Numerical modelling of highly swirling flows in a cylindrical through-flow hydrocyclone

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ABSTRACT

Three-dimensional turbulent flow in a cylindrical hydrocyclone is considered and studied by means of computational fluid dynamics using software packages CFX and Fluent. The aim has been to identify the methods that can be used for accurate simulation of the flow in three-dimensional configurations in hydrocyclones at high swirl numbers.

As a starting point, swirling pipe flows created by tangential inlets, where detailed experimental data were available in literature, were considered. It was found that the velocity profiles for the flow with a swirl number of 2.67 could be predicted accurately using a Reynolds stress model and an accurate numerical discretization on a fine-enough mesh. At a higher swirl number, 7.84, under-prediction in the tangential velocity profiles was observed; however the prediction of the axial velocity profiles was satisfactory. The validated methods were then used to simulate the flow in a cylindrical hydrocyclone at a swirl number as large as 21. The calculated tangential velocity profiles were compared against experimental data measured with a pitometer. Acceptable agreements were recorded except near the geometric axis of the cyclone. Due to the lack of the aircore in the numerical model, disagreements near the axis of the cyclone could be expected to some extent.

Numerical experiments performed in the present work indicated that the RNG k-ϵ model is not likely to be capable to predict highly swirling flows accurately and a Reynolds stress model is required. For three-dimensional models, where the computing capacity and the available memory set strong restrictions on the computational mesh, optimizing the maximum mesh resolution available play an important role on the accuracy and stability of the solution procedure. The most stable results in the present study were found using the Reynolds stress model proposed by Launder *et al.* on an as regular and structured mesh as possible using a higher order discretization scheme in Fluent. Therefore, the meshing capabilities of the pre-processor, the available turbulence models and the accuracy of the numerical methods must be considered in parallel. Acceptable results were also generated using the Baseline Reynolds stress model implemented in CFX, however, only with a transient procedure which was likely to be more time-consuming.

Present simulations present a complex flow structure in the cylindrical cyclone with a double axial flow reversal. The effect of such a flow pattern on the fractionation of the fibres with small differences in density needs to be investigated in future studies.

Descriptors: Hydrocyclone, fractionation, turbulence modelling, swirl flow, Fluent, CFX