Chapter 20

The Use of Microwave Energy at Thermal Treatment of Grain Crops

Dmitry Budnikov
Federal Scientific Agroengineering Center VIM, Russia

Aleksey Vasiliev
Federal Scientific Agroengineering Center VIM, Russia

ABSTRACT

Thermal treatment is used for different grain crops during the processes of drying, disinfection, and preparation to feeding, etc. The high cost of the processes is caused by the cost of energy and the energy-output ratio of the processes. The development of the processing regimes with the use of electric technologies in general and electromagnetic fields in particular can reduce the cost of the mentioned processes. When IR and MW fields are used, there occurs the direct heating of the grain material without the coolant, due to the effect of the field on water molecules in the kernels. As the grain is a colloid capillary-porous substance, moisture can be in a bound or free state that affects the properties of the material and the thermal processes in it. The use of the special programs gives vast possibilities for the design of such equipment. Using of MW fields allows reducing the cost of the thermal treatment 15-20% depending on the process and type of the processing material.

INTRODUCTION

Such processes of the postharvest treatment of grain crops as drying, disinfection, micronization and preparation for feeding require a thermal impact. All these processes possess a high ratio of energy consumption. The analysis of literature shows, that such consumption during the postharvest treatment is up to 20% on average in the countries with the developed agriculture, but with the unfavorable weather conditions (Baptista F, 2013).
This index reaches 40% for the countries with the unfavorable climate. Currently the equipment working on gas, diesel or other types of fuel tends to be used for such thermal treatment (Vasant P. 2011). At first the drying agent (working body) is heated by the flame of a burner, then there is a convective heating of the grain material, which is ventilated by the drying agent. In this case there are significant losses due to the intermediate heating of the drying agent and raised energy consumption on drying because of the opposite direction of the gradients of the thermal processes (Yunyang Wang, 2011). Considering all this, the development of energy saving technologies of the effects on agricultural materials, including the use of the electro physical effects, is of special significance and importance (Goronovskij I.T., 1987; Kraszewski A., 1989; Nelson S.O., 2008; Alexsandar Antic, 2003, Vasant P. 2016). Such devices as a microwave-convective dryer of the agricultural material and a microwave-disinfectant of the agricultural and food products are being developed. The present work deals with the basics of dielectric heating, which provides a direct heating of the grain material. Optimization of control algorithms based on the criteria of energy and economic efficiency, as well as their application in the processing processes, including the use of electrical technologies, will reduce the energy intensity of processes and reduce losses (Vasant P. 2017).

**BACKGROUND**

Dielectrics are a class of materials that are poor conductors of electricity, in contrast to materials such as metals that are generally good electrical conductors. Many materials, including foods, living organisms, and most agricultural products, conduct electric currents to some degree, but they are still classified as dielectrics. The electrical nature of these materials can be described by their dielectric properties, which influence the distribution of electromagnetic fields and currents in the region occupied by the materials, and which determine the behavior of the materials in electric fields. Thus, the dielectric properties determine how rapidly a material will warm up in RF or microwave dielectric heating applications. Their influence on electric fields also provides a means for sensing certain other properties of materials, which may be correlated with the dielectric properties, by nondestructive electrical measurements. Therefore, dielectric properties of agricultural products may be important for quality-sensing applications in the agricultural industry as well as in dielectric heating applications (Bakker-Arkema F.W., 1995; Nelson S.O., 2015, 2004; Suzan Tireki, 2006; Stanislaw Grundas, 2008).

A few simplified definitions of dielectric properties are useful in discussing their applications. A fundamental characteristic of all forms of electromagnetic energy is their propagation through free space at the velocity of light, \( c \). The velocity of propagation \( \nu \) of electromagnetic energy in a material depends on the electromagnetic characteristics of that material and is given as:

\[
\nu = \frac{1}{\sqrt{\mu \cdot \varepsilon}},
\]

where \( \mu \) is the magnetic permeability of the material and \( \varepsilon \) is the electric permittivity.

The absolute permittivity, \( \varepsilon_{\text{a}} \), can be represented as a complex quantity: