Design a microwave dryer with rotary drums, twelve magnetrons, and on-off sample temperature control: Simulations and experimental validation.

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Microwave technology is suitable for rapidly heating foods during domestic and industrial processing. However, this heating tends to be non-uniform, requiring strategies to minimize the hot spots that damage the food. This problem has been handled by suitable microwave cavity design, magnetrons arrangement, sample moving, and automatic temperature control by power manipulation. This study performed numerical simulations on the influence of the number and position of magnetrons on microwaves' distribution in a container with two rotating drums. Also, control strategies to improve heating uniformity were evaluated. Firstly, the numerical simulations using COMSOL Multiphysics® determined the electromagnetic field distribution inside an empty metallic container with octagonal sections (100 cm long and 60 cm wide), with twelve magnetrons (1.2 kW each) positioned on its walls. The experimental power dissipation in different water loads put inside the container in beakers validated the mathematical model based on the Maxwell equations (error of 15%). Besides, greater water masses inside the container and a higher number of active magnetrons resulted in higher equipment efficiency. The numerical results indicated that using six magnetrons is sufficient to obtain a uniform electric field. Moreover, the position of the magnetrons affected the distribution of the electromagnetic field. The control strategy was defined based on the best-operating conditions as determined by the numerical simulations. The controller was programmed to turn on or off as many magnetrons as necessary to control the sample temperature, measured with an infrared sensor. The temperature control strategy was tested using 8 kg (4kg per rotary drum) of expanded clay spheres, a porous and reusable material. The initial power was set as 7,2 kW (6 magnetrons on) to reach the sample temperature of 58 °C rapidly. Then, the power was reduced to 3,6 kW (3 magnetrons on) until 60 °C (set point). Afterward, the controller would turn off one, two, or all of the magnetrons to prevent the sample's temperature from increasing above 60°C. Therefore, sample moving, proper arrangement of magnetrons (number and position), and on-off temperature control guarantee the material's heating and drying, avoiding overheating.