STUDIES ON MIXING AND MASS TRANSFER ACROSS A SEPARATED SHEAR FLOW

By

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A THESIS PRESENTED FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

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Abstract

The study was concerned to examine the mixing and mass transfer processes in a separated shear flow with a free surface. The results of the experimental investigation yielded information regarding the flow field which are of fundamental importance and show effects not previously reported. These will provide a deeper understanding of the basic physical processes involved in mixing and mass transfer across the separated free surface flow field.

The experimental programme was conducted in three separate phases. In phase 1, flow visualization experiments were undertaken to obtain a qualitative understanding of the flow field. The most striking result of this visualization study is the realization of a pulsatile motion in the recirculating eddy in the separated flow region which can cause considerable differences in the mixing and mass transfer rates of such separated shear flows. A localized rapid mixing region in the separated shear layer was identified which is believed to be due to an interaction between the shear layer and the recirculating eddy in the separated region. The development and growth of the separated shear layer structures were found to have similarities and differences from those in other free shear flows, e.g., plane mixing layers.

The second phase of this experimental programme was concerned to the measurements of velocity field in the separated flow using a single channel laser-Doppler velocimeter. The results of this phase of experiments supported the findings of the flow visualization experiments and also provided useful information regarding the behaviour of the mean flow pattern and the turbulent characteristics for the separated shear flow considered. Analysis of the growth rate, similarity behaviour and the entrainment in the separated shear layer showed significant differences from the plane free mixing layer.

In phase III, tracer concentration measurements were undertaken at vari-
ous points of the separated flow region using electrical conductivity probes. The results, showing the temporal and spatial variation of concentration at different locations, provided an insight into the mass transport processes in the separated flow region. Mass transfer analysis and the demonstration of the effects of large coherent eddy structures in the separated shear layer indicated that the calculation of mass transfer rates applying conventional gradient transfer theory could lead to an improper estimate.