Available online at www.sciencedirect.com

ScienceDirect

Energy Procedia 139 (2017) 398–403

Energy Procedia

www.elsevier.com/locate/procedia

International Conference On Materials And Energy 2015, ICOME 15, 19-22 May 2015, Tetouan, Morocco, and the International Conference On Materials And Energy 2016, ICOME 16, 17-20 May 2016, La Rochelle, France

Experimental investigation the turbulent kinetic energy and the acoustic field in a rectangular jet impinging a slotted plate

H. H. Assoum[a], J. Hamdi[b], K. Abed-Meraïm[b], M. El Hassan[a], A. Hammoud[a] and A. Sakout[b]*

[a]*Beirut Arab University-Tripoli Campus, Corniche El Meena, next to the Olympic Stadium, Tripoli, Lebanon*
[b]*LaSIE, University of La Rochelle, Avenue Michel Crépeau, Pôle Sciences et Technologies, 17000 La Rochelle, France*

Abstract

Ventilation systems are of vital importance for buildings, not only to provide acceptable thermal conditions and air quality for occupants, but also with regards to energy usage. Impinging jets can be encountered in many ventilation strategies which have major impacts on the acoustic environment and energy performance. The self-sustaining tones can be generated in such applications where a feedback loop is installed in the system. This phenomenon is explained by the corollary of Howe who shows that the origin of noise in such configurations can be attributed to fluid rotations. Howe highlights the role of phase conditions between the vorticity, the velocity of the flow and the acoustic velocity for the optimization of energy transfers between the turbulent kinetic energy and the sound field. In this work, we use 2D-PIV technique and a microphone respectively to measure the kinematic fields simultaneously with the acoustic generation for a rectangular jet impinging on a slotted plate. This study aims to investigate the transfers between the turbulent kinetic energy and the sound field for two Reynolds numbers presenting a high and a low noise levels. It is shown that phase conditions are necessary for the optimization of energy transfer which allows the installation of the self-sustained loop in the flow. It was found also that the change of the aerodynamic mode which is directly related to the self-sustained frequency amplifies the sound intensity and promotes the transfer of energy to the acoustic field.

Peer-review under responsibility of the scientific committee of ICOME 2015 and ICOME 2016.

Keywords: Turbulent kinetic energy; Self sustained tones; PIV measurement

* Corresponding author. Tel.: +961 6 218 400 ext 4319; fax: +961 6 218400
E-mail address: h.assoum@bau.edu.lb

1876-6102 © 2017 The Authors. Published by Elsevier Ltd.
Peer-review under responsibility of the scientific committee of ICOME 2015 and ICOME 2016
10.1016/j.egypro.2017.11.228

1. Introduction

Several configurations in which a shear layer interacts with an obstacle can generate self- sustained tones. Self-sustained tones are generated due to a feedback loop which was described by [11,12]. Self-sustaining sounds related to aero-acoustic coupling occurs in impinging jets when a feedback loop is present between the jet exit and a slotted plate : the downstream-convected coherent structures and upstream-propagating pressure waves generated by the impingement of the coherent structures on the plate are phase locked at the nozzle exit. The upstream-propagating waves excite the thin shear layer near the nozzle lip and result in periodic coherent structures. The period is determined by the convection speed of the coherent structures and the distance between the nozzle and the plate [1,2,3,4,5,6,7,8,9,10]. Actually, in this case, the interaction between the flow and the obstacle generates an aero-acoustic source and the perturbation which is fed back upstream leads to a direct feedback path inducing an amplification of the flow fluctuations [16,18,19]. This feedback loop optimizes the transfer of energy between the aero-dynamic fluctuations, essentially incompressible, and the acoustic fluctuations [13,14,15]. The acoustic energy such created is principally distributed over well-defined frequency peaks. In this paper we consider a plane jet impinging on a slotted plate. The two-dimensional turbulent kinetic energy is calculated for different cases presenting low and high levels of the acoustic generation.

2. Experimental apparatus and procedures

A schematic of the experimental set-up is presented in Figure 1. A compressor (1) creates an air flow in the installation. This compressor is isolated from the experimental room and is commanded by a frequency controller (2) to regulate the air flow (the speed of air flow). The air flow is generated through a damping space (3) of 1m3 and a tube (4) of 1250 mm in length with a rectangular section (90×200 mm2) extended by a rectangular convergent (5), which provides a free jet of height H = 10mm and width Ly = 200mm. A 4 mm thick aluminium plate (6) (250×250 mm2) is fitted with a beveled slot (7) of the same dimension as the convergent outlet and is carefully aligned with the convergent using a gauge and a displacement system.

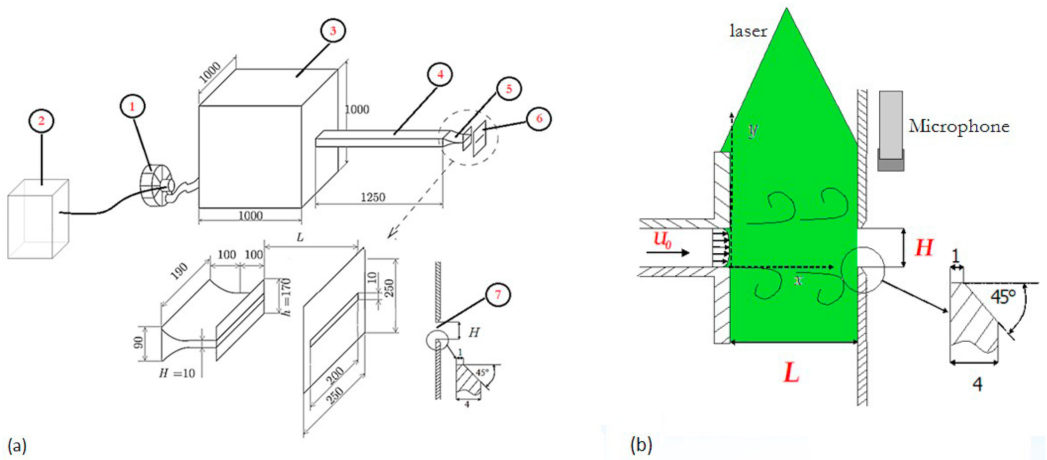

Fig. 1. Schematic of the experimental set-up (dimensions in mm). (a) The flow leaves the convergent section after entering a rectangular cross-section from a large settling chamber. (b) The geometry of the impinged plate

The distance from the impinged surface to the exit of the convergent section is denoted L. In this paper, the nozzle-to-plate distance is equal to 40 mm (L/H = 4). The origin is taken at the jet exit.

Simultaneous measurements of the acoustic pressure and velocity field were performed. A microphone was placed behind the plate, (away from the hydrodynamic disturbances) to measure the radiated sound pressure. The microphone was a B&K Free-Field 1/2 Type 4189, which has a sensitivity range from 7 Hz to 20 kHz.