NVH Metrics and the Cost Effectiveness of Retrofittable NVH Reduction Measures in the Automotive Industry

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PROJECT AIMS

- Research existing NVH metrics and control strategies
- Investigate low-cost alternatives
- Implement said alternative into a “budget” vehicle with minimal NVH reduction measures
- Test the noise levels inside the cabin pre and post treatment to see the impact the installed NVH reduction measures have had

METHODOLOGY

The method consists of a three-stage process. With stage one being the collection of the pre-treatment data. Stage two being installation of the NVH-Reduction measure, and stage three being post-treatment testing and analysis of the results. Tests were done using a HEAD Acoustics BHS II connected to a HEAD Acoustics SQobold - a 4-channel data acquisition system for mobile sound and vibration measurement. The SQoBold records a data at a rate of 48kHz, meaning there would be around 86 million rows of data for a 30-minute recording. As such, post-recording the data would need to be processed and filtered before being imported into Microsoft Excel, as the max number for rows of data in Excel is only 1,048,576 rows.

MATERIAL AND INSTALLATION

The material chosen was a 2mm mat made of a blend of a long-chain polymer callled “Polyolefin” and mineral fillers, which together create a dense material with good water ingress protection, and which is recyclable due to the Polyolefin polymer being able to be broken down to single-chain polymers via heating in a mixture of TCP (trichlorobenzene) or ODCB (1-dichlorobenzene). The mat has an Rw average of 24dB (100Hz to 4kHz) tested to the ISO 16283-2 standard.

The cost of the Polyolefin mat, and materials needed for installation came in at £96, this therefore meets the criteria set out at the start to be cost-effective. This cost included contact adhesive and strong water-resistant tape to keep the cut sections together.

Figure 1 -The test vehicle: a 2010 Citroen C1

Figure 2 - A top down view of the installed material in driver and passenger footwells

RESULTS

Averages			
Pre-Treatment		Post-Treatment	
Motorway (104<km/h)			
dB SPL	Speed (km/h)	dB SPL	Speed (km/h)
93	116	87	115
Medium Speed (50 – 100km/h)			
dB SPL	Speed (km/h)	dB SPL	Speed (km/h)
87	65	85	65
Low Speed (<50km/h)			
dB SPL	Speed (km/h)	dB SPL	Speed (km/h)
83	27	82	24
Engine Idle			
dB SPL	Speed (km/h)	dB SPL	Speed (km/h)
81	0.3	81	0.3

n.b. For idle speed, the value for average speed is above 0km/h. This is due to the SQoBold not having a strong GPS signal, and registering latency as a time difference between GPS satellites, resulting in speed being registered at <1km/h when the vehicle was stationary.

Table x - Pre vs Post treatment dBSPL figures for the driving speed categories

The results indicated the relationship between the installed material and the reduction in road noise level. This idea is reinforced when looking at the the difference in the amount of reduction between pre and post-treatment in the motorway driving, and under engine idle conditions, with a 6dBSPL reduction on the motorway, and no reduction at idle.

Figure 3 - Motorway Driving Pre vs Post-Treatment Frequency Response

MOTORWAY SPEED - 104<km/h

AVG SPEED 115.5km/h

Pre-Treatment is represented by the red trace, with post-treatment represented by the green trace. The graph shows an overall reduction across the frequency range of 3dBFS, however due to this being a measurement of dBFS this cannot be directly related to real-world performance.

Figure 4 - Medium Speed Driving Pre vs Post Treatment Frequency Response

MEDIUM SPEED - 50-100km/h

AVG SPEED 65km/h

Notable resonances are at 20Hz, likely to be an engine mode related to “take-off judder”, 45Hz and 150Hz. An increase in resonant frequencies could be attributed to the increase in engine load due to the increase in vehicle weight.

Figure 5 - Low Speed Driving Pre vs Post Treatment Frequency Response

LOW SPEED - <50km/h

AVG SPEED 25.5km/h

Low speed driving sections are defined as below 48kmh with frequent stopping, and uneven road surfaces. The low frequency resonances are a result of mechanical strain on the chassis, and low-rpm driving conditions

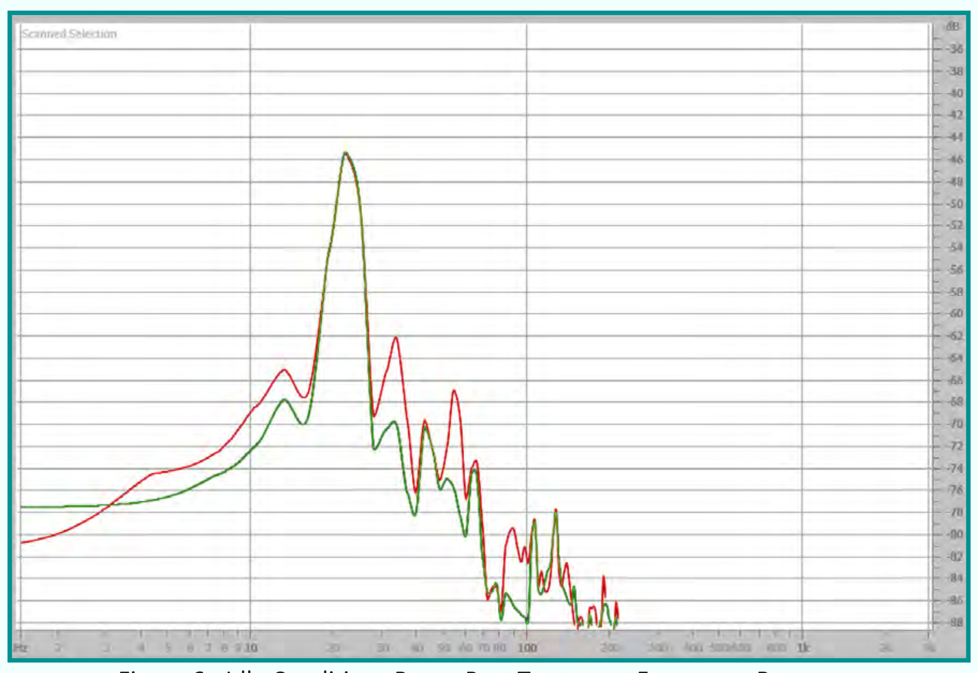

Figure 6 - Idle Conditions Pre vs Post Treatment Frequency Response

IDLE CONDITIONS

AVG SPEED 0.3km/h

Idle conditions are defined as being when the car is stationary, in neutral with the engine RPMs being at idle, in this case around 1000. The huge 20Hz resonant peak is a result of a 4-stroke engine idling at 1000 rpm, with no influence from any road or external noise.

CONCLUSIONS

The results showed an overall reduction in the internal cabin noise across the frequency range, and across various driving conditions. As the financial cost to the end user to retrofit the materials was low this can be considered a success.
In summary, this report shows that for less than £100 an end user can retrofit sound and vibration dampening material into a vehicle and significantly improve the perceived noise level in the car by lowering it by up to 3dB SPL when under the worst driving conditions, Motorway driving, high wind, and road noise. Whilst this project is then therefore a success, more testing would need to be done to evaluate the contribution other NVH reduction methods could have to noise level reduction.

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