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Theoretical and numerical study of air layer drag reduction in two-phase Couette-Poiseuille flow[1] DOKYUN KIM, PARVIZ MOIN, CTR, Stanford University — The objective of the present study is to predict and understand the air layer drag reduction (ALDR) phenomenon. Recent experiments (Elbing et al. 2008) have shown net drag reductions if air is injected beyond a critical rate next to the wall. The analysis is performed on a two-phase Couette-Poiseuille flow configuration, which mimics the far downstream region of boundary layer flow on a flat plate. Both theoretical and numerical approaches are employed to investigate the stability and mechanisms of ALDR. The linear stability of air-liquid interface is investigated by solving the Orr-Sommerfeld equations. From the stability analysis, the stability of the interface is reduced as the liquid free-stream velocity, Froude number and velocity gradients at the interface are increased, while the stability is enhanced as the gas flow rate and surface tension are increased. The Critical gas flow rates from stability theory are compared with experimental results, showing good agreement. Direct numerical simulations with a Refiend Level Set Grid technique has been performed to investigate the evolution of the interface, the turbulence interaction and nonlinear mechanisms of ALDR. It is observed that the Weber number has significant impact on the characteristics of the interface development.

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