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The Process of Polymer-Turbulence Interactions leading to Polymer Drag Reduction JAMES BRASSEUR, ASHISH ROBERT, Penn State U, T. VAITHIANATHAN, LANCE COLLINS, Cornell U — In a previous study we showed that the statistical properties of polymer drag reduction (DR) in the equilibrium state are found in homogeneous turbulent shear flow (HTSF) with the FENE-P model. We concluded that DR results fundamentally from an interaction among mean shear, turbulence, and polymer molecules. Here we develop insight into the mechanisms that suppress drag by analyzing the activation of polymer-turbulence interactions in HTSF and the transition to the equilibrium state as s function of shear Weissenberg number. We show that the initial state of polymer-turbulence interactions is different from equilibrium. Although both states follow from the suppression of smaller-scale turbulence strain-rate fluctuations by polymer stretching, the details depend on the ultimate level of DR. At early times and in the very low DR equilibrium state, DR is a direct consequence of the small-scale energy transfer from turbulence to polymer. At longer times and at higher drag reduction, DR results from the full elimination of the small scales and the restructuring of the remaining large-scale large vorticity by mean shear that statistically manifests as a suppression of slow pressure-strain energy transfer into vertical velocity. MDR is an asymptotic state in which the mean gradient interacts with polymer to maintain turbulence.

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