Best Practice Guidance Seminar

CFD for Dispersed Multi-Phase Flows 2018

Lecture on: **Flow modelling of concentrated fibre suspensions**

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Fibre suspension flows seem to be one of the most challenging flow configurations. Although a lot of work has been done in the field of multi-phase flow modelling, the existing knowledge is still far from being capable to describe the behaviour of flowing suspension using general constitutive formulas. While for typical solid particles (successfully modelled as spheres) or bubbles Eulerian approach may provide quite satisfactory solutions even for consistencies exceeding 10%, for fibre suspensions their mass content at the level 0.1% leads to the significant change of flow character and strong non-Newtonian behaviour. Fibres, i.e. objects with high length-to-diameter aspect ratio, create a network with the local non-uniformities (flocs) being responsible for the appearance of additional (even dominating) shear forces strongly varying with shear rate, fibre type and consistency as well as with their process history. Various modelling strategies find their application to predict fibre suspension behaviour, starting from particle-level simulations, through the meso- to the macro-scale simulations.

Modelling fibre suspension flows with multi-phase models

A significant progress in modelling of fibre suspension flows, allowing to formulate more general constitutive relationships, may be achieved by applying a 2-phase flow modelling strategy. With this approach it is possible to capture the discrete character of fibres and in turn to model their motion including orientation, deformation and interactions. With 2-phase flow modelling two different approaches may be considered:

i) Lagrangian approach - regarding fibres as discrete objects, moving, deforming and interacting with themselves and flow boundaries, allowing for detailed modelling of suspension behaviour including its viscosity (as a result of internal stresses),

ii) Eulerian - describing discrete phase in statistical way, i.e. enabling to determine distributions of fibre consistency and orientation, by solving convection-dispersion equation.

Predicting pulp behaviour with the use of single-phase continuum rheology

Fibre suspensions at medium and high consistencies may hardly be described as multi-phase fluids. The multilateral interactions between fibres make it too expensive to consider them as discrete objects and to predict suspension properties and dynamics. The presence of air bubbles leads to additional problems in flow description. As commonly agreed a single phase approach treating pulp as continuum seems to be the best simulation methodology providing reliable solutions. With this approach the material properties have to be modelled with the use of rheological laws.

Turbulence modelling

One of the important challenges is to capture the mutual interactions between fibres and turbulence. The presence of fibres change the nature of dissipation of the turbulent energy. It is believed that it leads to the well-known effect - the reduction of the turbulent friction drag observed experimentally at low fibre concentrations. Classical turbulence models fail when applied to fibre suspensions as they do not capture the specific features of fibres and their interactions with turbulent eddies. However, the application of modified low-Re turbulence models seem to be promising at least in predicting pressure drop in pulp transport installations.