Abstract Submitted
for the DFD05 Meeting of
The American Physical Society

Analysis of Mass Transfer in Polymer Turbulent Boundary Layers
ANSHUMAN ROY, University of Michigan, Ann Arbor, ALES ALAJBEGOVIC, Exa Corporation, RONALD LARSON, University of Michigan, Ann Arbor — In this work, we address the problem of drag reduction in a turbulent boundary layer over a flat plate by polymer injection. To predict the mean concentration of a constant flux of injected polymer both in the gradient and streamwise directions, we have constructed a mean flow model that faithfully reproduces the mean velocity profiles seen in experiments and direct numerical simulations. The constructed mean velocity gradient is dependent on the local polymer concentration, friction factor and the distance from the wall. To analyze polymer mass transfer, we integrate the momentum equation in the wall normal direction, reducing it to a one-dimensional equation for momentum thickness (or equivalently, friction factor). The mass balance equation for this problem can be reduced to a turbulent advection-diffusion equation by invoking the Chilton-Colbourn analogy between turbulent mass and momentum transport and using a turbulent diffusivity that is analogous to eddy momentum diffusivity. A reduction in turbulent drag results in reduced eddy momentum diffusivity and consequently, reduced turbulent mass diffusivity. Finally, we compare the rates of polymer mass transfer predicted by our theory and those measured experimentally.

Anshuman Roy
University of Michigan, Ann Arbor

Date submitted: 03 Aug 2005 Electronic form version 1.4