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TUNING THE DRAG COEFFICENT USED IN DISCRETE PHASE MODELLING TO PREDICT THE TOTAL COLLECTION EFFICIENCY OF A STANDARD CYCLONE PARTICLE SEPARATOR

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ABSTRACT

Experiments accompanied by simulations were conducted on an industrial-sized conventional cyclone particle separator to determine baseline metrics. The objective was to determine a modelling configuration that accurately predicts the motion of particulate matter (PM). This configuration will be used in the simulations of dynamic cyclones with the intent of finding an optimal classifier design.

The cyclone used in this work had a diameter of 0.496 m and a height of 2.242 m. The experiments were carried out at four mass flow rates (0.315-0.552 kg/s) and a constant powder feed rate (3.5 g/s). The PM tested was cornstarch with a mean particle diameter of 18 μm and a density of 1500 kg/m^3. The total collection efficiency (mass of PM collected / mass of PM injected) in the experiments ranged from 96-99%.

The turbulence closure models used in the numerical simulations were scrutinized for their ability to predict the strong swirling flow found in cyclones. The Standard k-ε and Reynolds Stress Model (RSM) closure models were evaluated as the former is computationally efficient and the latter offers increased accuracy when simulating swirling flows.

The PM motion was simulated using Fluent's discrete phase model (DPM). The simulated PM had a comparable particle size distribution to the cornstarch. The total collection efficiency found in the simulations using a drag law formulated for spherical particles was 100%, and as such, calibration of the drag force was required to decrease the total collection efficiency to that observed in the experiments. A drag law for non-spherical particles (using a shape factor) was used to increase the drag coefficient. However, due to the small particle Reynolds number, the drag coefficient was only slightly increased using this method. A user-defined-function was then adopted to apply a spherical-particle drag law with a multiplication factor to further increase the drag coefficient. The multiplication factor value was adjusted until the simulated total collection efficiency matched the collection efficiency observed in the experiments. The multiplication factor is justified because the assumption that cornstarch is perfectly spherical or elliptical in shape or having a smooth surface is not realistic.

Using the RSM turbulence model and the multiplication factor on the drag coefficient provided superior simulation of the PM motion inside the cyclone, yielding a more accurate prediction of the collection efficiency. Higher accuracy in the prediction of the collection efficiency provides greater confidence in determining the optimal classifier design used in the dynamic cyclone.

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