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Direct Noise Prediction and Control of an Installed Large Low-speed Radial Fan

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Abstract

The aeroacoustics of several configurations of a large complex radial fan module typical of ventilation systems used in building or large transportation systems has been directly simulated with a Lattice Boltzmann Method. For the reference configuration the available flow measurements are well captured by the simulation and excellent noise predictions are achieved for all microphones both in terms of levels and spectral shape. The inlet distortion and a flow separation at the fan blade foot are shown to cause the observed strong tonal noise at the blade passing frequency. The unsteadiness of the tonal noise is also traced to large "cucumber-like" coherent structures wandering on the fan hub and hitting the blade leading edge quite randomly. Fan hub contouring is shown to almost eliminate the flow detachment at the hub and improve fan performances. Yet it does not reduce the inlet distorsion and has only a marginal effect on the noise. Adding a thin filter on the bellmouth removes the large turbulent structures ingested by the fan and improves the flow-field uniformity at the fan inlet. Significant noise reduction is then achieved eventhough additional pressure losses are introduced. A final tonal noise control with a rotating obstruction placed on the fan bellmouth has been succesfully simulated yielding the expected sound modulation. All these flow and acoustic features compare remarkably well between the measurements and the simulations.

Keywords: Aeroacoustics, radial fan noise, flow and noise control

1. Introduction

Low-speed radial fans are used in many residential applications for ventilation, cooling and heating systems. The noise level produced by these systems is one of the main concerns for customers. Thus, aeroacoustic predictions are required by the manufacturers at the design level. Aero-acoustic sources are multiple in complex systems. Broadband noise component is produced by a wide range of turbulent excitations while tonal noise component is rather related to large coherent flow structures strongly depending on the installation. In the present work, unsteady compressible numerical simulations are used to predict tonal and broadband noise components of the acoustic spectra for a radial low-speed fan installed in a complex module typical of many ventilation systems in transportation applications. Very few numerical tools allow capturing