European Commission

PBNv2

Next Generation Pass-By Noise Approaches for New Powertrain Vehicles – H2020 Marie Curie ETN

First Public Technical Course

28th – 29th November 2018

INSA Lyon

Wednesday 28th November

1330-1400 **Registration**

1400-1445 **Karl Jansens, Siemens**

Pass-by Noise Engineering: a review of source contribution analysis techniques

The new pass-by noise regulation highly impacts the vehicle development process. The revised standard requires more tests in different conditions and the execution of the tests is also more complex. Secondly, and most importantly, the new directive forces A-OEM (cars, motorbikes, trucks…) to further reduce the emitted noise levels of their vehicles. The A-OEM are therefore looking for enhanced engineering techniques that allow quantifying noise contributions of vehicle subsystem components (engine, intake, gearbox, tires, exhaust, etc.) to enable them to validate designs for pass-by noise targets early in the design process.

This presentation gives an overview of different testing techniques, based on masking experiments, acoustic array measurements and enhanced time domain source contribution analysis that will help testing engineers properly quantify the relative contribution of the different noise sources. The presentation reviews the main principles of the techniques, their pro's and con's, and the major selection criteria. Different application examples are presented.

1445-1530 **Peter Kindt, Goodyear**

Tyre-Road Noise

The course provides insights into the noise generation from tire/road interaction, illustrates the balance between tire/road noise and other performances, and invites for reflection on a holistic approach for road traffic noise optimization addressing tires, vehicles and infrastructure.

1600-1645 **Juan Garcia, Idiada**

Warning Sound Systems for Electrical Vehicles

The rapid growth of Electric Vehicles (EV's) and Hybrid Electric Vehicles (HEV's) has increased the concern that the relative silence of this type of vehicles will result in an increased risk to pedestrian safety. A practical solution to this problem is to add an artificial sounds to EV's to aid their detection by pedestrians and other vulnerable road users.

Acoustic warning systems for EV's should increase pedestrian safety and simultaneously produce a small impact on environmental noise levels. This presentation shows the main advantage of using a directive acoustic source implemented as a beamforming loudspeaker array in an EV to increase pedestrian safety and control the effect on noise pollution. An example of such a system has successfully been implemented in a Nissan Leaf vehicle and its performance in realistic situations has been assessed. The results show that such a pedestrian acoustic warning system offers considerable improvements with respect to current systems.

1645-1730 **Jordan Cheer, ISVR**

Active and Adaptive Sound Control for Automotive Applications

Active control of engine and road noise in the automotive environment has been investigated within the automotive industry for around 20 years. This interest is due to both the potential to reduce vehicle noise, and the ability to remove passive noise control treatments and, therefore, improve fuel efficiency. The most successful commercial systems have generally used the loudspeakers of the car audio system to globally control engine or road noise at low frequencies. It is also possible to use such control systems to manipulate the sound quality of the engine, through targeted attenuation and enhancement of particular engine orders. In a similar way, an array of loudspeakers can be used to control the spatial distribution of reproduced sound within the automotive environment, in order to create a localised region of audio reproduction. This paper will first outline the limitations of global active control in the automotive environment, and then demonstrate how some of these limitations may be overcome by using a local active control strategy. The physical limitations of active noise control will then be linked to the limitations on the generation of localised audio sound zones within the car cabin. Practical examples of a number different automotive sound field control systems will be presented in order to demonstrate their potential performance.

Thursday 29th November

0900-0945 **Christian Dindorf, Bosch**

Vibration Testing at Bosch

A short overview of the Robert Bosch GmbH is given regarding business sectors, associates and international footprint. At the R&D center in Schwieberdingen, Germany, we have the largest vibration test lab of Bosch worldwide, and one of the largest labs in Europe outside of Bosch. The aim is testing for reliability of our (mostly) automotive components against vibration loads. The tests are designed to represent lifetime loading in the vehicle in an accelerated form. The vibration loads are gathered from vehicle measurements in order to better understand the actual excitation and especially the response of our components. Two case studies are shown, one on behavior of different vibration controllers and one on preliminary results with a 3D electrodynamic shaker. After unexpected failures of our components on the shaker we had to realize that the controller showed out-of-band excitations that happened to hit the resonance frequency of our component. This finding led to an extensive study of five different types of controllers regarding their fidelity with broadband random testing. Besides the type of controller that initiated this

study a second one showed significant out-of-band excitations, and many of the types of controllers had large deviations when running non-gaussian random profiles. This study will be continued with further types of excitations as well as for 3D or MIMO control, respectively.
At Bosch in Schwieberdingen we operate an electrodynamic 3D shaker with 30 kN/axis that can run up to 2 kHz. A second PhD student (besides our MSCA fellow, Nimish Pandiya) is investigating this system, eventually leading to a methodology how to derive a 3D test profile from a vehicle measurement on our components.
In this presentation, the results that led to the installation of that system into our lab are shown. Before, the system was operated at a test house in Munich. There, a team of four Bosch experts performed several days of testing and measurement to characterize that system. Also, a standard automotive component had been measured to determine the impact of 3D vs. 1D excitation. The results shown clearly underline the necessity to test 3D in the future to have more efficient and more realistic vibration testing.

0945-1030 **Jan Rejlek, ViV**

A patch transfer function approach for vibro-acoustic analysis with poroelastic materials

Transportation vehicles are typically made of complex build-up structures, which have to fulfil a variety of functional performance targets. Driven by the ever-increasing tightening of legal regulations and growing customer expectations, efficiency, noise and safety are becoming attributes of the upmost importance. As modern structures must be lightweight, comfortable and safe, new challenges are emerging when it comes to a design in terms of their multidisciplinary performance. The current trend towards green mobility forces car manufactures to adopt novel strategies to lower the fuel consumption and the exhaust emission levels alike. Lightweight design, downsizing and electrification of drivetrain, among others, are becoming common strategies to cope with. Unfortunately, these measures typically imply deterioration of noise, vibration and harshness (NVH) functional performance attributes.
The vehicle development process exhibits highly parallelised nature due to the fact that many participants (suppliers or departments inside the same OEM) work in parallel on the many functional aspects of different components of a new car. The final pre-series NVH development phase therefore substantially relies on experimental testing conducted on vehicle prototypes, as there is lack of reliable input data to feed the numerical models. Due to the parallel and iterative character of the development process it is nearly impossible to keep numerical models up-to-date with the physical prototypes. Introduction of hybrid computational-experimental techniques could therefore greatly enhance the role of numerical tools in the final phase of the vehicle optimization process.
This talk reports on recent developments and applications of a novel characterisation technique based on concept of so called patch transfer functions (PTF) method, which is adopted in framework of a sub-structuring coupling procedure. The methodology considered allows for separate characterisation of

different physical sub-domains (structure, trim, acoustic fluid), which are then coupled via their common interfaces in terms of surface impedances. These impedances can be determined either in experimental or numerical manner on areas referred to as patches. The main advantage of this approach consists in the fact that the respective sub-domains can be characterised on a component level without considering the interaction with the rest of the whole system.

1100-1145 **Elke Deckers, KU Leuven**

BEM and FEM for unbounded calculations

This lecture gives the basis for element-based simulation techniques for unbounded acoustic problems. The theory behind the Finite Element Method and the Boundary Element Method is given, together with their advantages and drawbacks. Different ways to account for the Sommerfeld radiation condition within the Finite Element Method are explained.

1145-1230 **Nicolas Totaro, INSA Lyon**

How Green's identity and FEM solver can be used for acoustic inverse methods

Green's identity is a well-known mathematical tool often used to solve acoustic problems. If two functions are twice continuously differentiable, an integral over a volume can be replaced by an integral over the surfaces of the volume. In acoustics, one of these two functions is often the acoustic pressure but the other one is completely arbitrary. The possibilities given by this arbitrary choice are numerous. In acoustics, the aim of inverse problems is to reconstruct the 3D vibration fields of a radiating source from measurements of the radiated acoustic pressure surrounding it. During this presentation, it will be shown how Green's identity and Finite Element solver can be used as acoustic inverse method. The so-called "homogeneous iPTF" (inverse Patch Transfer Functions with homogeneous boundary conditions) and "mixed iPTF" (inverse Patch Transfer Functions with mixed boundary conditions) will be presented. The powerful capabilities of the Green's identity will be illustrated on a 3D acoustic problem consisting in an engine block on a test bench. Interesting features like ranking of contribution of parts or FE model updating will be presented.

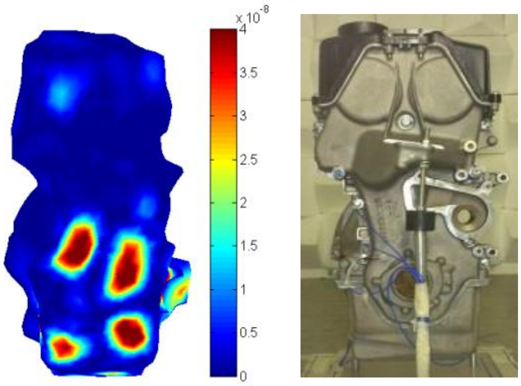

Figure 1: (a) reconstruction of the acoustic intensity fieldby an inverse method on the surface of (b) an engine block.