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NON-NEWTONIAN VISCOUS ELONGATION AND SHEAR FLUID MODEL BASED ON OPTIMAL TRIPLE TENSOR DECOMPOSITION

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The modelling of the distinct non-Newtonian fluid properties is an essential prerequisite for the computational simulation of associated flow fields. In particular, some non-Newtonian fluids reveal strong unequal viscosity response behaviours to irrotational straining or elongational and pure shearing flows. Therefore, it is necessary to be able to distinct between these flow types even in complex flow configuration. Unfortunately various flow types are occurring naturally mixed and its distinction becomes difficult. Most CFD approaches prefer the Eulerian framework, accepting to loose the natural flow path alignment of moving and deforming fluid particles, a benefit of the Lagrangian framework, where the fluid element's deformation can be tracked naturally. Hence, in fixed-grid based approaches pure shearing and irrotational straining rates are barely separable [1]. In this work a decomposition method developed in the context of vortex dynamics is presented, which allows to distinct between these flow types and enables a novel non-Newtonian fluid modelling. In vortex dynamics the problem occurs to separate shearing effects from vortical rotation in order to examine purely vortex induced hydro- and aerodynamic flow effects. Although various separation methods were proposed [2], the most stringent kinematically interpretable decomposition was introduced by Kolář [3], the so called optimal-triple-tensor decomposition, which is able to separate not only vortical from shearing flows but also, after some modification, irrotational straining from pure shearing flows. In this work this decomposition method and its algorithmic extension is now used to calculate elongational and shearing rates mandatory as input variables into classical non-Newtonian fluid models [1] for the calculation of the local elongational and shear viscosities. After the explanation of the resulting fluid model characteristics a 4:1 contraction channel flow, often used in literature, is investigated as application show case. Thereto, for a specific Carreau fluid model-parameter values have been taken from literature [1]. Then, in a case study the impact of the additionally modelled irrotational strain rate on the flow field is shown and discussed. Associated flow separation and attachment structures are investigated. It is demonstrated that the modelling of different viscous elongational and shear-thinning fluid properties affects significantly the contraction flow topology.

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