Abstracts

Heat Transfer in Surface-Cooled Objects Subject to Microwave Heating

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Several investigators in microwave bioeffects research have exposed biological preparations to intense microwave fields, while at the same time cooling the sample with flowing water. We examine the heat transfer characteristics of this situation, to estimate the maximum temperature increase and thermal time constants that might be encountered in such an experiment. The sample is modeled as a uniform sphere, cylinder, or slab subject to uniform heating, which is located in an unbounded coolant flow. The heat transfer is determined by the Biot and Reynolds numbers (which reflect the geometry, fluid flow, and material thermal properties of the system) the temperature rise is governed by the heat conduction equation coupled with external convection. The results are expressed in terms of nondimensional quantities, from which the thermal response of a heated object of arbitrary size can be determined. At low coolant flow rates, the maximum temperature rise can be biologically significant, even for relatively small objects (of millimeter radius) exposed to moderate levels of microwave energy (with a SAR of ca. 100 mW/g). The results are valid also where the coolant is a gas or a liquid different from water, the only restriction being on the Reynolds number of the flow.

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