Behavior of Single Particle and Group Particles in Vertical Lifting Pipe in China

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ABSTRACT

Fluidization is one of fundamental relative motion forms in solid-liquid two-phase flow. The fluid velocity, particle concentration, etc. are important parameters in engineering design. Proper parameters could avoid pipeline clog, and increase transport efficiency. With single particle, uniform and non-uniform group particles, there are three kinds of suspension experiments have been done. The testing apparatus is an indoor nodule lifting system with 30-m height and 200-mm inner diameter. This article describes the status of particle and group particles move upward in the vertical pipe. It also analyzes the influence of factors such as particle concentration, diameter, gradation and boundary conditions on single and group suspension velocity. At the same time, it obtains empirical formula of suspension velocity of particle and group particles in vertical lifting.

KEY WORDS: Deep-sea mining; solid-liquid two-phase flow; swimming movement; boundary conditions.

INTRODUCTION

In vertical pipe lifting, blockage is serious concerning for safe operation (Yang, 2007). Safety in the hydraulic lifting in pipe is one of the key research topics of China deep-sea mining technology research and development. Large particle liquid-solid two-phase flow has wide applications in deep-sea mining, coal slurry transportation, offshore sand mining, dredging, oil drilling. Dynamic suspension of the large particles, which means to hover particles in the water, is one means to observe particles’ stratification and choke referring to settlement in still water. Based on a large amount of experiments, this article presents a velocity data analysis on single, uniform group particles with a diameter range from 5 to 50 mm under different concentrations. Reasonable lifting parameters and design basis for safe and efficient transportation are proposed.

EXPERIMENT SETUP AND METHODS

The pipe system of the testing installation (Fig. 1) is composed of a main lifting pipe of 200 mm inner diameter with a height of 30 meters, a return flow pipe, a pipe for pressure regulation and a 0.9 m³ water tank for buffering. The water complement system includes a 10m³ water tank, a water supply pipe with an inner diameter of 100mm, and an overflow pipe with an inner diameter of 150 mm, a 4m³ water tank for pressure normalization and a pump for water complement. A submersible slurry pump with circular passage for the particles produces the flow, and a G150 drive converter is used to realize stepless revolution regulation of the motor in the lifting pump. As the measurement segment, one segment of lifting pipe above the pump is made of transparent plexiglass with a length of 4 m, and a diameter of 200 mm. At the lower end of the plexiglass pipe, a metal mesh screen is placed; an electromagnetic flow meter with a drift diameter of 200 is installed.

Fig. 1 The pipe system of the testing installation