講演番号	224

文献番号	20225224

Evaluation of a New Accelerated BEM Method (H-Matrix) to Support Vehicle Pass-By Noise and Acoustic Vehicle Alerting System Design and Performance Prediction

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KEY WORDS: **vibration, noise, and ride comfort, acoustic material, boundary element method (BEM), Pass-by Noise, H-Matrix**

The use of virtual prototyping in the pre-certification phase is very important for automotive OEMs who, in the context of electrification, are challenged by the regulations for Acoustic Vehicle Alerting Systems (AVAS) and for pass-by noise. Virtual prototyping helps designers make engineering decisions “right the first time” by leveraging proven simulation methodologies such as Boundary Elements and Ray Tracing. The Boundary Element Method (BEM) is considered to be very accurate but can be too expensive in terms of computation time and memory, while the opposite can be argued for the Ray tracing method whose computations are very fast and efficient but more approximate. An accelerated Boundary Element Method using a “Hierarchical Matrix” (H-Matrix) approach has been developed to achieve a good compromise between speed and accuracy. The comparison between this method, the standard BEM and the Ray Tracing method is presented in this paper for three different models: pass-by noise (PBN), Acoustic Vehicle Alerting System (AVAS) and a wheel loader construction heavy vehicle (Fig. 1). The PBN boundary element model consists of 83835 wetted nodes, 13 monopoles modelled as compact acoustic sources with the strength of 1 Watt (8 for the tires, 1 for the exhaust, 4 for the engine) and the model is valid up to 4200 Hz. The AVAS model consists of 136661 wetted nodes, 6 monopole sources that define 6 different load cases based on potential locations for the sound actuator, 2 planes of virtual microphones and 2 polar directivity virtual microphones and is valid up to 6540 Hz. The wheel loader boundary element model consists of 76892 wetted nodes, an infinite plane to represent the ground, 3 monopole sources with realistic sound pressure spectra (exhaust, engine, and hydraulic pump) and a hemisphere of virtual microphones positioned at 6.5m from the center of the model according to exterior noise regulations and is valid up to 2000 Hz. The results of the comparison between the H-Matrix method, the standard Boundary Element method and the Ray Tracing method were presented for three different representative vehicle models: PBN, AVAS and a wheel loader heavy vehicle. The results show a very good correlation between H-Matrix and standard BEM (Fig. 2) and an average reduction of 35% in terms of computation time and 50% in terms of memory consumption (Fig. 3), which allows more models to use standard laptops instead of HPC for vibro-acoustic performance prediction and design.

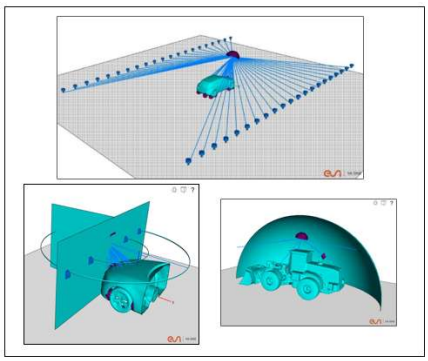

Fig.1 H-Matrix BE models

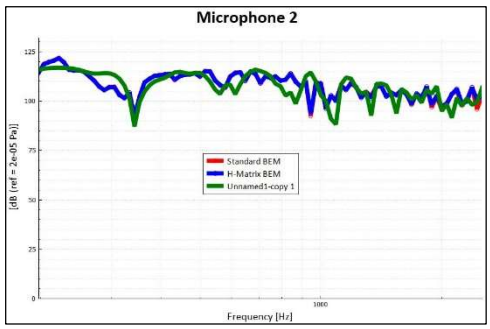

Fig.2 Example of microphone correlation

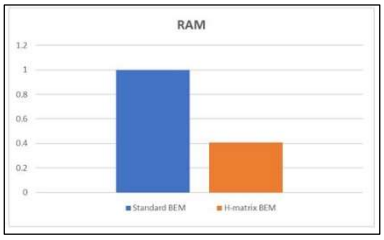

Fig.3 Example of RAM consumption comparison