N84 20542 D17

THE INFLUENCE OF LARGE-SCALE MOTION ON TURBULENT TRANSPORT FOR CONFINED COAXIAL JETS*

David C. Brondum and John C. Bennett

Mechanical Engineering Department
University of Connecticut

The existance of large-scale coherent structures in turbulent shear flows has been well documented in the literature (ref.1). The importance of these structures in flow entrainment, momentum transport and mass transport in the shear layer has been suggested by several researchers (ref.2,3). Comparisons between existing models and experimental data for shear flow in confined coaxial jets (ref.4,5) reinforce the necessity of further investigation of the large scale structures. These comparisons show the greatest discrepency between prediction and actual results in the developing flow region where the large scales exist. It was also observed that the momentum transport rate comparisons were very bad. Finally, Schetz (ref.6) has reviewed mixing flows and concluded that large-scale structures were essential aspects of future modeling efforts.

The present analytical effort is a follow-on to a previous contract (ref.7) under which the experimental data was collected. The data consists of all three velocity components as well as concentration data for a turbulent shear flow in a confined coaxial jet with a sudden expansion. The analysis undertaken is similar to that of Blackwelder and Kaplan (ref.3) which was an analysis of a turbulent boundary layer. As they discovered, the bursts within the boundary layer were found to contribute greatly to the momentum transport. As part of the previous contract effort, flow visualization was used extensively and identified large-scale structures within the shear layer. The appearance of these large-scale structures in the mixing layer has led to the search for a burst detector along with detection criteria. Preliminary conditional sampling of the data has been performed and has revealed much information about the transport processes. All analysis to this point has been limited to data acquired at one axial location (102 mm from the origin).

Various conditionally sampled parameters of the data have been plotted and trends observed. Initial efforts were directed toward

* NASA Grant #NAG 3-350

the use of these results in the identification of a suitable burst detector for the flow and also the development of better understanding of the effects on the flow (i.e., mass transport). One such plot is the scatter plot where the velocity fluctuation is plotted as a function of the concentration fluctuation or where fluctuation of one velocity component is plotted against the fluctuation of another velocity component. These types of plots help establish the existance of the large scale in the flow and assist in separating these structures from the general low level turbulence (Fig.1,2). They are also beneficial in determining if the large scale correlation is significant (non-zero, Fig.1 or zero Fig.2).

Other interesting parameters can be established from conditonally sampled data pairs that are contained in the large structure. Based on the scatter plots, the initial choice for a burst detector was large excursions (positive or negative) in concentration fluctuations. The first parameter investigated was the large scale fraction (or ratio of samples with large concentration excursions compared to the total sample size). Plotting this ratio as a function of radius (at a given axial location) yields some trends in the data (Fig.3). The percentage appears to be maximized in the shear layer where the large-scales are known to exist. This adds credibility to the choice of detector of course.

Having established some credibitity for the detector, the efforts were concentrated on the effects of large-scale structure on mass transport. Specifically, the ratio of conditionally-sampled mass transport to overall mass transport was plotted (Fig.4). As with boundary layers, the large-scale structures in shear layers appear to exert considerable influence on mass transport.

Having established procedures for investigating large-scale structures, future efforts will be directed toward several goals: (1) establishing a model of a typical 3-D structure, (2) investigating the regional extent of the influence of large-scale structures, (3) investigating the influence of large-scale structures on counter-gradient transport identified previously (Ref.7), and (4) investigating the recently completed swirl data for similar large-scale effects.

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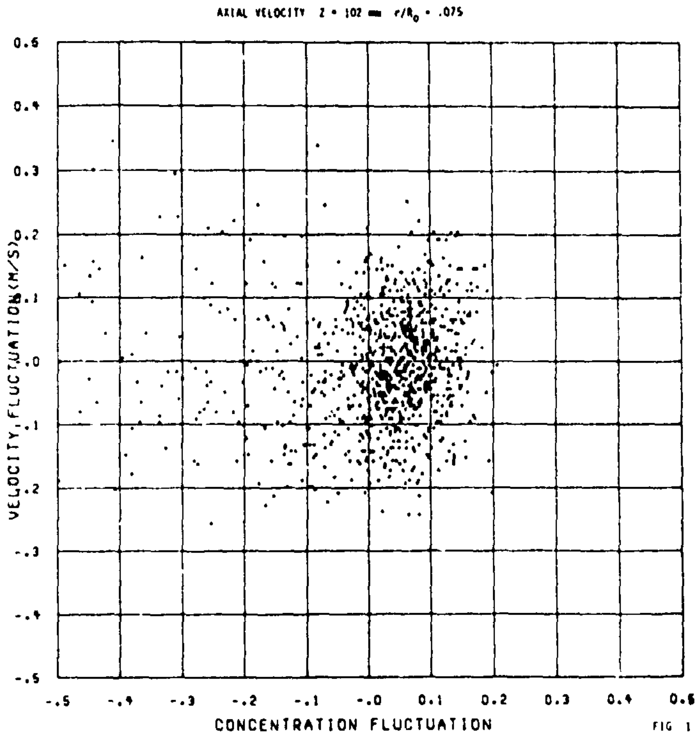

FIG 1

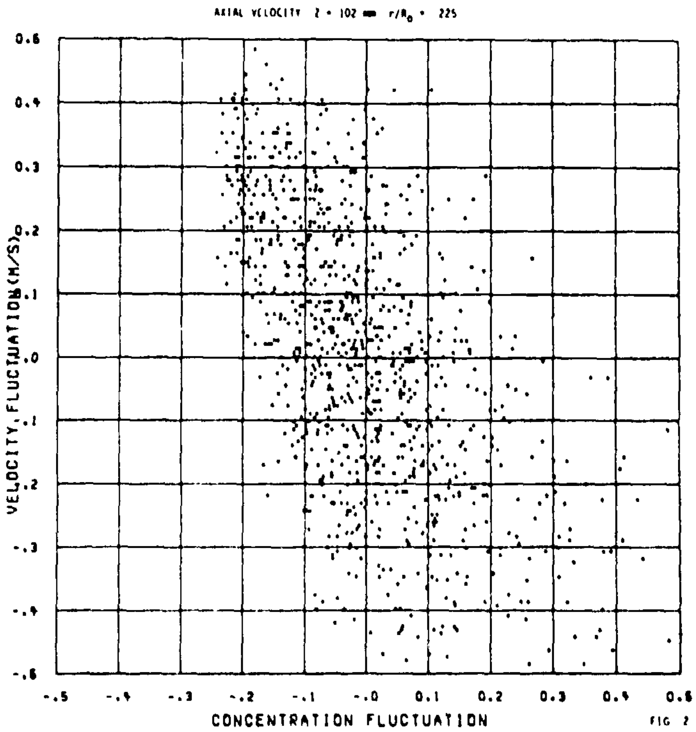

FIG 2

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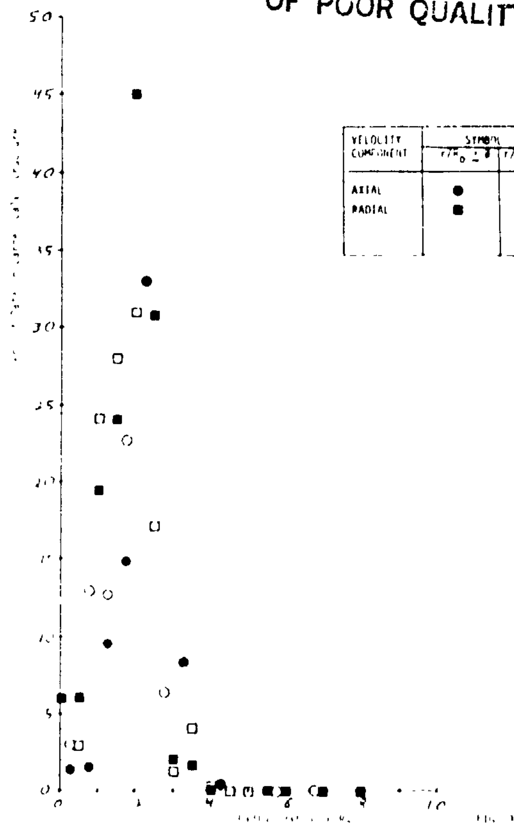

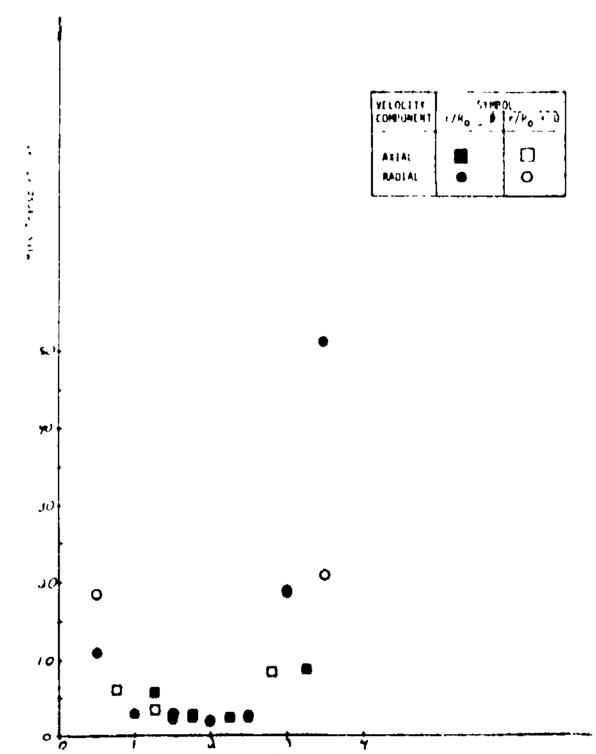

FIG. 4