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DNS of Drag Reduction by Dilute Polymer Solutions at MDR

DONG-HYUN LEE, RAYHANEH AKHAVAN, University of Michigan — The phenomenon of Maximum Drag Reduction (MDR) by dilute polymer solutions is investigated by DNS. The objective is to establish the flow features and critical parameters needed to reach MDR. Simulations are performed in turbulent channel flows at $Re_{\tau_o} \approx 230$ & 570 using a pseudo-spectral mixed Eulerian/Lagrangian scheme with either the FENE-P dumbbell or the FENE-LSMR chain models of the polymer and realistic polymer parameters. It is observed that the Weissenberg number (We_{τ_o}) is the critical parameter for achieving high drag reduction, with the other parameters, such as concentration, having little effect. Results to date suggest that a $We_{\tau_o} \sim Re_{\tau_o}$ is required to achieve MDR. At $Re_{\tau_o} \approx 230$, Virk's MDR asymptote is reached at $We_{\tau_o} \sim 100$. The flow statistics here agree with the experimental data of Ptasinski *et al.* [*Flow Turbulence Combust.* **66**, 159–182 (2001)]. At higher We_{τ_o}, DNS shows a relaminarization of the flow. The flow statistics during the intermediate states leading to relaminarization agree with the experimental data of Warholic *et al.* [*Exp. Fluids.* **27**, 461–472 (1999)]. At $Re_{\tau_o} \approx 570$, the highest We_{τ_o} we have so far achieved in DNS ($We_{\tau_o} \sim 300$) is not sufficient to achieve MDR. These results suggest that in poly-disperse polymer solutions, it is the trace amount of the highest molecular weight polymers which contribute most to drag reduction.

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