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Analysis and Optimization of Frequency Response of Electrodynamic Speaker Driver

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1. Electrodynamic speaker driver

The danish based company Børresen Acoustics has developed and patented an electrodynamic speaker driver without iron components. This new construction poses great advantages over the generic speaker driver, though with this new design 2 resonance peaks, with undetermined origin, has been discovered. These are discovered by measuring the electrical impedance of the speaker drivers, and are also detectable by measuring the Sound Pressure Level (SPL) of the speaker driver.

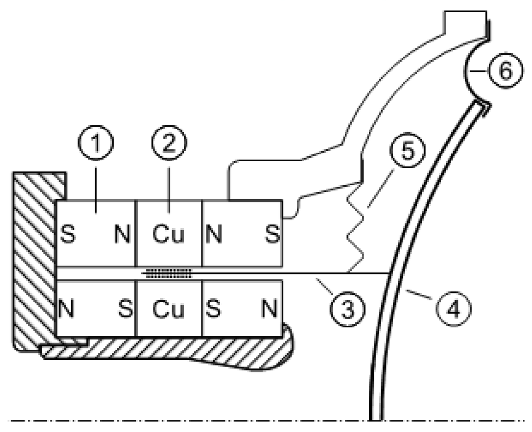

Figure 1. (1) Neodymium magnet (2) Copper pole pieces (3) Voice coil (4) Membrane (5) Spider (6) Surround.

Figure 2. Børresen Acoustics speaker driver.

2. Frequency response

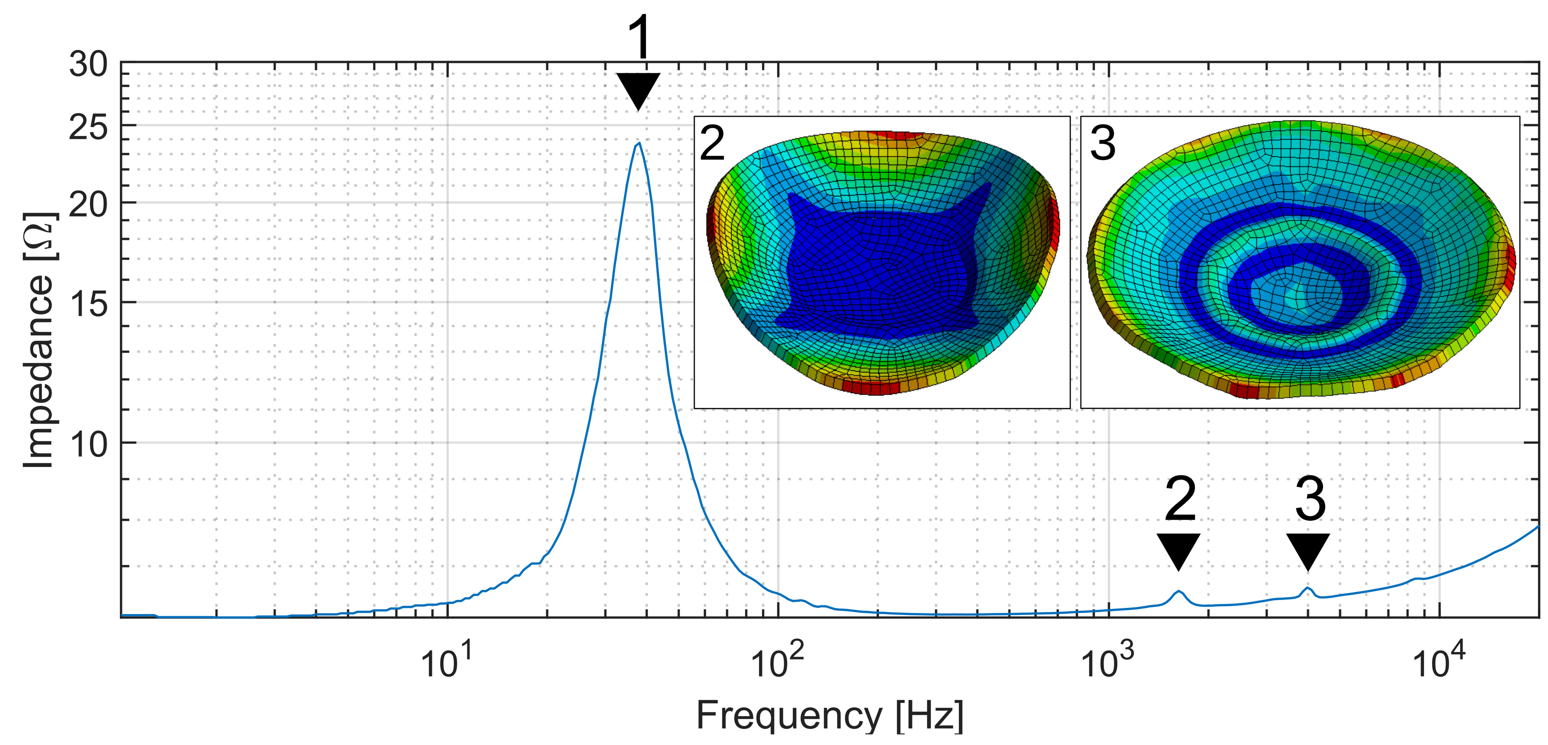

Figure 3. Impedance measurements with associated vibration modes.

Modal and harmonic analyses are performed to determine the frequency response of the speaker driver. From these, it is proposed that the impedance peak (2) at 1625Hz has origins in a membrane vibration mode with 4 radial nodes at 1444Hz seen in Figure 3. Furthermore, it is proposed that the impedance peak (3) at 3979Hz has origins in a membrane vibration mode with one concentric node, which is related to the vibration mode to the right in Figure 3. This vibration mode was identified at a frequency of 4278Hz. The frequency response of the speaker driver is illustrated on Figure 4.

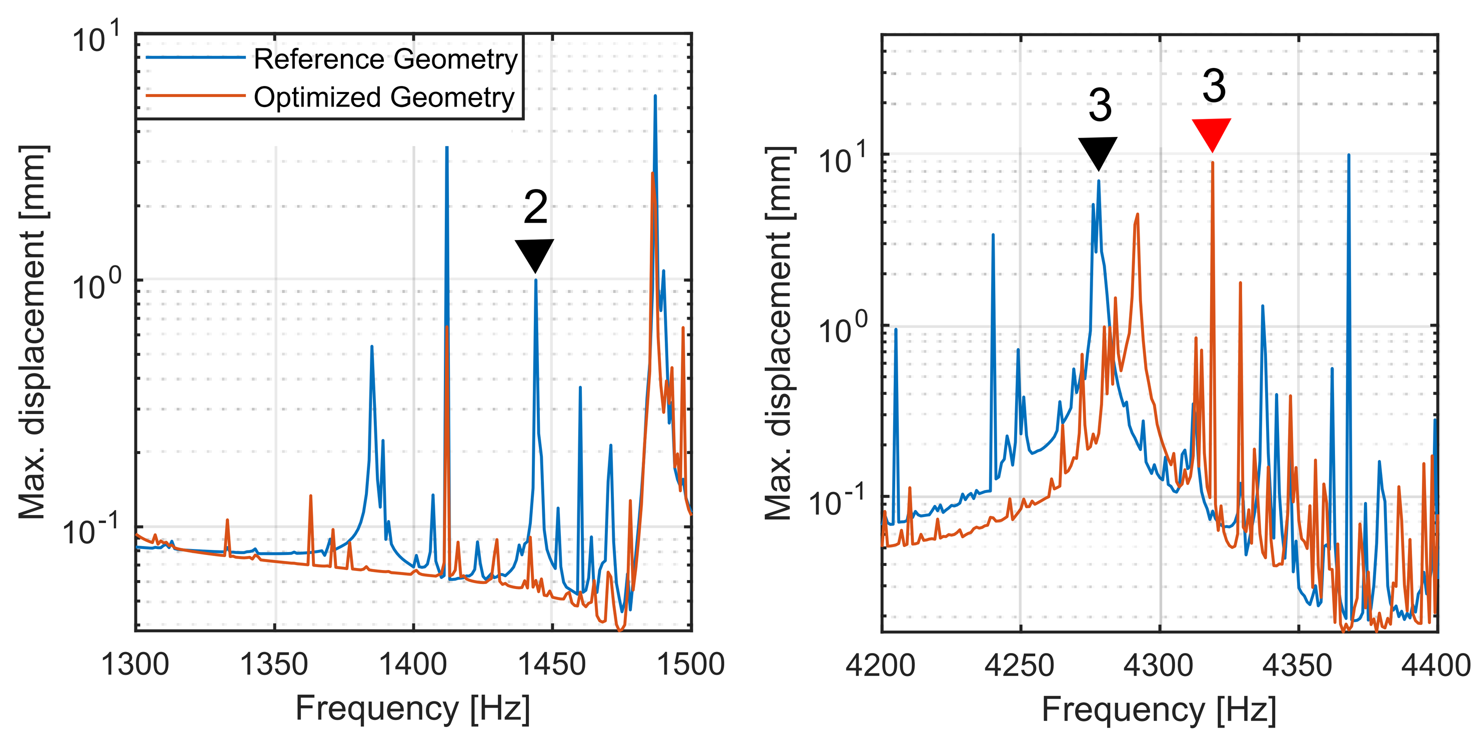

Figure 4. Identified peaks with origin in mechancial system, Black marker indicates reference geometry. Red arrow indicates optimized geometry.

3. Material analysis

A material analysis is performed to determine or calculate the material parameters of the components in the speaker driver. When analysing the core material of the membrane, local buckling effects were observed, when draping the honeycomb structure over the double curved surface of the membrane face sheets, as illustrated on Figure 5.

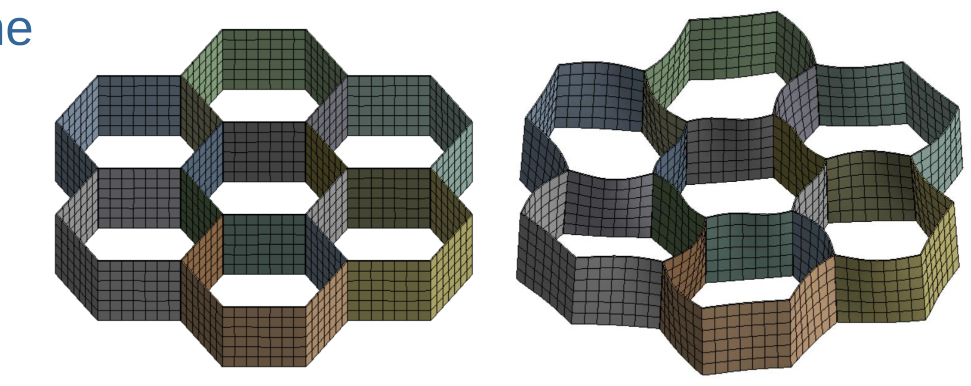

Figure 5. Honeycomb buckling effects.

4. Optimization

The speaker driver is optimized with regards to the problematic eigenfrequencies and their corresponding mode shapes, thus a shape optimization is performed in order to shift the eigenfrequencies outside of the operating range form 0Hz to 2500Hz. The thickness of the membrane core is parameterized, as illustrated on Figure 6, and a maximization of ω_1 is the objective.

$$\underset{x_k}{Maximize} \quad \omega_1(x_k)$$
$$Subject\ to \quad \underline{x_k} \leq x_k \leq \overline{x}_k$$
$$g_1: M_{Total}(x_k) - 15.34\ g \leq 0$$

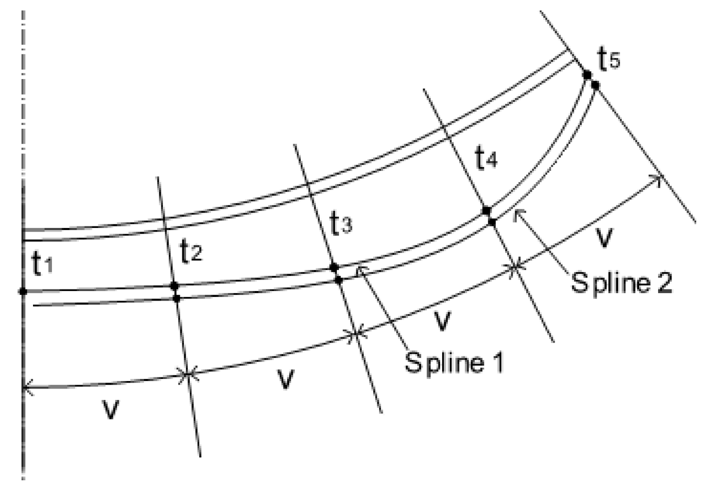

Figure 6. Parameterization of core thickness.

The optimized membrane is implemented and a new modal and harmonic analysis is performed, in order to determine the eigenfrequencies and their corresponding mode shapes of the optimized membrane. The optimized geometry is compared to the reference geometry on Figure 7 and 8.

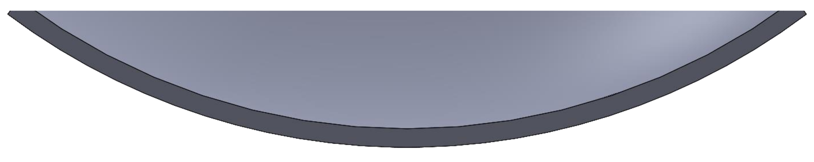

Figure 7. Cross section view of original design.

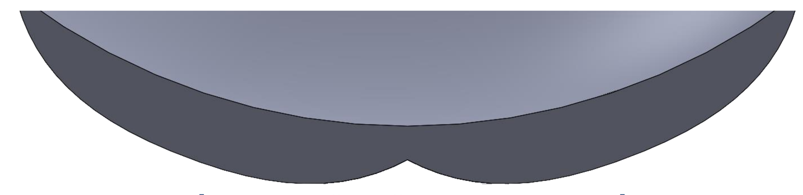

Figure 8. Cross section view of optimized.

5. Conclusions

The impedance peaks from Figure 3 was identified as membrane vibration modes. By performing a shape optimization of the membrane, all frequencies of the membrane vibration modes have been shifted outside the operating range of the speaker driver of 2500Hz. The first identified vibration mode was shifted from 1444Hz to 2880Hz, and the second identified vibration mode was shifted from 4278Hz to 4292Hz. In order to compare the model to the Børresen speaker driver the model should be verified experimentally.

Acknowledgement

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