# Preface

Drying is essential in many sectors, such as food and ceramic materials. For the food sector, drying is used as a method of preservation. The vaporizing of water provokes a cracking of ceramic materials during firing at high temperatures. So the water used for forming must imperatively evacuate before firing, so the necessity of the drying operation. Hence, in this thesis, an investigation has been carried out to analyze coupled heat and mass transfer phenomena during steady-state and different drying modes. To carry out this study, a non-equilibrium drying model and related computer program have been developed for different drying processes considering other materials like biological and ceramic. Governing equations include moisture mass balance, enthalpy balance, heat transfer rate, an element's mass transfer rate, along bed height. And diffusion equation of moisture inside a single kernel has also been solved simultaneously through an implicit scheme using TDMA (Tri-Diagonal Matrix Algorithm). An iterative approach has been used to solve the governing equations for a selected geometry of the dryer. The rating analysis can be used for arriving at improved quality and higher dryer efficiency. The simulation program developed is fairly general and can be used for any material. The detailed performance prediction results can be used to arrive at an optimum design. To quantify the enhanced performance characteristics and fulfill the research gaps, numerical and experimental investigations have been done on a different type of dryer using different kinds of material.

This thesis is divided into 11 Chapters.

**Chapter 1** introduces the thesis work, including the background related to drying and drying phenomena. It describes different drying techniques, other types of dyer, the need for drying, and their application for biological and ceramic materials.

**Chapter 2** includes the literature review and objective of the investigations. The literature review sought the recent drying trend like different drying models for different dryers, different types of drying materials, and different drying mechanisms. The objective of the present study includes the importance of a new mathematical model and related computer programs.

**Chapter 3** describes the experimental procedure and preparation of materials and a brief description of the instruments used and characterization techniques.

**Chapter 4** depicts the mathematical modeling in detail for different types of dryers.

**Chapter 5** reports Performance analysis of deep bed drying of canola seeds using a numerical technique in detail. And full drying performance and rating analysis of deep bed dryers have been investigated, and numerical study has also been validated with experiment.

**Chapter 6** presents a sequential numerical technique for efficient utilization and quality improvement of rough rice using multistage deep bed drying with tempering. This study investigates the effect of tempering in drying, and multistage drying has been studied in detail. And the experiment has been done to validate the mathematical results.

**Chapter 7** presents a sequential numerical technique for analyzing coupled heat and mass transfer phenomena during fluidized bed drying of particulate materials with exhaust gas recirculation and application to wheat drying. In this chapter, the performance of a fluidized

bed dryer has been studied. The effect of recirculation on the drying performance of the dryer has been investigated in detail. An experiment has also been done to validate the program.

**Chapter 8** describes the design analysis of continuous counter-current deep bed drying of corn through modeling and simulation.

**Chapter 9** explains an experimental and sequential numerical technique to study the effect of environmental conditions during fluidized bed drying of kaolin clay. The effect of drying rate on the quality of the product has also been examined. And the experiment has been done throughout the year in different sessions to test the mathematical model.

**Chapter 10** The outcome of the entire investigation was summarized. This chapter also includes the future scope, a suggestion based on the results, and explanations acquired in this effort.

**Chapter 11** Summarizes the overall general conclusions covering chapter 6 to chapter 10 and future scope of the drying.