OSCILLATING LINEAR ENGINE AND ALTERNATOR

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DOE ARPA-E GENSET Kick-off meeting

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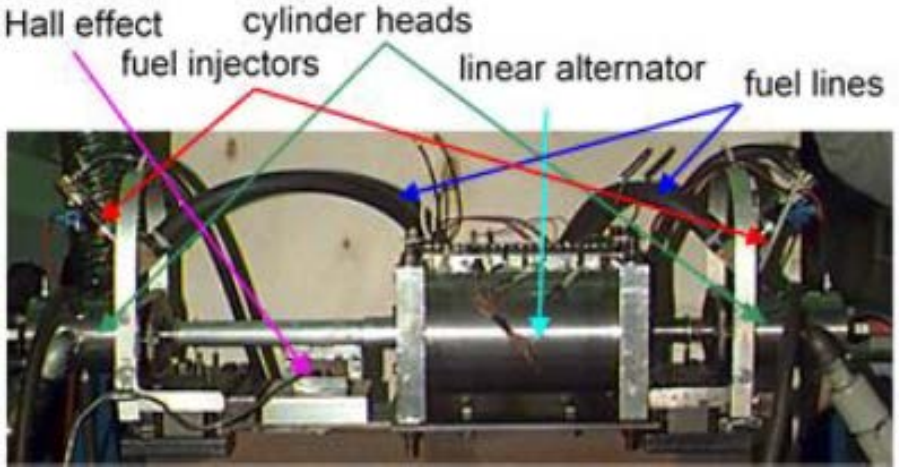
History

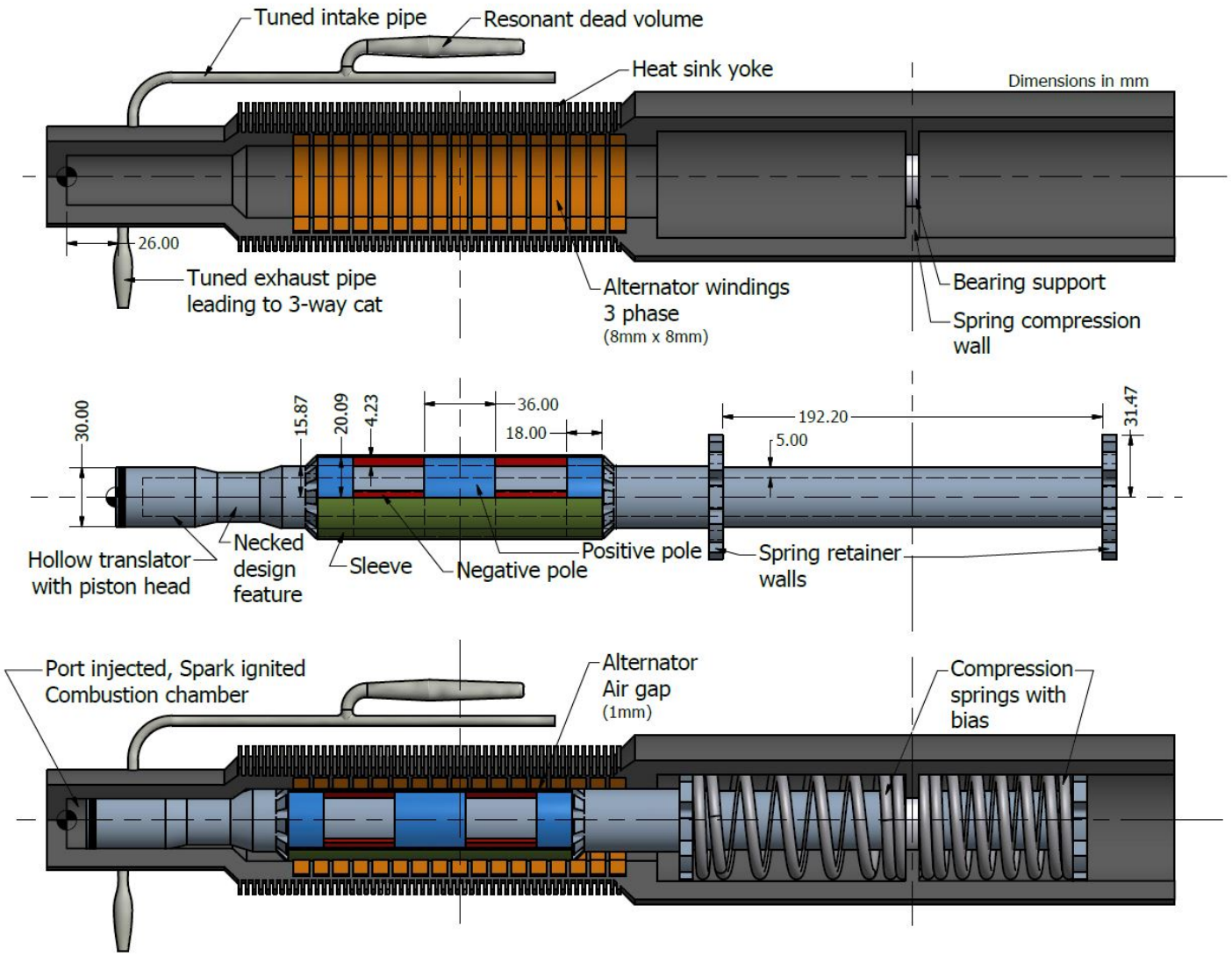


- Beginning in 1998
  - o Operation of spark-ignited and diesel compression benchtop models
    - Ad-hoc gasoline machine produced 309W [1]
    - Second generation diesel prototype operated between 50-60 Hz [2]
  - o Analytical/numerical simulations of various configurations [1, 3]
    - Initial understanding of adverse work and cycle-to-cycle energy balance
    - Parametric study observed relationships between heat addition, combustion duration, peak pressure, frequency, translator mass, stroke and compression ratio
- Need for increased engine speed and flywheel-like energy storage mechanism position sensing difficult and necessary for control

Famouri, P., Cawthorne, W., Clark, N., Nandkumar, C., et al, "Design and Testing of a Novel Linear Alternator and Engine System for Remote Electrical Power Generation," in IEEE Power Engineering Society 1999 Winter Meeting, New York, NY, 108-112, 1999, doi:10.1109/PESW.1999.747434.

The proposed system

- Rigidly connected pistons oscillating between 2-stroke HCCI combustion cycles
- Springs included to
  - raise frequency
  - enable stroke-to-stroke energy storage
  - tailor translator motion
- Ported intake/exhaust events designed for steady state operation
- Coil and magnets designed for desired state power output



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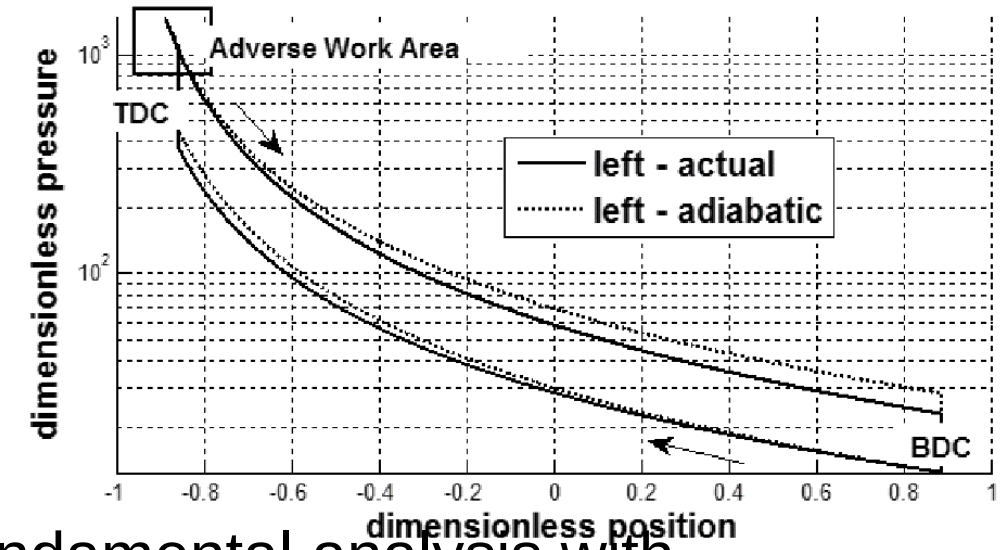
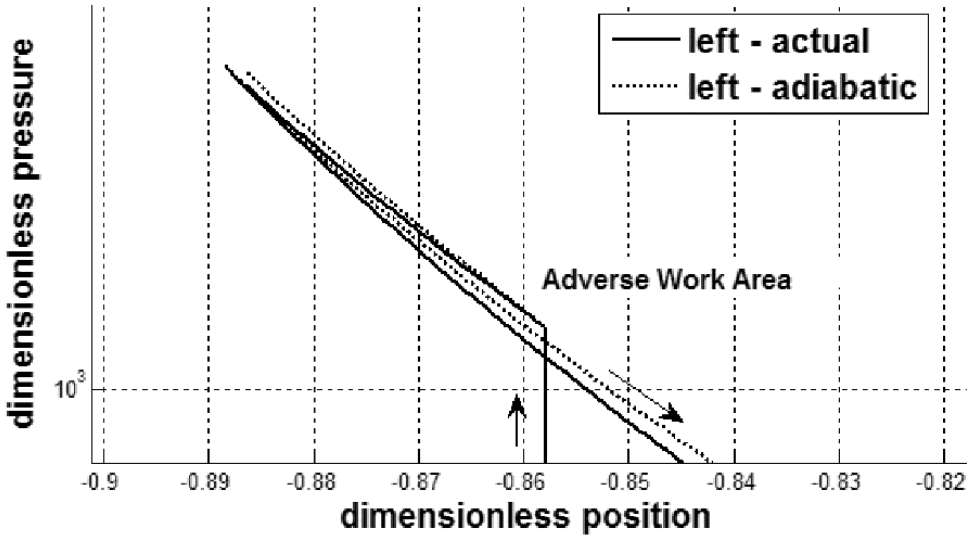
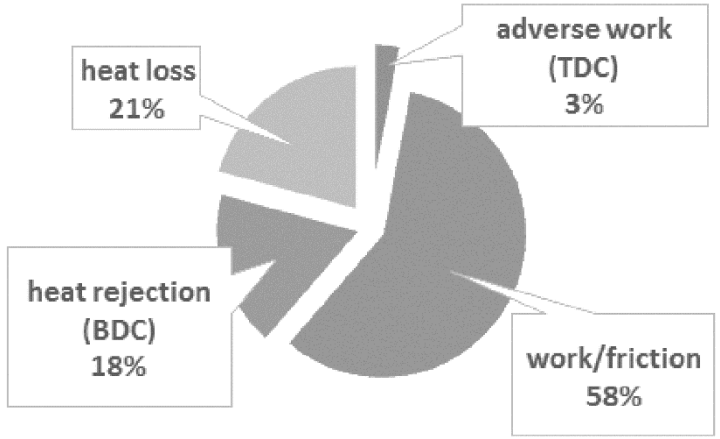
System simulation





- Fundamental analysis with nondimensional terms demonstrated
  - o Otto cycle stability
  - o Adverse work due to pre-TDC combustion and heat transfer losses
  - o Multi-cycle transient response of stroke/compression ratio
  - o Minimal effect of work force profile



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Simulation

- Initial optimization depends on existing simulation
- Parametric study to explore design space
- Highly interdependent and nonlinear input/output relationships
- Component design iterations embedded within multi-cycle system simulation
- Validated by closed form parametric study