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PA37) Flow Analysis within a Small Reverse Flow Cyclone

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1. INTRODUCTION

Cyclone separators are widely used for cleaning gas streams or for catalyst recovery. For many years, the complexity of the gas flow pattern in cyclones has been a matter of many experimental and theoretical work. At present, precise flow measurements have been performed by means of LDA and hot-wire anemometry (Patterson and Munz, 1996; Hoekstra et al., 1999; Peng et al., 2002). In the theoretical work, Computational fluid dynamics (CFD) codes are frequently employed for simulating cyclone gas-particle flows(Hoekstra et al., 1999).

As a part of our work to understand the effects of dimensions on the cyclone performance, numerical simulation of the flow pattern within a small reverse flow cyclone was performed in this study.

2. NUMERICAL MODEL

Due to the complexly shaped flow domain, flow field in a cyclone is usually treated as being axisymmetric and the simulation is performed on a 2-D axisymmetric geometry (Hoekstra et al., 1999). However, the flow asymmetry has also been discussed in the literature. Therefore, flow analysis in our study is conducted through 3-D simulation rather than 2-D. In the computational model, the gas flow rate is simply imposed by a uniform velocity in the cyclone inlet. The cyclone being modelled is a small reverse type cyclone with body diameter of 31mm and overall height of 71mm.

The simulation was performed with the commercial CFD package FLUENT 5.5. According to the previous simulation work, the RNG based $k - \varepsilon$ model was employed to model the swirling turbulent flow in the cyclone. Differential viscosity model and Swirl dominated flow option were enabled to account for the low Reynolds effect and the strongly swirling in a cyclone.

3. RESULTS

Figure 1 shows the radial profiles of the tangential velocity at various axial stations in the vertical plane through the center of the cyclone body. This vertical plane is parallel to the tangential inlet of the cyclone.

Although it is not possible to judge quantitatively the accuracy of the simulation due to the lack of experimental data, it can be seen from the figure that the simulation captures the well - known features of the flow within a reverse type cyclone. The tangential velocity profiles show the expected combined vortex, consisting of an outer free vortex and a solid body rotation at the core region. In the outer vortex region, tangential velocity increases with decreasing radius, up to a maximum at the demarcation between the inner and outer vortex region. Within the inner vortex region, tangential velocity decreases with decreasing radius, and falls ultimately to a value near zero at the cyclone geometrical center.

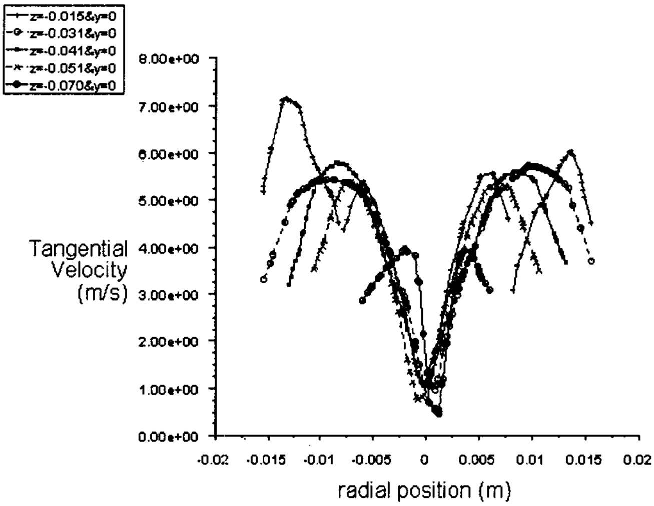

Fig. 1. Tangential velocity profiles at various axial stations in a vertical plane

Preliminary results discussed above show that CFD could be very helpful in investigation of the flow field inside a cyclone. Further work is ongoing to understand the effects of cyclone dimensions on the cyclonic flow.

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