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COMPUTATION OF TRANSIENT VISCOELASTIC FLOW PROBLEMS APPROXIMATED BY A VMS STABILIZED FINITE ELEMENT FORMULATION USING TIME-DEPENDENT SUBRID-SCALES FOR MONOLITHIC AND FRACTIONAL STEP SCHEMES

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Recent studies indicate that classical residual-base stabilized methods for unsteady incompressible flows may experience difficulties when the time step is small in relation with the spatial grid size. The aim of this work is, on the one hand, the design of finite element stabilized techniques based on the Variational Multiscale (VMS) method that allow to compute time-dependent viscoelastic flow problems with high elasticity and considering an anisotropic space-time discretization. Although the main advantage is to achieve stable solutions for anisotropic space-time discretizations, other benefits related with elastic problems are proved in this study. In particular, the proposed methods are designed for the standard and logarithmic formulations in order to deal with high Weissenberg number problems, ensuring stability in all cases. A comparison between formulations and stabilization techniques will be performed to demonstrate the efficiency of time-dependent sub-grid scales and term-by-term methodologies. On the other hand, fractional step methods are introduced also at the purely algebraic level, when the equations have already been discretized in space and in time, considering the dynamic sub-grid scales. The aim of introducing this schemes is the reduction of the computational cost, validating the results in some numerical examples. In case of viscoelastic flows, the main difficulty is the appearance of the stress, a new variable that evolves in time or, in the log-formulation case, the variable ψ. This uncoupling will need to satisfy two conditions: on the one hand the stability of the time discretization must be preserved together with the order accuracy. In this algebraic level, such as it is explained, apart from uncoupling velocity from the pressure in the momentum equation, it is necessary to uncoupled the elastic stress. All of these tools are validated suitably in different numerical examples, where the savings in computational cost are highlighted for the fractional step schemes together with the benefits of using time-dependent subgrid-scales.