

Innovative Food Processing Techniques

Enhancing Safety, Quality,
and Shelf Life

Edited by

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Induction Heating of Foods

Asfaq, Mohammed Haris Siddiqui, and Gazia Nasir

7.1 Introduction

Induction heating (IH) is a noncontact method that employs electromagnetic induction to generate heat within the material itself. This technology provides advantages such as precise temperature regulation, rapid heating, and efficient energy use, making it well-suited for various industrial applications. The principle behind IH is based on "Faraday's law of electromagnetic induction", which explains how a fluctuating magnetic field creates an electric current, known as eddy currents, within a conductor. These currents produce heat as a result of the material's electrical resistance. Unlike traditional methods like conduction, convection, or radiation, IH generates heat directly inside the food product or container, resulting in significant energy savings.

Several factors influence the performance of IH systems, such as the frequency of the alternating current, the characteristics of the material, and the design of the induction coil. IH offers various benefits, including uniform temperature distribution, compact system design, enhanced safety, and automation capabilities. It is also recognized for its repeatability, reliability, energy efficiency, and cost-effectiveness. The ability to accurately target specific areas on metal components allows for greater precision and consistency in heating applications (Vairamohan et al., 2011).

This technology has garnered attention across different sectors, such as the metal, glass, and semiconductor industries, as well as in chemical processes. IH has also been successfully applied in both residential and commercial cooking by transferring electromagnetic energy to the cooking vessel (Rudnev et al., 2003). Moreover, it has been used in other processes, including generating steam for drying, sterilization, and cleaning applications, and heating agricultural by-products (such as rice husks, coconut shells, and sugarcane bagasse) through fast pyrolysis (Tsai et al., 2006; Tsai et al., 2009).

A study by Lucia et al. (2013) explored advancements in IH systems and highlighted the key components used in various applications, including homes, industrial settings, and medical environments. The study discussed modulation and control algorithms that ensure the precise operation of the heating system and its power converter. Although the fundamental principle of IH remains the same, each application requires unique design considerations. Industrial systems must incorporate efficient cooling and control mechanisms to manage high power outputs, while residential applications often prioritize cost-effective solutions due to limited cooling capacity.

7.2 Principle of Induction Heating

An IH system consists of key components like the induction coil, power supply, converters, and a quenching system (Figure 7.1). The system applies a fluctuating magnetic field to the material being heated, typically a conductive and ferrous material. During cooking or food processing, heat is transferred indirectly through conduction via the ferrous material. The process relies on Joule heating, caused by eddy currents (also known as Foucault currents) generated by the electromagnetic field in the material being heated.