ANALYSIS OF PNEUMATIC CONVEYING OF PARTICLES

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Abstract - **A one-dimensional model for pneumatic conveying of particles is presented. The model includes momentum transfer between gas and solid phases. A plug-flow model assumption is made for the pipeline model and the non-spherical shape of particles is considered in drag coefficient. The set of coupled non-linear ordinary differential equations is solved numerically for the velocity of particles and air along the duct. The model is applied to simulate the conveying of particles under different conditions. Effects of pipe diameter, velocity and temperature of air, shape and size of particle, and flow direction on pressure drop are studied.**

Keywords - Pneumatic conveying, drag coefficient, shape factor.

I. INTRODUCTION

Pneumatic conveying systems are pipeline conveyors (with different arrangements) for transporting particles of solid materials from one point to another in a plant. Basically, they consist of a source of compressed air, a feed device, a conveying pipeline, and a receiver to disengage the conveyed material and carrier gas. The different flow directions, shape and size of particles and cost are discussed in the literature (Kraus, 1986; Mills, 1986, 1999).

Pneumatic conveying systems can carry a considerable amount of solid at a low cost and permit storage in silos or storage areas. A variety of processors employ pneumatic conveying to move agricultural, pharmaceutical, chemical and powdered-metal products. Fertilizers and food products (sugar, tea and rice) are transported in plants using this method. Petroleum and plastics industries also use the pneumatic pipeline (Mills, 1990).

The design of pneumatic conveyors includes pipe size, air flow rate, overall pressure drop and flow pattern in the pipe: *dilute phase flow*, in which the solid particles are carried as a dispersed suspension with low volumetric solid concentration, or *dense phase flow*. In dense phase flow, two types of flow can be distinguished: slugging dense phase flow and dense phase flow without slugging. For systems in which dense phase slugging occurs, the transition point from upflow of solids as a dilute phase to slug flow is referred to as the choking point (Leung & Wiles, 1976). Considering the velocity ratio between air and solid phase, other regimes of flow could appear (Bohnet, 1985).

The literature has presented several works about modeling of conveying systems but in most of them vertical flow direction and spherical geometry for particles have been considered. Reedi & Pei (1969) studied particle dynamics of narrow spherical glass beads transported vertically by a turbulent air stream in a 10 cm. i.d. pipe. They concluded that the particle axial velocity profile in the pipe core region was found to be similar to that of the gas and to follow a power-law type relationship. Arastoopour & Gidaspow (1979), calculated pressure drop in vertical transport of solids using four hydrodynamic models: a relative velocity model, a model with pressure drop in the gas and solid phases, and a model with pressure drop in the gas phase only. They concluded that pressure drop and choking behavior in dilute phase vertical pneumatic conveying can be predicted using a relative velocity hydrodynamic model. Molerus (1980), analyzed pneumatic conveying of suspensions in a horizontal tube and derived dimensional equations for the additional pressure drop in the transport of both fine and coarse particles from the power loss between fluid and particle. In particular, the contributions of individual mechanisms (particle-wall friction of sliding particles and losses due to particle-wall and particle-particle collisions) can be found from the total pressure drop. Kmiec (1986) developed a hydrodynamic model for the vertical pipe section of a pneumatic drier and he studied the effect of the pipe roughness. More recently, Lampinem (1991) analyzed the pressure drop for pneumatic conveying pipe flow and derived a equation for calculating the pressure drop based on two parameters: the velocity difference between gas and the falling velocity of material in the vertical pipe.

Modeling the flow of solid and gas phases and calculating its pressure loss is important in the design of pneumatic conveying. The motivation of this work was to find a mathematical model to simulate a conveying line, taking into account the pneumatic transport of particles with different geometry and the effects of elbows and different direction flow on pressure drop. Then, this work pretends to show the ability of this model to fit the experimental data rather than to compare with available mathematical schemes in the literature. For this reason, the simulation results