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NUMERICAL ESTIMATION OF THE PARTICLE COLLECTION EFFICIENCY OF A CYCLONE SEPARATOR

Paweł KOZOŁUB, Wojciech ADAMCZYK, Ryszard BIAŁECKI, Gabriel WĘCEL
Institute of Thermal Technology, Silesian University of Technology, Gliwice, Poland
E-mail: pawel.kozolub@polsl.pl

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Cyclone separators are widely used in various branches of industry for the separation of solid particles from air or process gases. An important application of these type of devices are in Circulating Fluidized Bed (CFB) installations, where they are used for the separation of recirculating material. Cyclones utilize the centrifugal force caused by the swirling motion of fluid as a separation mechanism. These type of particle separators gained their popularity due to simple design, low manufacturing and maintenance costs. Moreover, they have a relative high efficiency and ability of operating at wide ranges of temperature and pressures which make them accessible for adaptation to the specific installations.

The pressure drop through the cyclone and particle collection efficiency are the key parameters that characterize the cyclone performance. They depend on the cyclone geometry and operating conditions (e.g. gas inlet velocity, particle mass loading). The work presents numerical simulation of the flow inside a cyclone separator carried out by the commercial Computational Fluid Dynamics (CFD) code ANSYS FLUENT. Based on the flow field solutions the cyclone pressure drop and separation efficiency is obtained. Despite the simple design of a cyclone, the flow pattern inside this device is very complex. The swirling fluid motion has high turbulence level and strong anisotropy. Standard turbulence models based on eddy viscosity (k-epsilon) are insufficient to model this type of flows. Thus, the accurate CFD solution requires more advanced turbulence models such as Reynolds Stress Model (RSM) or Large Eddy Simulation (Shalby et al., 2005 and Slack et al., 2000). The difference in velocity profiles obtained by the use of different turbulence models in comparison with experimental data (Solero et al., 2000) is presented in Fig. 1.

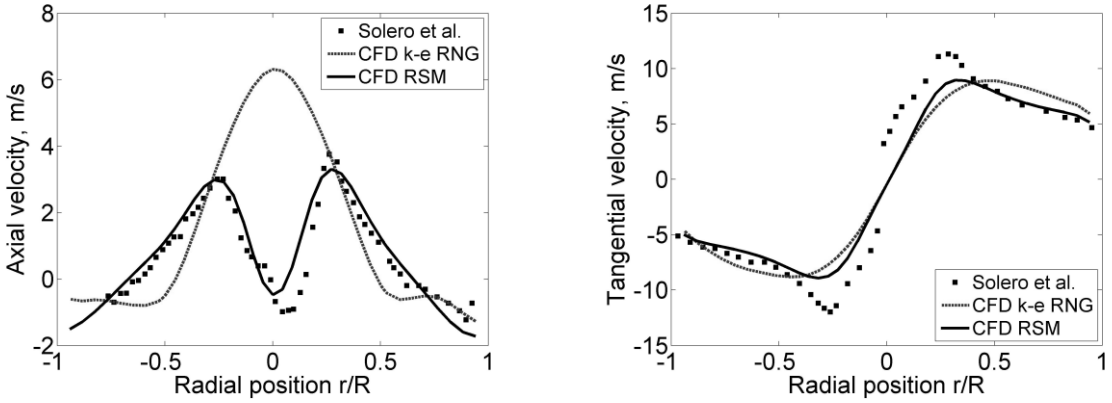

Fig. 1. Radial profiles of axial and tangential velocities at 330 mm of the cyclone height

In order to estimate the cyclone separation efficiency two-phase flow simulation is required. The gas and solid particles flow can be modeled by the use of Euler-Lagrange approach. In this methodology the trajectories of individual groups of particles are tracked during their flow through the continuum fluid. In the present work the Discrete Phase Model (DPM) implemented in ANSYS FLUENT is used. The cyclone separation efficiency is obtained by calculating the mass of particles of different sizes which are collected within the cyclone. The calculations are performed for the conditions of experiment described in (Cristea et al., 1996). Fig. 2 presents the separation efficiencies of particles with different diameter sizes, which are obtained by CFD simulations. The calculated total cyclone separation efficiency value is in an agreement with experimental data.

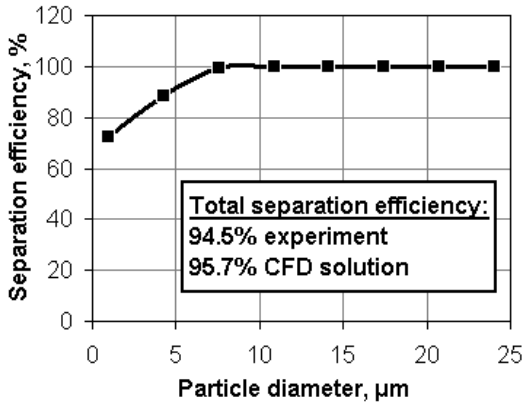

Fig. 2. Computed separation efficiencies of particles with different diameter sizes

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