CHAPTER I

INTRODUCTION

1.1 Significance of problem

In several industrial processes a slurry or suspension has to be dewatered in order to obtain a dry product. Mechanical dewatering and thermal drying are often used to achieve this target. In the latter case the heat transfer mechanism can be convective, conductive, or both. Industrial dryers are often classified according to their dominant heat transfer mechanism. The pneumatic conveying dryer, also known as flash dryer, is one of the most common types of industrial dryers. Basically, the pneumatic conveying dryer, which can be characterized as a convective dryer, processes a continuous flow of particulate material that is dried during contact with warm or hot air while being transported (conveyed) by the air stream. This type of dryer is also especially suitable for processing heat-sensitive, explosible, degradable or flammable materials because the average residence time of solid particles in the dryer is short and hot inert gas can be used instead of air.

A reliable mathematical model is required to design and scale up a pneumatic conveying dryer. However, producing a general mathematical model with reasonable accuracy has proved very difficult in the past. As a result, manufacturers have universally designed pneumatic conveying dryers by using pilot-plant test to evaluate the drying rate of material and to determine the condition required, and then scaling up to the full-size dryer. Some moderately general mathematical models have been developed in recent years. Generally the model is composed of two submodels which are, first, a hydrodynamic model that describes the velocities and temperatures of the air and solid and, second, a single particle model that describes the drying rate of the solid. Most of the first-generation models, such as those proposed by S. Matsumoto and D. Pei (1984a), J. Baeyens et. al. (1995), S.C.S. Rocha and A.E.A. Paixao (1996), W. Tanthapanichakoon and C. Srivotanai (1996), judge the drying rate of a solid by considering only the external conditions such as temperature and humidity of air and relative velocity of solid. Typically, the drying rate below the critical moisture content is assumed to be a known function of the remaining free moisture content, or simply a linear function of the free moisture content.

On the other hand, below the critical moisture content internal liquid or vapor movement within the solid generally dominates the drying rate in the second-generation models proposed by S. Matsumoto and D. Pei (1984b), J.S. Qi (1996) and A. Levy et. al.(1998). The above two types of models, however, have not been combined to cover both the surface evaporation and internal moisture diffusion controlled periods. Meanwhile, several semi-empirical single particle models for the drying rate have been proposed by H. Martin and A.H. Saleh (1984), I.C. Kemp et. al.(1994), C. Fyhr and A. Rasmuson (1996).

The present work is an extension of W. Tanthapanichakoon and C. Srivotanai (1996). A comprehensive model which is applicable to both the surface evaporation and internal moisture movement controlled periods is proposed. The comprehensive model is based on two separate models proposed by S. Matsumoto and D. Pei (1984a and 1984b). The present model is validated with experimental results on a full-scale industrial pneumatic conveying dryer for cassava flour and with reported operation results for five other materials. The model is next used in the improvement of the pneumatic conveying dryer for cassava flour.

1.2 Objectives

The main objectives of the present work are as follows:

1.2.1 To code a computer program for a comprehensive model of the pneumatic conveying dryer with surface evaporation and/or internal moisture movement controlled periods.

1.2.3 To validate the model by comparing the simulated results with experimental and published results.

1.2.2 To apply the validated model to find a more suitable condition for operating the industrial pneumatic conveying dryer.

1.3 Scope of research

1.3.1 Development of a comprehensive model for an industrial pneumatic conveying dryer in order to predict the change in

1.3.1.4 Air temperature

1.3.1.4 Air humidity

1.3.1.4 Solid temperature

1.3.1.4 Solid moisture content

during drying for both surface evaporation and internal moisture movement controlled rate of drying.

1.3.2 Test the validity of the model by comparing simulated results with experimental and reported industrial pneumatic conveying drying results.

1.3.3 Applying the model to search for improvement in operating conditions.