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Modeling interior noise due to fluctuating surface pressures from exterior flows

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Interior noise resulting from exterior flow over a structure is an important issue. The prediction of interior “windnoise” requires to model (i) broadband spatial and spectral statistics of the exterior fluctuating surface pressures (FSP) and (ii) how these FSP are transmitted through / radiated from the structure to the interior (broadband). Usage of unsteady compressible flow CFD simulation to characterize exterior FSP for broadband interior noise problems is relatively new; the accurate prediction of both the convective and acoustic wavenumber content of the flow can therefore be challenging. A numerical investigation of the flow characteristics downstream of a simplified side-mirror is presented here. A complex windnoise source is then described in terms of the superposition of two simple analytical sources derived from wavenumber analysis using CFD data. An example is presented in which the FSP are applied to a side glass with prediction of interior noise by SEA method.

Keywords: windnoise, CFD, aero-acoustics, fluctuating surface pressure, SEA, Turbulent Boundary Layer

1 Introduction

Interior noise generated by unsteady exterior flows is often referred as windnoise. Predicting windnoise upfront in the design process to reduce source content and modify paths is needed to meet cost, weight and noise targets. To model windnoise, the source (FSP characteristics), paths (transmission through parts of the structure and nearby leaks/seals, plus isolation and absorption from interior sound package) and receiver (occupant location and frequency range(s) where windnoise contributes) all must be understood. The FSP on the front sideglass (due to vortices and separated flow generated by the A-pillar and mirror) are often an important contributor relative to other parts of the structure. In this paper, an analysis of FSP downstream of a simplified side mirror is performed as shown in Figure 1. The mirror is mounted in the floor of a windtunnel and was used in a recent JSAE benchmark study that compared (exterior) aero-acoustic predictions from various commercial CFD codes [1].

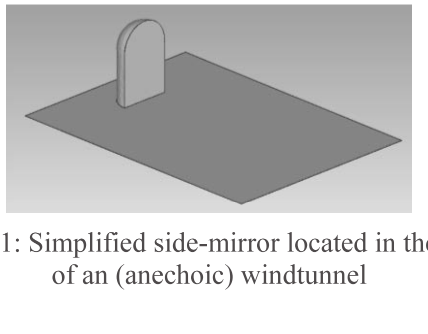

Figure 1: Simplified side-mirror located in the floor of an (anechoic) windtunnel

It is often found that the glass acts as a spatial filter and preferentially transmits certain wavenumbers in the fluctuating surface pressure [2]. A simple numerical example is shown in Figure 2 with two glass panels of dimension 1m×1m×4mm both set to 6% constant damping and both radiating into a 1 m3 acoustic cavity. A Diffuse Acoustic Field (DAF) excitation is applied to the first panel and a Turbulent Boundary Layer (TBL, with a 50 m/s free stream velocity) is applied to the second panel. An SEA model is used to predict the interior sound pressure level (SPL) of each cavity [3]. While both loads are set to the same surface pressure amplitude (1 Pa), the interior SPL due to the TBL is approximately 30dB lower than that due to the DAF (both peak at the glass coincidence frequency at ~3kHz).

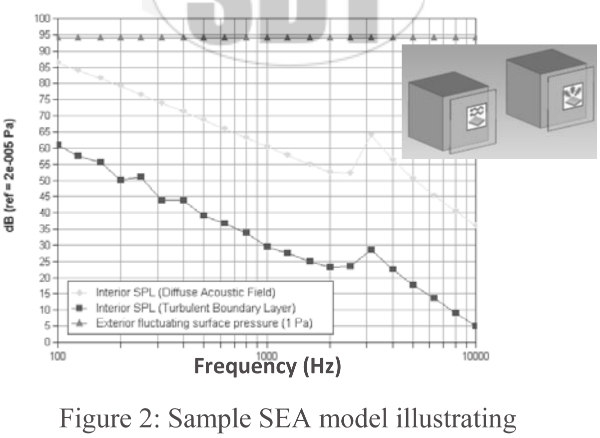

Figure 2: Sample SEA model illustrating wavenumber filtering effect.