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Acoustical investigations on sunroof booming using a generic wind tunnel model

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Introduction

By the purchase of a new vehicle beside space, safety, optical and emotional aspects also drive comfort is in the center of interest for the customer. This is significantly influenced by the interiour noise of the vehicle.

The aeroacoustic noise has a big impact on the overall invehicle noise. For example, the experienced overall noise in a sedan is dominated by aeroacoustic noise at driving speeds over 130 km/h [La].

Especially annoying airborne noise sources are the so cavity resonances. These can lead to high frequency noises at door chinks. But with opened sunroof or opened side windows it causes low frequency noises, also called booming, that are at the lower range of audibility or infrasonic range.

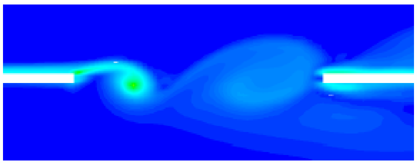

Fig. 1: Excitation mechanism at the overstreamed cave

The sunroof booming is very unpleasent for the passengers at higher noise levels. The so generated Infrasonic-noise can lead to fatigue, dizziness or nausea [ER].

That´s why it is in interest of the automobile manufacturors to solve the problem.

Set-Up

For measuring the noise development a measurement microphone is placed in the interiour of the vehicle. With a Dynamic Signal Analyzer, the signal was transferred from time to frequency domain using a FFT-analyses. The data was saved as frequency spectrum. Per sunroof configuration 36 measurements were done with airspeeds from 5 to 40 m/s.

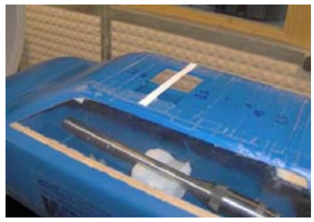

Fig. 3: Microphone in interiour vehicle

The acquired frequency spectras are then combined to a so called spectrogram, which show information on airspeed, noise frequency and level in the interiour vehicle at a glance.

Comparing the spectrograms you get an impression of the impacts of parameter changes or the effects of measures for sunroof booming reduction.

In contrast to full-size vehicles, the smaller generic model is producing the booming noise around 200Hz instead of around 20Hz.

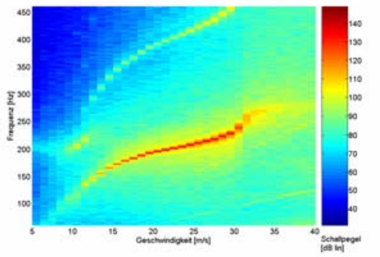

Fig. 4: Spectrogram, sunroof length: 40mm, sunroof width: 60mm

Focus of Investigation

Following parameters take impact on frequency and intensity of the sunroof booming:

•Airspeed and length of sunroof have impact on the excitation frequency (Fig.1)

•The vehicle with opened sunroof acts as so called Helmholtz-Resonator. The eigenfrequency depends on the size of the sunroof opening and of the inner volume of the vehicle [DC1]

•If both frequencies are close together, this leads to the resonance experienced as booming inside the vehicle.

Through acoustical investigations the influences of sunroof-position, -length and width as well as side-wind should be clearified.

Additional patents as well as own solutions for sunroof-booming reduction should be tested and evaluated.

The tests took place with a self designed and manufactured generic (principle) model of 1:10 scale in the wind tunnel at the University of Applied Sciences in Regensburg.

Fig. 2: Generic wind tunnel model

Conclusions

During this thesis 16 parameter, four patent investigations and four investigations on own solutions were done.

The influence of sunroof position, length and width as well as the side wind influence could be largly clarified.

One of the patents turned out as fully effectless. The others acted moderate on the reduction of the sunroof booming.

Two of the own solutions produced the best success. The booming was reduced from over 138dB (lin) to under 120dB (lin) (Fig. 4 vs. Fig. 5). Particularly the reduction exceeds over 37dB (lin).

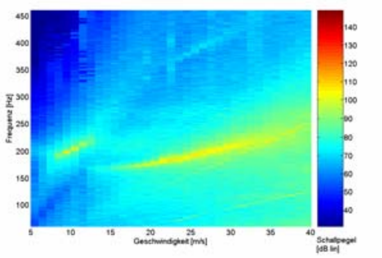

Fig. 5: Spectrogram, sunroof length: 40mm, sunroof width: 60mm, mounted noise attenuator

References:

- [La] Lämmlein, S.: *Fahrzeugaerodynamik*, University of Applied Sciences Regensburg, 2004
- [ER] www.ergonomic.de/... (Date 30.08.05)
- [DC1] DaimlerChrysler AG, Stuttgart, patent DE 19706673 C2