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A NEW APPROACH FOR SOLVING THE OLDROYD-B MODEL FOR 3D FREE3 SURFACE FLOWS

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This work presents a new implementation of the Oldroyd-B model to simulate three-dimensional viscoelastic free surface flows of highly elastic fluids. The classical EVSS methodology [1] for solving the Oldroyd-B model splits the total extra stress into a sum of a solvent Newtonian stress with a modified elastic stress. However, it has been reported that this transformation can cause problems of numerical convergence when solvent viscosity (η_S) becomes very small. In this modified EVSS approach, the total extra stress split is written also in terms of an elastic tensor but the Newtonian stress tensor is now defined in terms of the total viscosity ($\eta_0 = \eta_P + \eta_S$) instead of just using η_S, thus, eliminating the causes of instability when $\eta_S \to 0$. The Oldroyd-B equation written in terms of the conformation tensor A is solved using the log-conformation tensor transformation and its stress is then transformed into the modified stress to be used in the solution of the momentum equation. The mass and momentum equations are solved by the GENS-MAC3D method [2] which employs the finite difference method on a staggered grid and models the fluid (also the free surface) by a modified marker and cell method [2]. This new methodology is more robust than the previous method based on the classical EVSS as the numerical method always converges even when $\eta_S = 0$. The implementation of the log-conformation technique is verified by simulating the flow in a 3D pipe and a jet impinging on a solid flat surface. Numerical results include the simulations of jet buckling and extrudate swell for high Weissenberg numbers. Moreover, it is demonstrated that if the solvent viscosity tends to zero then the Oldroyd-B results converge to those obtained with the corresponding UCM model.

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