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Lobed grilles for high mixing ventilation – An experimental analysis in a full scale model room

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ABSTRACT

In the present study it is shown that jet flows from innovative rectangular air diffusion grilles with lobed ailerons ensure higher mixing in a room than baseline jets from classical rectangular air diffusion grilles with straight ailerons. The experimental approach uses time resolved and classical large scale PIV measurements.

The estimated entrainment in the case of the jet issued from the grille with lobed ailerons is found to be greater than in the case of the standard grille with straight ailerons. This way, lobed ailerons might be a solution for the optimization of air diffusion grilles in order to insure more uniform flows and to reduce thermal discomfort and draught sensation.

An analysis of the phenomena being at the origin of this performance is proposed. The jet issued from an elementary slot with lobed geometry is compared to the linear slot jet. Based on the elementary slot jets analysis, it is shown that the vortical dynamics in the lobed flow is complex and is governed by large streamwise structures generated by the lobed nozzle lip. This explains the recorded performance in terms of induction and mixing.

The special geometry of the lobed grille was not found to generate supplementary noise as the sound pressure levels were recorded for both grilles for different discharge flow rates. Pressure losses were also found to have similar values for both grilles.

1. Introduction

The primary aim of HVAC systems is to provide clean air and to maintain comfortable conditions for occupants in buildings, both in terms of air quality and thermal comfort. According to the European Commission's recommendations the EU members have to reduce their energy consumption within 20% before 2020. In the resulting low-energy buildings, the thermal powers to inject in the occupied zone are low and the flow rates will be lower. The reduced air mass fluxes being introduced in the occupied zone must uniformly distribute conditioning cooling or heating loads in order to achieve thermal comfort and acceptable air quality. Thus, innovative diffusers should be designed to improve mixing. This represents an essential condition for the success of the energy policy fixed by European leaders.

As a passive control of mixing ventilation, lobed orifices introduced in the perforated panel ceiling diffuser design were found to perform larger induction, without reduction of the jet throw [1]. It was shown that the cross-shaped perforation allows an increase in the entrained flow rate as much as twice the value in the case of the reference flow issued from the panel with circular perforation.

For horizontal jet blowing near the ceiling, a grille with lobed ailerons is proposed in this study. Such a grille is more convenient in horizontal blowing case since the air can be oriented toward the ceiling by the inclination of the ailerons. The lobed lip edges allow the increase of the shear boundary between the primary and the secondary flows. Then, jet induction boundary increases whereas effective injection area is kept constant. Furthermore, the lobed lip edge of the nozzle generates large streamwise structures known as responsible of jet induction phenomenon [2–6].

In fluid mechanics it is well established nowadays that streamwise vorticity dynamics affect and control the mixing process to a great extent. In many industrial and aeronautical applications are used the so called "lobed" mixers which are generating strong streamwise vortices in the mixing layer. Besides the streamwise vortices, the small scale Kelvin-Helmholtz vortices would also be generated simultaneously, due to the velocity difference between the two mixing streams. Many researchers, for example Paterson [7], Presz et al. [8–10], Eckerle et al. [11] and Yu

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