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Polymer Induced Drag Reduction: The Interplay Between Vortex Dynamics and Drag Reduction C.-F. LI, Jiangsu U., P.R. China, R. SURESHKUMAR, WUSTL, B. KHOMAMI, WUSTL and U. of TN — Hi-fidelity DNS of polymer induced DR in turbulent channel flows up to the maximum drag reduction (MDR) limit have been performed using a fully spectral method in conjunction with kinetic theory based elastic dumbbell models for the description of polymer chain dynamics. The simulation results over the friction Re number range of 125 to 395 have been extensively analyzed to decipher the effect of polymer additives on vortex dynamics and the extent of DR. Specifically, we have observed that from the onset of DR to MDR, the Deborah number defined as the product of an effective Weissenberg number and the rms streamwise vorticity fluctuation remains O(1) in the near wall region. This observation further underlines the intricate balance between elastic forces and average rotation speed of the near-wall axial vortices that mediate upwash and downwash events that give rise to Reynolds stress production. Moreover, it is shown that the average lifetime of axial vortices increases with increasing DR while their rotation speed decreases. However, the rate of decrease in the rotation speed exceeds the enhancement in lifetime of axial vortices as a function of DR. Hence. MDR is achieved when these time scales become nearly equal. This simple framework is capable and can adequately describe the influence of polymer additives on extent of DR from onset to MDR as well as the universality of the MDR in flow systems with polymer additives.

Bamin Khomami
Dept of Chemical Engr., WUSTL, MO 63130, and
Dept of Chemical Engr., Univ of Tennesse, Knoxville, TN 37996, U.S.A.

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