CHAPTER 1

INTRODUCTION

Drying is a necessary process in several industries, such as agriculture and ceramic materials. Drying is a preservation procedure used in the farming industry. At temperatures exceeding 1000 degrees Celsius, the vaporization of water causes ceramic materials to fracture. [Hammouda & Mihoubi, 2014] As a result, the water used for shaping must be removed before it can be burned, necessitating the drying process. The success of the drying procedure is assessed on two stages: the expense of production and the quality of the finished product. Because of the high manufacturing rate, drying time becomes crucial in many circumstances. Time is less significant in other cases, but the look and biological qualities of items (in the case of food and medicines) or strong mechanical durability (in the case of woods and ceramics) are essential.

Feeding the world's growing population is a monumental task. There is an 80% chance that the world's population, which is currently 7.2 billion, will rise to between 9.6 and 12.3 billion by 2100. Furthermore, as incomes and urbanization rise, dietary patterns throughout the world are changing toward resource-intensive, animal-based meals. More than twice as many people are expected to reside in cities by 2050 as they were in 2000, and 40 percent more land will be required to feed the growing urban population by 2030. Changing climate, water scarcity, soil contamination and degradation, industrialization and urbanization, and other concerns threaten food security [Xiao & Mujumdar, 2020]. The temperature rises and precipitation declines in tropical, subtropical, and semi-arid regions are expected to diminish corn, maize, paddy, and other key crops in the coming days; changing climate, particularly extreme weather, would definitely have a significant influence on world food supply. Considerable modifications in current food production, storage, distribution, and consumption systems are required to maintain food security. Drying plays a crucial role in strengthening global food security as an essential industrial procedure for the safe storage of farm goods and food. Drying can decrease post-harvest loss, extend its shelf life, and enhance added value by removal of water to a safe limit, preventing microorganisms proliferation and reproduction, mitigating humidity deteriorative biochemical changes, and lowering packaging, logistics, storage, and operational cost. It is worth noting that the quality of food may be improved cost-effectively by drying in a sustainable manner under ideal operating parameters in well-designed dryers with reduced energy and physical impacts. This necessitates global research and innovation that are inter- and Trans disciplinary.

Artificial techniques are used for many dehydration and conditioning of staple crops. Higher yields and the necessity for long-term storage necessitate a high degree of control over the end product's different qualities. Excessive water content, for example, might promote the formation of molds and insect infestations, resulting in crop loss. Grain is graded based on water content, bulk density, germination, contamination, and other physical characteristics. Its evaluated quality serves as the foundation for defining its eventual use and commercial worth. The production of cereal grains per acre has been increasing rapidly. The global contribution of agriculture and allied sectors like forestry and fisheries to gross domestic product (GDP) is around 4% and 20% of the Indian GDP in 2020-21.

Between 2000 and 2019, the worldwide value-added from farming, forestry, and fishery increased by 73% in cash terms, reaching USD 3.5 trillion in 2019. In comparison to 2000, this implies a USD 1.5 trillion gain. Asia (primarily India and China) contributed 64 percent of worldwide agricultural, forestry, and fishery value added during 2019. The continent shows an increase of 84 percent, from USD 1.2 trillion in 2000 to USD 2.2 trillion in 2019. The global workforce employed in the agriculture sector is around 27%, and for India, it is about 50% of the total workforce [economic survey 2020-21, government of India]. World grain output is expected to reach about 2821 million tonnes in 2021, a new high and 1.9 percent higher than in 2020. Maize is expected to account for the majority of this year's rise, with output expected to increase by 3.7 percent from 2020. Wheat output is predicted to rise 1.4 percent year over year, while rice production is projected to rise 1.0 percent. In 2021/22, global cereal usage is predicted to rise 1.7 percent to 2826 million tonnes, a record high. Total cereal grain consumption is expected to climb in lockstep with global population growth, resulting in an annual per capita usage of 150 kg.[FAO, 2021]

The drying, handling, post-harvest processing, and long-term storage of grains are therefore of primary significance. Thorough knowledge of the physical, chemical, mechanical, and thermodynamic properties of cereal grains is imperative to optimize the drying and processing-related operations and to improve quality control during storage and handling.

Therefore, efficient harvesting and drying of grains have become necessary for economically preserving the crop produced. Removal of moisture from grain is called drying and is used to prevent the development and growth of molds and insects that generally cause spoilage. The art of drying is as old as civilization. It is the most widely practiced grain preservation method. A large amount of water is evaporated from the grain in the drying process. Drying requires about 60% of the total energy used in production in fig 1.1.[Brooker et al., 1992]

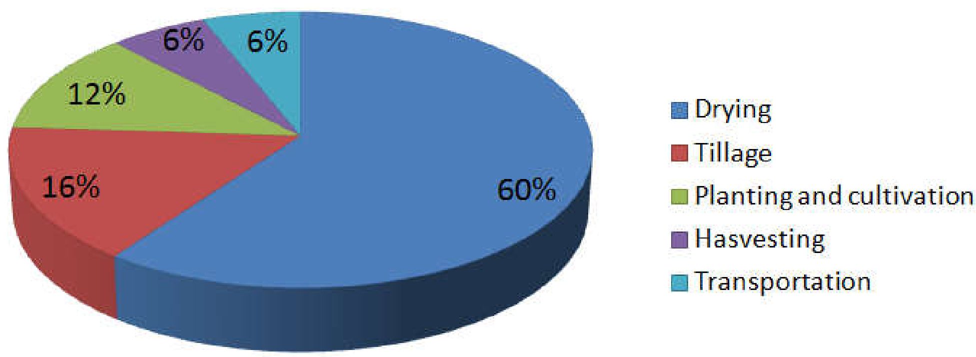

Figure 1.1 Energy distribution in the grain production process

Drying also plays a very important role in ceramic production. As we know, with few exceptions, the methods by which ceramics are formed depend on the workability that is developed when the finely granulated solid material is intimately mixed with a suitable proportion of water. This water may be considered to serve as a carrier for the solid phase, enabling the individual particles in the mixture to be displaced when the mass as a whole is deformed. When shaping is completed, the water ceases to perform any useful function and must be removed so that the shape becomes sufficiently rigid to withstand handling and set in the kiln. Drying is an important phase of the ceramic manufacturing process. Because drying must be done carefully to avoid warping and breaking of the green body components, the drying process often puts greater stress on the ceramic pieces than burning. However, for effective production, ceramic manufacturers must reduce the time spent on this procedure. Without an industrial dryer, drying time might range from two to seven days. It is extremely important to dry clay appropriately. If a clay object isn't totally dry before the first burning, it could fracture, deform, or even explode, potentially destroying not just that piece but also the rest of the kiln's materials. If the clay is dried too fast in a drying chamber, therefore, cracks will occur, and the item will most likely be damaged during kiln burning. So numerical analysis paly a very important role to come over this problem, and with the help of our developed computer program, we can exactly predict the average moisture content and temperature distribution inside the grain in varying climate conditions and reduce the drying time, predict the drying rate and hence in the result of good product quality and enhanced efficiency. In general, the energy required for the ceramic industry production is distributed, as Shown in Fig.1.2.

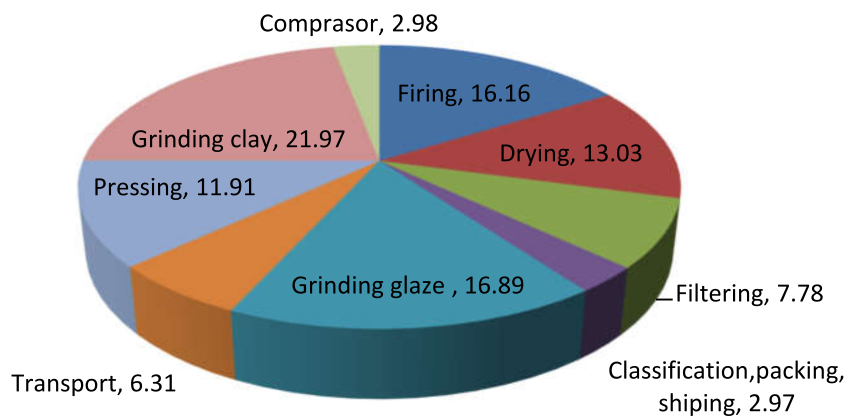

Figure 1.2. Energy distribution in ceramic production process [Ciacco et al., 2017]

The drying of a wet solid is still as much an art as science, even after more than half a century of investigation at universities and in industry. This is so because drying is one of the most complex and the least understood operations, which often involve simultaneous and coupled multiphase flow, and there are difficulties and deficiencies in the mathematical description of the phenomenon of simultaneous and coupled heat, heat, and momentum transfer in solid media. As a result, computerized drying process modeling is an effective, low-cost, and quick tool for predicting the fluctuation of key operational parameters such as air temperature and humidity, sample temperature, and, particularly, material moisture content during the drying process. Having enough reliable data on these characteristics might help designers create more efficient dryers and enhance the ultimate product quality.