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High-fidelity simulations of a standing-wave thermoacoustic-piezoelectric engine JEFFREY LIN, Stanford University, CARLO SCALO, Purdue University, LAMBERTUS HESSELINK, Stanford University — We have carried out time-domain three-dimensional and one-dimensional numerical simulations of a thermoacoustic Stirling heat engine (TASHE). The TASHE model adopted for our study is that of a standing-wave engine: a thermal gradient is imposed in a resonator tube and is capped with a piezoelectric diaphragm in a Helmholtz resonator cavity for acoustic energy extraction. The 0.51m engine sustains 500Pa pressure oscillations with atmospheric air and pressure. Such an engine is interesting in practice as an external heat engine with no mechanically-moving parts. Our numerical setup allows for both the evaluation of the nonlinear effects of scaling and the effect of a fully electromechanically-coupled impedance boundary condition, representative of a piezoelectric element. The thermoacoustic stack is fully resolved. Previous modeling efforts have focused on steady-state solvers with impedances or nonlinear effects without energy extraction. Optimization of scaling and the impedance for power output can now be simultaneously applied; engines of smaller sizes and higher frequencies suitable for piezoelectric energy extraction can be studied with three-dimensional solvers without restriction. Results at a low-amplitude regime were validated against results obtained from the steady-state solver DeltaEC and from experimental results in literature. Pressure and velocity amplitudes within the cavities match within 2% difference.

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