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Transport Phenomena in Porous Media: Modeling the Drying Process

O. A. Plumb
Washington State University, Pullman, Washington

I. INTRODUCTION

Drying has been practiced since it was first discovered that foods could be preserved and that clay, through drying, could be converted to a useful structural material. Today, many products are dried for a variety of reasons including preservation, reduction of weight or volume for shipping and packaging, improved dimensional stability, or as a step during processing. The drying process has been the focus of considerable fundamental and applied research because the processing variables have a direct effect on energy consumption, product quality, and productivity. Many of the products that are dried are porous materials or particulate materials or powders dried in such a manner that they behave as a porous medium. As an example of the economic importance of the problem, Franzen et al. (1987) estimated that in excess of 2×10^8 kJ are consumed annually in drying food products alone. Strumillo et al. (1995) estimate that 12% of all industrial energy expenditures are for drying.

The early fundamental work on drying of porous materials is based on the theories for simultaneous heat and mass transfer in porous media developed by Luikov (1966) and Phillip and de Vries (1957) in the 1950s. The more recent modeling efforts are typically based on the work of Whitaker (1977), who applied volume averaging to the well-known transport equations for continua in an attempt to arrive at a general theory for drying of porous materials. The more recent reviews include those by Hartley (1987), which focuses on soil, Bories (1991), Waananen et al. (1993), Turner and

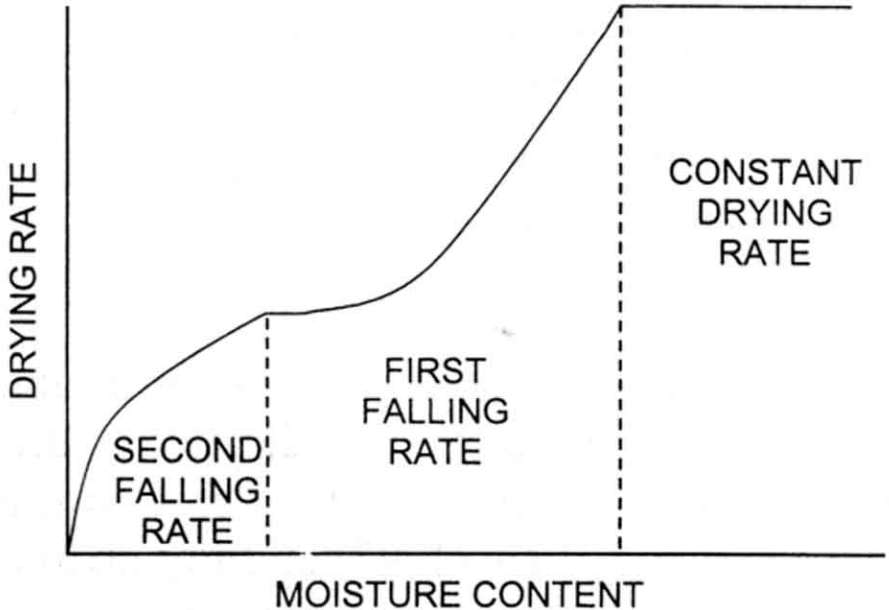

Figure 1. Drying rate as a function of moisture content for a porous material.