37th AIAA Fluid Dynamics Conference and Exhibit
25 - 28 June 2007, Miami, FL

AIAA 2007-3858

Compressibility and Density Effects in Free Subsonic Jet Flows: Three Dimensional PIV Measurements of Turbulence

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The behavior of compressible subsonic turbulent jets issuing in still air has been investigated at three different subsonic Mach numbers, 0.3, 0.6 and 0.9. Helium, nitrogen and krypton gases were used to generate the jet flows and investigate the effects of density on the structure of turbulence. Stereo Particle Image Velocimetry was used in the present investigation. Helium jets were found to have the largest spreading rate among the three different gas jets used in the present investigation, while krypton had the lowest spreading rate. All jets attain self-similarity at downstream locations. Extremely large velocity fluctuations and correlations were measure in the case of helium jets.

Nomenclature

b_u	=	half width
C_P	=	Specific heat
D	=	jet exit diameter
M_C	=	convective Mach number
M_g	=	Gradient Mach number at jet exit
M_J	=	Mach number at jet exit
S	=	spreading rate, db_u/dx
S_{ij}	=	strain rate
U	=	longitudinal velocity
U_{CL}	=	velocity along centerline of jet flow
U_J	=	velocity at jet exit
γ	=	ratio of specific heat
η	=	$r/(x-x_0)$, similarity coordinate
ρ_J	=	density of jet gas
ρ_a	=	density of ambient air

I. Introduction

Although a substantial amount of work has been devoted in the past to study the behavior of turbulent flows, turbulence remains an unsolved problem for the science and engineering community. Thus a better fundamental understanding of the turbulent flow structure is essential. The most significant effect of compressibility on a free shear flow is the reduction in its growth rate. Early reference of this behavior can be found in Birch & Eggers (1972) and Bogdanoff (1982) and Papamoschou & Roshko (1988) used the concept of convective Mach number to characterize the shear layer compressibility. More detailed studies have shown a suppression of mixing-layer growth rate with increasing compressibility (see Chinzei et al. 1986; Papamoschou & Roshko 1988; Samimy & Elliott 1990;

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