Innovative vibro-acoustic metamaterials to provide compact lightweight NVH solutions


ABAV networking event 2nd October 2015
Noise is the second most deadly pollutant in western Europe

“At least one million healthy life years are lost every year from traffic related noise in the western part of Europe”

Burden of disease from environmental noise - World Health Organization 2011
The EU noise policy after the second round of noise maps and action plans - Paviotti et al 2013
How to block noise?
How to block noise?

by adding volume
How to block noise?

by adding **volume** and/or **mass**
Adding **volume** and/or **mass**?
Novel Acoustic Insulation

Sound insulation

Conflict

Ecologic Trends

Space Limitations
Metamaterial based acoustic enclosure

http://youtu.be/hMCfRHshjXc
Metamaterials with stop band behaviour

What  How  Apply
Stop band behaviour

... certain frequency zones do not propagate

\[ f_1 \]

\[ f_2 \]

\[ f_3 \]

... due to resonant additions on a subwavelength scale
Metamaterials with stop band behaviour

What  How  Apply
Unit Cell Modelling

Propagation Direction

Stop Band
Metamaterials with stop band behaviour

What  How  Apply
Application: lightweight structures...

... good weight/stiffness, worse vibro-acoustic behaviour
Resonant inclusion

Mass

Spring

Mass

Spring
Metamaterial concept

Resonant Inclusions
Versatile concept & large design freedom

- Resonant structure
- Hosting structure
- Cover layer
Metamaterial inserts

- Aluminium mass
- Steel bar
- Polyamide plate

- Decay test
  - Hammer input
  - Response per unit cell further away

- Clamped A4 panel
Lasercutted layered design

- Decay test
  - Hammer input
  - Response per unit cell further away
- Freely suspended A4 panel

- Plexiglass
- Layered concept
Functionally graded design

<table>
<thead>
<tr>
<th>SB 1</th>
<th>SB 2</th>
<th>SB 3</th>
<th>SB 4</th>
<th>SB 5</th>
<th>SB 6</th>
</tr>
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<tbody>
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<td>311-351 Hz</td>
<td>331-376 Hz</td>
<td>374-421 Hz</td>
<td>413-481 Hz</td>
<td>452-532 Hz</td>
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</tbody>
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1  5  9  13  17  21
2  6  10  14  18  22
3  7  11  15  19  23
4  8  12  16  20  24
28  27  26  25

[Image of a grid with numbers and frequencies]
Acceleration response on hammer input

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- SB 6: 452-532 Hz

The graph shows the amplitude response across different frequency bands.
Metamaterials research

Current status
• Feasibility shown structurally and acoustically
• Working together on industry project for feasibility in application

Focus points
• Manufacturing with conventional production techniques
• Integration in/on existing components.
Metamaterials

- Sound Isolation
- Compact
- Light
- Easy to Design
- Ecologic Trends
- Space Limitations
Thank you for your attention!

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