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Optimization of tonal noise control with flow obstruction

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Abstract

The tonal noise control of an axial low-speed fan system with flow obstruction has been achieved both numerically and experimentally. Its primary noise source caused by rotor-wake interaction has been directly and accurately simulated with a Lattice Boltzmann Method. The latter has then allowed deciphering the noise control mechanism of an upstream sinusoidal obstruction: the vortex rings shed by the obstruction yield a second noise source at the rotor-blade leading edge. The obstruction itself does not create any significant noise and is acoustically transparent. An industrially-applicable numerical methodology has then been proposed to obtain the optimal obstruction design for a given fan geometry and operating condition, with a maximum of six simulations of the fan system without and with the obstruction being static and slowly rotating. Simulations with rotating obstructions provide the optimal lobe amplitude and an optimal obstruction angular position, which are found to be 20 mm and about 16° respectively for the present fan system both numerically and experimentally. The frequency selectivity of the obstruction and the linear variation of the secondary source level with the lobe amplitude have also been confirmed.

Keywords: Aeroacoustics, Axial Fans, Ventilation Noise, Noise Control

1. Introduction

The present study focuses on the tonal noise produced by low-speed axial fans that are often used in cooling and air-conditioning systems. Such a noise component is not only a major part of the overall noise produced by such ventilation systems (about half or more depending on the operating condition), but also the major source of annoyance (subjective noise) when the tones emerge by more than 10 dB over the broadband level. In order to limit this nuisance, several passive and active noise control devices have been

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