ABSTRACT

Aphale, Atul, M.S.M.E., Purdue University, August, 2003. Segregation of Granular Fertilizers. Major Professor: Dr. Carl Wassgren, School of Mechanical Engineering.

Segregation of agricultural fertilizer blends is an undesirable phenomenon. Significant costs in yield, equipment, labor, and pollution can be attributed to the poor distribution of granular fertilizer blends. A number of previous studies have investigated the particle dynamics of granular fertilizers as well as segregation of blends during handling. However, there have been no studies investigating segregation of fertilizer blends during the spreading process. This thesis presents the first work to investigate, both experimentally and analytically, segregation of fertilizer blends from a spinner spreader.

Measurements of the material properties significant to segregation are made for sixteen commercial granular fertilizers. These properties include particle size, shape, density, aerodynamic resistance coefficient, and coefficient of friction. The aerodynamic resistance coefficient is the most significant physical property affecting the off-spinner particle dynamics as it combines information on particle size, shape, and density. The properties measured here are compared with those reported in the literature.

Analytical models are developed for fertilizer particle on-spinner and off-spinner dynamics. The on-spinner models include the effects of frictional, Coriolis, and centrifugal forces acting on the particle and assume either pure-sliding or pure-rolling conditions. The off-spinner model includes gravitational and steady drag forces. The on-spinner model predicts the experimentally measured radial velocity of particles reasonably well. The off-spinner model predictions are less accurate when compared to experimentally measured mean deposition distances. Additional analyses show that drop radius and mass flow rate have a relatively small effect on the distance a particle travels from the spinner while the aerodynamic resistance coefficient and wind speed play a much more significant role.

Measurements of the mass fraction distributions are made experimentally. Estimates of segregation are made utilizing a deposition efficiency, defined as the mass of deposited fertilizer that is within allowable proportions to the total mass of deposited fertilizer. Deposition efficiencies of less than 50% are observed despite the component materials having nearly identical mean distribution distances. In addition to deposition efficiency, the concept of a “virtual blend” is presented whereby the mass ratio distributions of the component species in an actual blend can be modeled using linear combinations of the single species mass fraction distributions. Experimental measurements indicate that the virtual blend concept is reasonably accurate.

Lastly, three approaches are proposed to improve the deposition efficiency of fertilizer blends including modifying the overall blend component proportions, modifying the component mass fraction distributions, and modifying the spreader pass distance. The recommended approach for reducing blend segregation from the spinner is to modify the spinner plate geometry or dynamics so that the standard deviations of the mass fraction distributions are increased.