Chapter 1

Introduction

Pneumatic conveying of solid particles has been practiced for over 100 years. Despite its diversified technology with numerous application in various industries, the theoretical analysis for gas-solid flow is far from perfect. In practice, typical pneumatic transport, whether vertical or horizontal orientation, comprises of feeder, transport pipe and collector on the other end. Gas (usually air) as a carrier will pickup solid particles at feeding point and convey the particles along the pipe. At the destination of transport pipe, gas and solid particles will be seperated by a gas-solid seperator such as cyclone, gravity seperator, bag filter, etc.

In chemical industry, various applications have been found to convey solid particles for short distance. This study focuses on detergent powder industry where a key unit is vertical airlift which is used to convey detergent powder after dried in a spray dryer to further screening process. Figure 1.1 show airlift system diagram. The airlift pipe is frequently clogged by detergent powder and a lot of production time loss has been spent in plant shutdown in order to remove the clogging. The airlift pipe length is approximately 70 time of diameter which is within the flow region defined as acceleration zone. In this region the particles and the gas accelerate from their inlet condition to the steady state condition.

To understand flow phenomena in the airlift pipe together with the various effects according to change of some parameters or the pipe geometry, some telescopic observations are needed, especially for clogging problem. Particle velocity vectors and concentration have to be investigated in details. Experimental study would be very expensive for detailed investigation, for example, velocity and concentration should be measured by Laser Doppler velocitymeter and electrostatic probe, respectively. Therefore, suitable mathematical modeling together with cost-effective computation is one feasible alternative. However, mathematical model validation with experimental work is essential and shall be done carefully in order to prevent any misleading results. No matter how well-established model is validated, the simulation results should be cautious interpreted and applied due to its approximation nature.

A considerable amounts of research have been performed to ascertain fundamental properties of gas-solids system as well as to provide usable model from which system design and operation problem solving can be performed. There exist various correlations for existing data as well as different views of the primary machanism in this type of transport. Various modeling approaches are thus emerged from difference of researcher's view. Classical approach researcher views the system as a mixture of solid and gas and pressure drop empirical expression is their main objective .Two fluid model approach researcher views the system as a coexisting of two fluid, one is gas and one is "fluid behaved"solid, both fluid interact to each other whilst being transported. This approach provides more information of flow variables

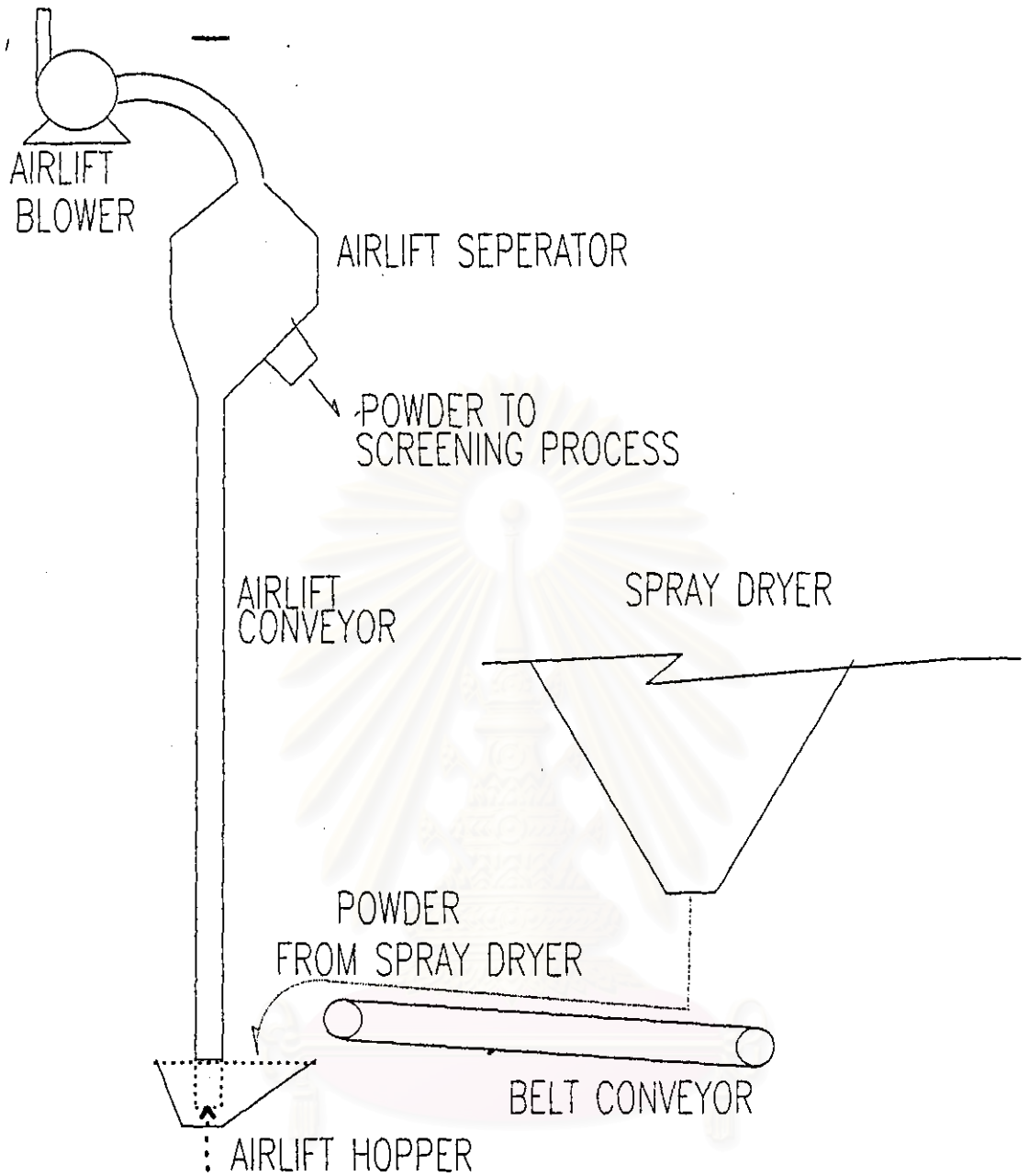

Figure 1.1
AIRLIFT CONVEYOR DIAGRAM

especially in more-than one dimensional study. Particle trajectory approach researcher feeds solid particle into fluid stream of interest on one by one particle basis. Particle path and properties of thousands of particle flights are integrated statistically. This approach is very useful in more complex flow geometry.

Gas phase flow in common pneumatic conveyor is generally turbulent. The effects of particles being present on turbulence gas stream have been studied by number of researchers. Some of them report gas turbulence modulation and some comment on turbulence amplification due to presence of particles. In this study, three turbulence models, namely, standard k-ε model (Harlow- Nakayama [1968]),

Chen-Wood's model [1986], Mostafa-Mongia's model [1988] are discussed in order to find out an appropriate model.

This study is confined to the system of dilute, homogeneous, axisymetric vertical, turbulent pipe flow of gas-solid particle in acceleration zone. The modeling is based on "Two fluid " model considered from its simplicity yet still capable for handling this type of flow and geometry, moreover, its computational results provide adequate flow information to meet the study purpose. As will be seen in Chapter 5, "two fluid" model is validated to be appropriate for the flow considered.

The Finite-Volume method of Computation Fluid Dynamics (CFD) is applied to solve mathematical model. Its advantage is the flexibility in changing of pipe flow geometry and configuration. As a result, various gas-solid pipe inlet configurations (for example uniform gas-solid mixture inlet, gas-solid mixture in core inlet with gas-only annulus inlet or gas-solid mixture in annulus inlet with gas-only core inlet) are able to be simulated and easily investigated.

The purpose of this study are twofold:

- To validate the accuracy of the developed "Two-fluid" flow model computation against the experimental data obtained from reliable experimental work.

- To apply the validated model to simulate industrial scale airlift conveyor flow in order to propose the better conveyor configuration predicted to be capable for minimising the powder-wall deposition problem.