84e Particle Attrition during Dense and Dilute Phase Pneumatic Conveying

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We present an analysis of gas-solids flow in a pneumatic conveying line wherein by collisions with the wall, the particles undergo breakage. Knowledge of particle attrition, the often-undesirable damage to particles, is necessary for design of many fluid-particle operations. For example, proper design of cyclones requires knowledge of the amount and size distribution of fines produced from attrition. In the past, attrition effects have been gross estimates based on the extent of exposure to the breakage-prone environment.

This study uses population balances and kinetic theory to describe how the local variables, such as the particle velocity, the particle volume, and the volume fraction of the conveyed phase at a specific point in the system, affect the rate of attrition at that point. Particle breakage, which modifies the average size of the particles, affects the characteristics of the multiphase flow. Specifically, the kinetic theory constitutive models proposed by Lun et al. (JFM, 1984) for the particle phase stress tensor are dependent upon the diameter of the particles. In this study, the typical equations for multiphase flow, conservation of mass, momentum and energy for both the gas and particulate phases (as implemented by Sinclair and Jackson (AIChE J, 1989), Zhang and Reese (AIChE J, 2003) and others), are now coupled in the computational fluid dynamics with additional equations for the particle size distribution. Simulation yields the particle size distribution as a function of downstream distance and pipe radius.

The amount of attrition varies depending upon the operating conditions of the conveying system – whether the particles are conveyed in the dense or dilute phase, for example. Computationally, a wide range of conditions can be simulated and compared, including the behavior of many different types of particles. As attrition is typically an abrasive breakup of particles, a wide range of resultant sizes may occur. This diversity of sizes can lead to a miscellany of flow behavior. Additionally, in comparison to the previous studies of gas-solids flow without breakage, there is an additional sink of fluctuation energy at the walls, which represents the extra energy necessary to break apart the particles. How the various operating conditions and the breakage events affect the multiphase flow is explored.