Aerodynamics and Aeroacoustics Investigation of a Low Speed Subsonic Jet

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Low and high speed subsonic jets have been studied in the last 50 years mainly due to their many applications in industry, such as the discharge of turbojets and turbofan engines. The purpose of this work is to investigate the aerodynamics and the acoustical noise generated by a single stream jet flow operating at low Mach number 0.25 and Reynolds number of $2.1 \times 10^5$. The main focus is the flow and acoustical characterization of this low speed jet by applying different experimental techniques for evaluating the velocity field by using measurements with a Pitot tube, hot-wire anemometry, and farfield noise acquisition by free field microphones. In order to verify the validity of aeroacoustic predictions for such a low speed jet, a Computational Fluid Dynamics by means of RANS simulations via $k-\omega$ SST model have been employed coupled with a statistically low-cost Lighthill-Ray-Tracing method in order to numerically predict the acoustic noise spectrum. The sound pressure level as a function of frequency is constructed from the experiments and compared with the noise calculations from the acoustic modeling. The numerical results for the acoustics and flow fields were well compared with the experimental data, thus showing that this low-cost flow-acoustic methodology can be used to predict the acoustic noise of subsonic jet flows, even at low speeds.

NOMENCLATURE

$D_j$ Jet’s diameter [m]
$U_j$ Jet’s velocity [m/s]
$M$ Mach number
$k$ Turbulent kinetic energy [J/kg]
$\epsilon$ Turbulent dissipation rate [J/kgs]
$\theta$ Observer’s polar angles [rad]
$R$ Observer’s radius [m]

1. INTRODUCTION

The noise produced by an aircraft has been an important subject in the past few decades in both industry and academic research. It is well known that noise is generated by different components and by the interaction of external flow and the aircraft parts. According to the aircraft performance, during each phase of flight, one region or piece of equipment should contribute more or less to the "total noise." In other words, the aircraft on the ground, while taxing, is on a run-up from the jet exhaust; during the take-off, it is underneath to departure and arrival paths. If it is over-flying while in route and landing, it produces different noise signatures not only in terms of amplitude but also in its composition, as seen in Fig. 1.

According to Fig. 1, aircrafts have various noise sources, meaning that the engines are one of the major contributors to the total noise. At take-off and climb, the fan exhaust and jet are mainly responsible for the noise levels of an aircraft. During the approach, the engine noise is also considerable. Although high bypass ratio turbofans engines have expe-