

Prediction and improvement of the solid particles transfer rate for the bulk handing system design of offshore drilling vessels

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Received 16 May 2015; Revised 11 July 2015; Accepted 30 July 2015

ABSTRACT: Numerous experiments with a scaled pilot facility were carried out to compare the relative bulk transfer performance of three special devices for applications to drilling systems. The pipe diameter for bulk transportation was 3 in., which corresponds to around half of the actual system dimensions. Two different pressures, 3 and 4 bar, were considered to check the relative performance under different pressure conditions at a bulk storage tank. And to make a practical estimation method of the bulk transfer rate at the early design stages of the bulk handling system, a series of experiments were conducted for real scaled bulk handing systems of two drilling vessels. The pressure drops at each pipe element as well as the bulk transfer rates were measured under different operating conditions. Using the measured results, the friction factor for each pipe element was calculated and a procedure for transfer rate estimation was developed. Compared to the measured transfer rate results for other drilling vessels, the estimated transfer rates were within a maximum 15% error bound.

KEY WORDS: Pneumatic conveying; Bulk handling system; Drilling system; Multiphase flow; Transfer rate.

INTRODUCTION

In general, multiphase flows are categorized as listed in Table 1. In particular, in the case of gas-solid multiphase flows, applications can be found in many industries and environmental conditions, such as fluidized beds, pollution dispersion and pneumatic transport. This paper focuses on gas-solid multiphase flows in a bulk handing system in offshore drilling vessels. The flows in the bulk handling system belong to pneumatic flows. Pneumatic conveying systems have many industrial applications in various chemical processes, pharmaceutical, mining, agricultural, mineral, and the food and energy exploration industries. One of the representative examples in energy exploration can be found in a bulk handling system for drilling operations. To produce the drilling mud used for the lubrication of drill bits and as pressure compensation against borehole pressure, bulk particles should be mixed with water or oil at a specific location in a drilling vessel. The bulk particles in storage tanks need to be transported to the mixing location via a pneumatic system. That is, the particles are moved through the bulk storage tank outlet with compressed air injected into the tank.

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Table 1 Examples and categories of multiphase flow (Desai, 2005).

Category	Examples
Gas-liquid flows	Bubbly flows, Separated flows, Gas-droplet
Gas-solid flows	Gas-solid flows, Pneumatic flows, Fluidized beds
Liquid-solid flows	Slurry flows, Hydrotransport, Sediment transport
Gas-liquid-solid	Bubbles in slurry flow, Droplet/particles in gaseous flows

To deliver the required muds down to the drilling holes, the bulk particles transfer rate is important in bulk handling system design. Generally, the system piping layout is determined to satisfy the specific transfer rate in a Contract specification. Therefore, it is essential to predict the transfer rate adequately for this multiphase flows on a real scale.

The bulk transfer rate depends on five major parameters, the pipe bore diameter, conveying distance, pressure available, conveying air velocity, and material properties transferred, as shown in Fig. 1. The straight and curved arrows can be alternative pipeline routes during the design stage. The straight line would be the best route for optimum system design and bulk transfer rate, however, a feasible route could not be the straight line considering various structures, pipes and equipment to be installed in drilling vessels. The flow patterns are generally categorized according to the size, shape and density of particles transferred as follows:

- Dilute phase : $20 < v < 40$ m/s
- Medium phase : $10 < v < 30$ m/s
- Dense phase : $1 < v < 15$ m/s

In the dilute phase, higher energy consumption and system erosion in the pipelines and bends are some of major problems due to the higher velocity of particles (Mills, 2004), and the quantity of transferred particles becomes smaller. In the dense phase, quantity transferred can be highest but the possibility of repeated flow blockage in a pipe system becomes higher due to the lower particle velocity, and severe pipe vibrations are experienced frequently. In the medium phase, the flow patterns are a mixture of a dilute and dense phase, and the transfer rate can be higher without blockage in a pipe system.

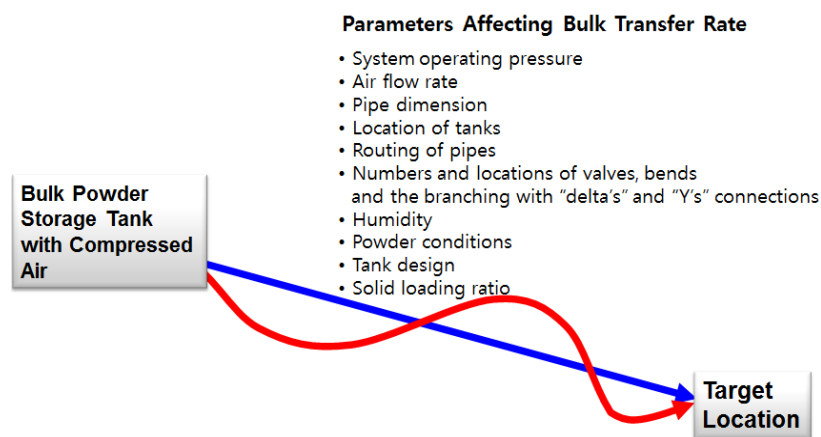


Fig. 1 Parameters affecting the pneumatic bulk transfer rate.

Fig. 2 from Ratnayake's study shows the contours for several constant solids mass flow rates when the conveying gas velocity and system pressure drop varies independently. The gas only line, $M_s=0$, corresponds to a single phase flow characteristically. When the solid particles are introduced to the system, the pressure drop increases to higher values and many different flow regimes occur due to the interaction of gas and solid flows under certain operating conditions. In vertical gas-solid flows shown in Fig. 3, the flow patterns and conveying regimes are changed considerably because of the influence of gravity and are totally different from those of the horizontal sections, even though the general appearance of the mass flow rate contours are similar.

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