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Wind noise prediction on the HSM(Hyundai simplified model) using ANSYS Fluent and LMS Virtual.Lab

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1. Introduction

Assessment of aerodynamic noise is becoming increasingly important for automotive manufacturers. Flow passing a vehicle may indeed lead to high interior noise level and affect cabin comfort. Interior noise results from various mechanisms including aerodynamic fluctuations of the disturbed flow around the side mirror or pillar, hydrodynamic and acoustic loading of the car panels and windows, vibration of these panels and acoustic radiation inside the vehicle. Objective of the present study is to capture these important mechanisms in a simulation model and demonstrate the ability of the combined simulation tools Fluent / Virtual.Lab to provide accurate aerodynamic and interior noise prediction results. The simulation is performed on the HSM (Hyundai simplified model) where noise transmission is assumed to happen through the side windows and the front windscreen and where most of the aerodynamic loading is considered to be generated by the A-pillar. Complete modeling process is presented including details on the unsteady CFD simulation and the vibro-acoustic model with absorption materials. Guidelines and best practices for building the simulation model are also discussed.

2. Simulation Methodology

2.1 Introduction

The modeling methodology for assessment of aerodynamic noise consists of two important aspects - first to capture transient noise sources accurately and second to propagate these external noise sources into passenger compartment. This entire methodology is demonstrated using combined simulations tools Fluent / Virtual.Lab Acoustics. The noise sources are captured using transient CFD and scaled resolving turbulence modeling available inside ANSYS Fluent. Transient noise source data on the side glass and windshield surfaces are stored for every time step. This transient noise source data is used in Virtual.Lab Acoustics model as boundary condition where acoustics modeling of sound propagation inside cavity is carried out.

The wind noise assessment will be carried out for two yaw positions of the HSM – zero degree and 10 degree [counter clock-wise]. Each yaw position will be simulated for two inlet air speeds – 110 km/h and 130 km/h with BL off velocity profile. Details of Transient CFD modeling is discussed in the subsequent section.

2.2 Transient CFD Simulation

Figure 1 shows placement of model inside the wind tunnel for two yaw positions. A hybrid mesh consisting of hex-core, tetra and prismatic elements are used. Total cell count used in each yaw model is approx 45 million cells. The mesh is strategically refined around the HSM body to capture the wind noise sources accurately. Figure-2 shows cross-section of mesh.

Figure-3 describes the boundary conditions used in the transient CFD modeling. BL Off velocity profile is used at the nozzle inlet, the tunnel inlet is modeled as pressure inlet and the tunnel outlet is modeled as pressure outlet.

Table 1 Solver setup, turbulence model & boundary conditions

Function	Settings
Solver	2^{nd} order implicit transient formulation, Least Square cell based Gradient scheme
Material	Air as Ideal Gas
Turbulence Model	DDES SST K-Omega
Pressure Discretization	2^{nd} Order
Momentum Discretization	Bounded Central Difference
Turbulence	2^{nd} Order up-wind
Energy Discretization	2^{nd} Order up-wind

Boundary Conditions :

1. Nozzle Inlet – Velocity Inlet with BL OFF velocity profile (U_∞ = 110 km/h & 130 km/h)
2. Tunnel Inlet – Pressure inlet (Gauge Total Pressure= 0 Pa)
3. Tunnel Outlet – Pressure outlet (Gauge Pressure = 0 Pa)
4. Tunnel Top, Floor, Sides – Wall Boundary (No-slip)

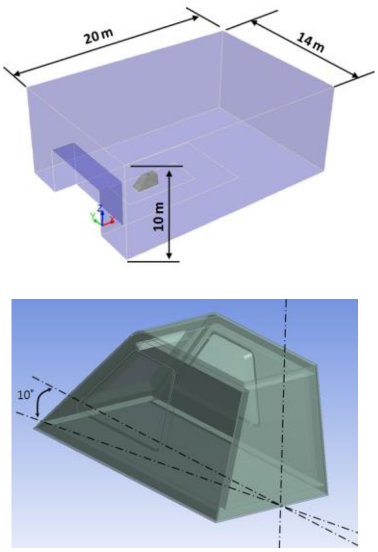

Figure-1 Placement of model inside wind tunnel and 10 degree yaw position

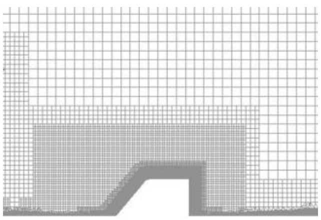

Figure-2 Mesh on y=0 cut plane

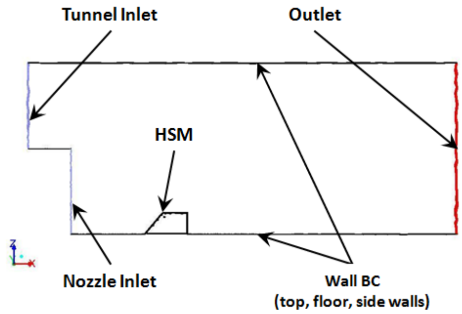

Figure-3 Boundary Conditions

The transient pressure monitors are set to capture the external noise as per microphone locations shown in Figure-4

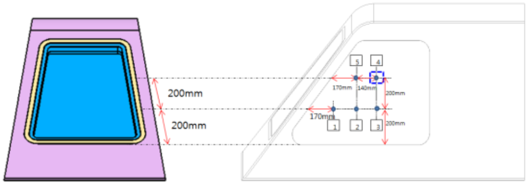

Figure-4 External Microphone Locations

Currently, the transient CFD simulations for all four cases are in progress. More details in terms of results will be provided in the final manuscript of this paper along with comparison with test data.

2.3 Acoustics Simulation

The acoustics simulation of sound propagation inside HSM cavity will be modeled using LMS Virtual.Lab Acoustics. The sound source data on side glass and windshield obtained from transient ANSYS Fluent simulations will be applied to this model. Currently the acoustics modeling process is in progress and more details will be provided in the final manuscript of this paper.