Performance of Hot Gas Cyclone Separating Particles with Different Shapes: An Euler/Lagrange Study

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In biomass gasification plants, the behaviour of non-spherical particles, ranging from regular shapes like cylinders, cubes, or cones to irregular forms such as mixed wood chips, softwood pellets, and rape straw pellets, plays a pivotal role in system performance. Despite their ubiquity, particulate flow studies often simplify particles as perfect spheres or approximate them using regular shapes due to the complexity of characterising irregularly shaped particles and their associated drag forces. Unfortunately, little is known on the effect of particle non-sphericity on transverse lift forces, which are also important in a cyclone flow environment. Therefore, spherical particle lift force formulations are only applied at the moment (Sommerfeld & Taborda, 2024).

This study evaluates and compares drag force relations for non-spherical particles using shape descriptors such as sphericity, equivalent diameter, and base height (Bagheri & Bonadonna, 2016). The LES Euler/Lagrange approach implemented in Open FOAM is employed for simulating the performance of a gas cyclone for isothermal cases and at elevated temperatures. Drag coefficient models proposed by Haider and Levenspiel (Haider & Levenspiel, 1989), their modifications proposed by (Ganser, 1993) and an empirical relation based on shape descriptors as referenced in the literature Particle Shape Matters by (Suri & Patel, 2024) are applied to represent non-spherical particles. The results are then compared with those for spherical particles under the same cyclone operating conditions. Additionally, heat transfer characteristics are analysed through Nusselt number correlations, also accounting for particle non-sphericity. and cyclone grade efficiency is assessed for non-spherical particles. Thereby, the sensitivity of the numerically computed grade efficiency curves on the applied drag force formulations will be analysed in detail.

By examining drag, heat transfer, and efficiency for non-spherical particles, this work contributes to optimizing cyclone performance in an industrial biomass gasification process.

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