NHV CHALLENGE OF HYBRIDE VEHILE

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ABSTRACT

Noise, vibration, and harshness (NVH), also known as noise and vibration (N&V), is the study and modification of the noise and vibration characteristics of vehicles, particularly cars and trucks. While noise and vibration can be readily measured, harshness is a objective quality, and is measured either via "jury" evaluations, or with analytical tools that can provide results reflecting human subjective impressions. These latter tools belong to the field known as "psychoacoustics." Interior NVH deals with noise and vibration experienced by the occupants of the cabin, while exterior NVH is largely concerned with the noise radiated by the vehicle, and include drive-by noise testing. NVH is mostly engineering, but often objective measurements fail to predict or correlate well with the subjective impression on human observers. For example, although the ear's response at moderate noise levels is approximated by A-weighting, two different noises with the same A-weighted level are not necessarily equally disturbing. The field of psychoacoustics is partly concerned with this correlation.

Keyword *Noise, vibration and harshness*

1. INTRODUCTION

NVH is mostly engineering, but often objective measurements fail to predict or correlate well with the subjective impression on human observers. For example, although the ear's response at moderate noise levels is approximated by A-weighting, two different noises with the same A-weighted level are not necessarily equally disturbing. The field of psychoacoustics is partly concerned with this correlation. In some cases, the NVH engineer is asked to change the sound quality, by adding or subtracting particular harmonics, rather than making the vehicle quieter. NVH includes Physical matters (structural dynamics, fluid mechanics and acoustics) Physiology (hearing) Hybrid vehicle are the vehicles which uses two or more distinct types of power, such as internal combustion engine and electric motor. The depleting supplies of fossil based fuels and associated increase in the price of fuel has prompted the automotive industry to focus efforts on development of fuel efficient vehicle technologies. While the development of fuel efficient propulsion technologies such as downsized/boosted internal combustion engines (ICE) and use of direct injection technology is expected to continue, there is increasing focus on the development of varying degrees of hybrid technology. Figure 1.1 provides a view of the tradeoffs between fuel consumption and cost of complexity for varying degrees of hybridization (shown for port fuel gasoline and directed injected Diesel engine based HEV's). As the costs related to added complexity from the hybrid system go down, the degree of hybridization can be expected to go up to fully realize the potential to reduce overall vehicle fuel consumption.

Noise Sources

Power train Noise

Rotating machinery: periodic forces (torque and inertial forces)
Combustion noise: shocks
Mechanism noise: gears noise
belts vibrations Function of rpm and torque

Road noise and Vibrations

Tire-road interaction: random forces Isolated
Obstacles: shocks
Corrugated road: quasi-periodic excitation
Function of speed and road surface

2. THEORY AND LITERATURE

There has been considerable study and research done and still going on NVH study in hybrid vehicles and its optimization. In these section findings of these results are given. Laurent Gagliardini given all the basic details regarding interior, exterior noises sources along with examples. Also airborne and structure borne frequency details are given. Kiran Govindswamy and Thomas Wellmann given the detailed idea of different types of hybrid vehicles along with challenges in NVH of hybrid vehicles. Georg Eisele, Klaus Wolff, Michael Wittler, Roozbeh Abtahi, Stefan Pischinge given details NVH aspects of hybrid vehicles into three categories viz. Dominant Noise Due to Missing Masking Effects ; Unexpected Acoustic Behavior and Specific acoustic phenomena. Tim Holton gave the opportunities to explore improvements in engine and starter technology, to develop better analytical capability relating electric machine noise to performance, and to explore the psychoacoustic response to electric vehicle driving sounds.Benjamin Meek, Herman Van der Auwear and Koen De Langhe[5] highlighted key areas where Electric vehicle pose challenges in NVH alomng with pedstrain warning system. Georg Eisele, Klaus Wolff, Norbert Alt, Michel Hüser illustuted the application of vehicle interior noise simulation in the vehicle NVH development process. Shahram Azadi, Mohammad Azadi,and Farshad Zahedi given the details of analysis and improvement of a vehicle body structure using DOE method. Surface modelling and meshing by CATIA,HYPERMESH, NASTRAN is also given and algorithm is proposed to improve the overall car NVH behavior.

3. GENERAL NVH CHALLENGES IN HYBRID VEHICLES AND CASE STUDY

1. Global power train vibration
2. Driveline vibration
3. HEV component-specific noise
4. Motor/generator whines
5. Accessory noise
6. Gear rattle
7. Noise pattern changes

3.1ICE Start/Stop Vibrations

It is important for the engine start/stop behavior to be transparent to the driver from both a tactile (vibrations) and acoustic (noise) standpoint. shows an example of seat track vibrations measured during ICE start-up conditions on a Hybrid vehicle. The start-up event can be split into the engine cranking phase and initial start of combustion. cranking the engine to start the vehicle) is expected from the driver of the vehicle. For HEV, the start-up of the ICE is linked to factors such as the state of charge of the battery and driver torque demand, which can result in “unexpected” vehicle vibration. Depending on the layout of the driveline, the start-up vibrations for HEV can be further complicated by the fact that the start-up of the ICE does not occur in neutral, causing excitation of driveline tensional modes

3.2For Successful NVH Optimization and Integration

A significant contributor to the vehicle vibrations during an ICE start-up (or shut down) event is the excitation of the engine rigid body modes. Specifically, the roll mode of the ICE (motion about the crankshaft axis) is excited under ICE start-up and shut down events. In order to minimize the transmission of vibration to the passenger compartment during these transient events, it is essential to optimize the mounting layout of the engine. This is accomplished by using a multi-body systems based analysis of the ICE installed in a simplified vehicle model. Specifically, the model includes a rigid body representation of the ICE (and transmission or motor/generator, as appropriate) and vehicle body with appropriate values for the location of the center of gravity, masses, and mass moments of inertia. A simplified wheel and suspension assembly is often used with appropriate mass, geometry, stiffness, and damping information. The power plant mounts are represented using specific mount models that capture the static nonlinearities and frequency dependent dynamic (stiffness and damping) behavior.
The multi-body systems based model is utilized to decouple the ICE rigid body modes. Specifically, it is important to decouple the ICE roll mode from the other rigid body modes as far as possible. Figure 5.2 shows an

example of optimization study conducted on a hybrid ICE application with the goal of decoupling the ICE rigid body modes, within other program constraints (maximum allowable motion of ICE under road excitation, packaging, etc.). The motion of the ICE at each rigid body modal frequency is analyzed to ensure that optimal decoupling of key modes has been achieved.

Typical engine control related parameters which have an influence on the ICE start/ stop vibration are:
1. Injection time
2. Amount of initial injection
3. Compression rate at cranking, which can be influenced by valve opening time and throttle position
4. Crank speed rise rate
5. Engine speed at which the combustion process starts.
6. Defined crank angle positions for engine stop. The position of the crank shaft when starting influences, the vibration levels.

For conventional power trains the engine start/stop is usually performed with the transmission in neutral. Hence, tensional vibrations during the start/stop events are decoupled from the vehicle driveline. However, HEV drive trains do not necessarily have this decoupling, as a result of which the torsional vibrations from the ICE cranking and combustion phase can excite low-frequency driveline torsional modes such as driveline shuffle. As part of the start/stop calibration, it is important to ensure that these torsional modes are not excited by engine torsional during these transient events. As indicated previously, seat track acceleration ESD analysis can be used to diagnose the presence of resonances excited and focus development effort to refine the ICE start/stop behavior.

Finally, the use of the electric motor to actively damp the engine torsional vibrations should be explored. In such a scenario, the electric motor applies a torque fluctuation with a 180° phase offset relative to the torque fluctuation caused by the ICE cranking, so that the torsional excitation of the driveline can be minimized. For the implementation of active damping, the crank shaft position must be known and a good understanding of the cranking torque is mandatory.

4. VEHICLE INTERIOR NOISE SIMULATION (VINS)

VINS is a time-domain transfer path synthesis technique that allows for a detailed breakdown of the power train induced interior sound at a target location in a vehicle As show schematically in figure 6.1 the VINS process begins with measurements of the airborne and structure borne noise sources. Radiated power train noise, intake orifice noise, and exhaust tailpipe noise measurements are considered for characterization of vehicle interior airborne noise contributions. Similarly, mount vibration measurements (engine side) are used to quantify the source levels of structure borne inputs into the vehicle. The source measurements are used in conjunction with corresponding vehicle level transfer functions (airborne and structure borne) to simulate the power train-induced interior noise shares from the various airborne and structure borne paths. The primary advantage of the time-domain simulation over comparable frequency-domain techniques is that the resulting path contributions can be evaluated both objectively and subjectively via listening studies. In addition to the typical quasisteady- state results, the VINS process can be applied to transient test conditions. Therefore, events such as ICE start/stop noise can be understood using the VINS process.

5. CONCLUSION

In this report background information on different types of hybrid electric vehicles is given. Following this, unique NVH challenges inherent in the operating of such vehicles were discussed. Example with case studies on issues such as internal combustion engine (ICE) start/stop noise and vibration and electric motor/generator whine noise were provided. the use of metrics and methods such as vibration dose value (VDV) and energy spectral density

(ESD) analyses and multi body systems (MBS) based processes to characterize and refine the ICE start/stop behavior. In addition, the application of advanced time-domain based transfer path techniques such as Vehicle Interior Noise Simulation (VINS) to understand and solve challenging HEV noise problems was demonstrated. The presented case studies provide a discussion of the root cause of the specific NVH issues, objective optimization methods.

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