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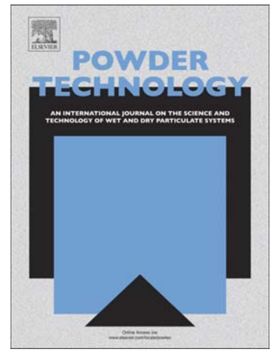

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On the drag of freely falling non-spherical particles

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Abstract

We present a new general model for the prediction of the drag coefficient of non-spherical solid particles of regular and irregular shapes falling in gas or liquid valid for sub-critical particle Reynolds numbers (i.e. $Re < 3 \times 10^5$). Results are obtained from experimental measurements on 300 regular and irregular particles in the air and analytical solutions for ellipsoids. Depending on their size, irregular particles are accurately characterized with a 3D laser scanner or SEM micro-CT method. The experiments are carried out in settling columns with height of 0.45 to 3.60 m and in a 4m-high vertical wind tunnel. In addition, 881 additional experimental data points are also considered that are compiled from the literature for particles of regular shapes falling in liquids. New correlation is based on the particle Reynolds number and two new shape descriptors defined as a function of particle flatness, elongation and diameter. New shape descriptors are easy-to-measure and can be more easily characterized than sphericity. The new correlation has an average error of $\sim 10\%$, which is significantly lower than errors associated with existing correlations. Additional aspects of particle sedimentation is also investigated. First, it is found that particles falling in dense liquids, in particular at $Re > 1000$, tend to fall with their maximum projection area perpendicular to their falling direction, whereas in gases their orientation is random. Second, effects of small-scale surface vesicularity and roughness on the drag coefficient of non-spherical particles found to be $< 10\%$. Finally, the effect of particle orientation on the drag coefficient is discussed and additional correlations are presented to predictthe end members of drag coefficient due to change in the particle orientation.

drag coefficient, terminal velocity, free fallparticle shapenon-spherical, irregular

1. Introduction

Non-spherical particles are encountered in numerous fields of science and engineering, such as chemical engineering, civil engineering, mining engineering, physical sciences, biology and earth sciences [1,2]. The category ofnon-spherical particles, in general, includes both regular (e.g. ellipsoid, cube, cylinder) and irregular shapes (e.g. pharmaceutical powders, spore, pollen, coal particles, cosmic and atmospheric dust, sand, pebble, volcanic particles). Nonetheless, in many studies that deal with particulate flows, particles are assumed to be perfect spheres. This is mainly due to the fact that the shape characterization of irregular particles is a complex process and numerous shape descriptors have been developed in the past

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