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Resonance, Rayleigh Flows and Thermal Choking: Convective Electromagnetic Energy Harnessing from Absorbing Porous Media.

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Electromagnetic (EM) Heat Exchangers (HX) are systems which convert EM energy into heat or mechanical work. One potential design consists of a porous lossy ceramic material heated by EM waves saturated with a compressible gas coolant. EM heating of ceramics is nonlinear, since the loss factor is temperature dependent. Designing such EM HXs requires an understanding of the coupling between temperature, the electric field, and gas dynamics at the pore scale. To mimic this microscale phenomena, a single channel with a high-speed gas coolant in perfect thermal contact with a thin solid ceramic layer is considered, with an applied plane-wave electric field propagating normal to the channel walls. From a thin-domain asymptotic analysis, the conservation laws reduce to a Rayleigh flow in the gas coupled with averaged thermal energy conservation equations at leading order. The kinetic energy of the gas increases about 10 times the inlet value when thermal runaway occurs in the ceramic region, and thermal choking is possible when the coolant reaches the sonic state. Extensions to high-speed flows in ceramic porous media are discussed. This work was supported by a grant from the US Air Force Office of Scientific Research (AFOSR) award FA9550-18-1-0528, for which the authors are grateful.

Participation

In-Person

References

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