Flow of an elasto-viscoplastic fluid around a blade by means of the FEM with Lagrangian Integration Points (FEMLIP)

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ABSTRACT

Industrial processes include complex fluids often used for specific needs such as dip-coating and removal of objects embedded in those fluids. Therefore, a better understanding of their behaviour may help to better respond to the needs. In this context, this numerical analysis focuses on the creeping flow of a yield stress fluid (carbopol gel) around a blade.

In order to deal with large deformation processes of complex materials in the continuum mechanics framework, the Finite Element Method with Lagrangian Integration Points is used [1]. This method originates from the Particle-In-Cell method for which the numerical integration weight is recomputed in each configuration in order to keep the finite element properties of the Gaussian integration scheme. Indeed, the Lagrangian particles owing all constitutive and history variables are used in a given configuration as integration points in order to compute the nodal velocity field. At the end of a step, the particle positions are updated based on the velocity field and by means of FE shape functions. This method has already been applied to geophysics [2], fresh concrete flow [3] and landslides [4].

Based on the unified constitutive law recently developed in [5], a 3D Herschel-Bulkley model has been implemented in numerical tool based on the FEMLIP. The yield stress is detected by means of the second invariant of the Cauchy stress tensor and the material behaves elastically below the yield stress.

The originality of the study relies on the understanding of the flow properties especially below the yield stress. The numerical results in terms of velocity field and analysis of the unyielded zone are then compared to the experimental results based on PIV measures.

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