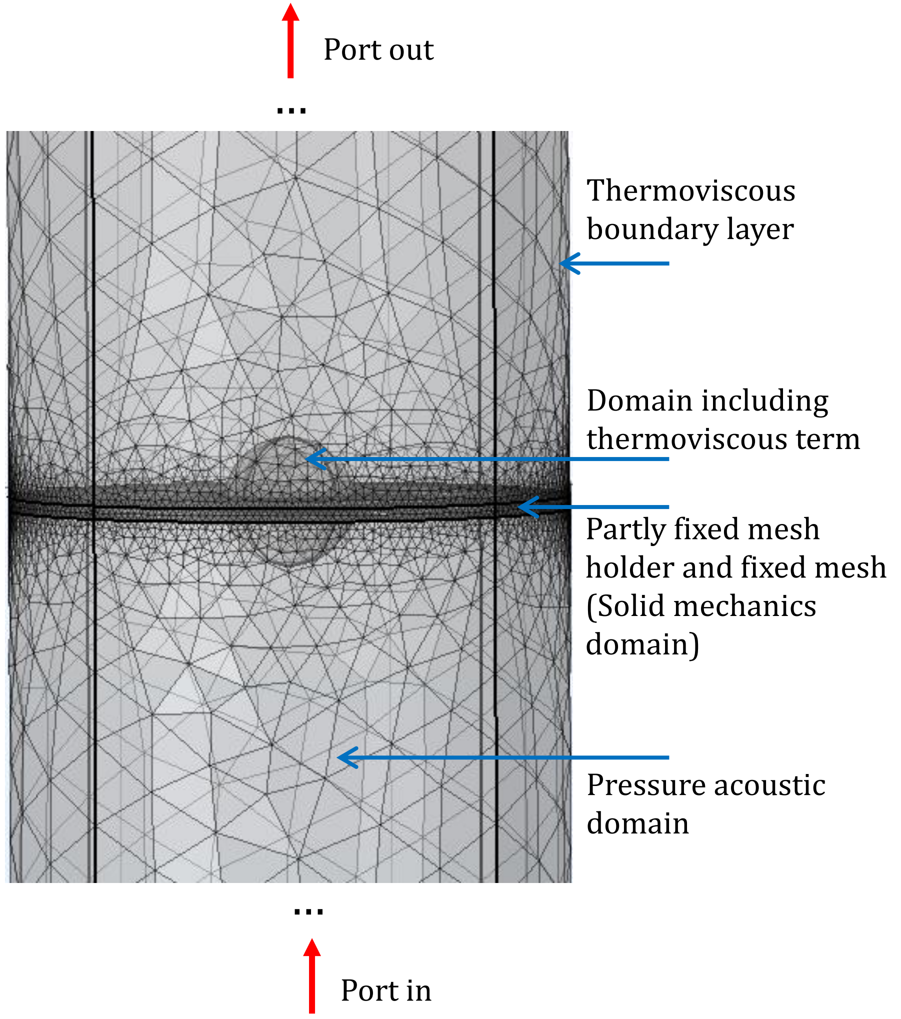
Transmission loss investigation



In simulation

tube diameter 15 mm (same as the experiment);

tube length 100 mm



Future work and outlook

- Analyze other mesh structures that resonance in the audible range
- The mesh structure's application prospects of the low-frequency sound isolation
- Applying the mesh's lumped dynamic model in the ingress protection design optimization (alarm for possible resonance)

Thanks for listening!