WORCESTER POLYTECHNIC INSTITUTE MECHANICAL ENGINEERING DEPARTMENT

MASTER OF SCIENCE THESIS DEFENSE

ENTITLED

COMPUTATIONAL MODELING OF TRIPLE LAYERED MICROWAVE HEAT EXCHANGERS

By

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Abstract:

A microwave heat exchanger (MHE) is a device which converts microwave (MW) energy into usable form of heat energy. The working principle of the MHE is based on a collective effect of electromagnetic wave propagation, heat transfer and fluid flow, so the development of an efficient device requires complicated experimentation with processes of different physical nature. A peculiar phenomenon making the design of MHE even more challenging is *thermal runaway*, a nonlinear phenomenon in which a small increase in the input power gives rise to a large increase in temperature. Such high temperature may result in material damage through excessive thermal expansion, cracking or melting. In this Thesis, we report on an initial phase in the development of a computational model which may help clarify complicated interaction between nonlinear phenomena that might be difficult to comprehend and control experimentally.

We present a 2D multiphysics model mimicking a layered MHE which simulates the nonlinear interaction between MW, thermal, and fluid flow phenomena involved in the operation of the MHE. The model is built for a triple layered (fluid-dielectric-fluid) MHE and is capable of capturing the S- and SS-profiles of power response curve which determines steady-state temperature solution as a function of incident power.

The model is implemented on the platform of the COMSOL Multiphysics modeling software. A MHE with particular thickness and dielectric properties of the layers, can operate efficiently by keeping temperatures during thermal runaway under control. We show that overall temperatures increase rapidly as soon as the local maximum temperature reaches a critical value. This condition is held true both in absence and in presence of the fluid flow. It is demonstrated that the efficiency of MHE increases when thermal runaway is achieved. As the amount of heat energy, which is being transferred to the fluid from the heated dielectric, increases, incident power required to achieve thermal runaway also increases. It is also shown that, with appropriate length of the layered MHE, thermal runaway can be achieved at a lower power level. The model developed in this Thesis studies the basic operation of a three layered MHE, and can further be developed to investigate optimum design parameters of the MHE so that maximum thermal efficiency is achieved.

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Higgins Lab 102

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