Efficient Small Engines for CHP :

Opportunities and Research Needs, from Combustion and Heat Transfer to System Integration

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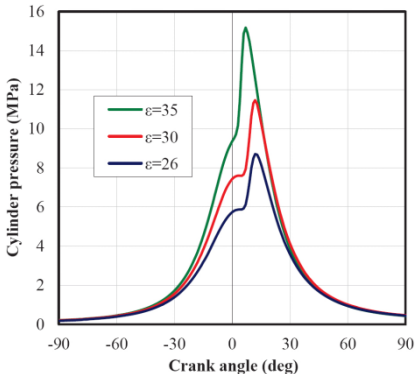
Opportunities and Research Needs for Small ICE CHP

- Compression Ignition of Natural Gas would provide:
  - Exceptional efficiency
  - Low engine-out emission, a proven advantage of HCCI
  - Reliability: removal of ignition system, reduced complexity

- Research questions:
  - 2-stroke or 4-stroke; architecture?
  - Reduced heat loss is a must, ceramic coatings
  - High CR, but how high ?
  - Starting might need assist, e.g. glow plug
  - Integration of the waste heat recovery

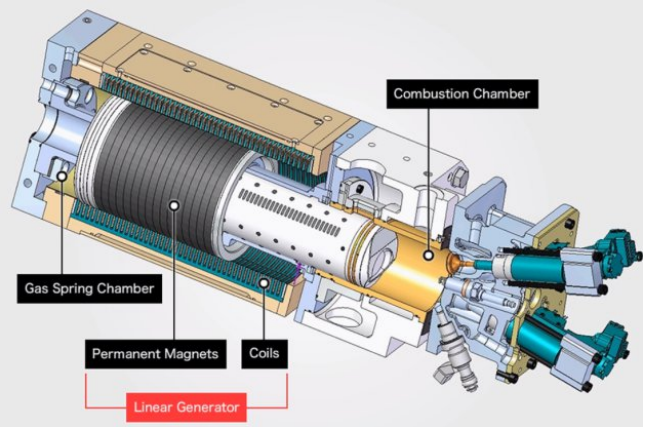


High CR NG research engine, pressure traces for three CR, SAE Paper 2013-32-9098 (Honda)

Opposed piston 2-stroke, Achates Power

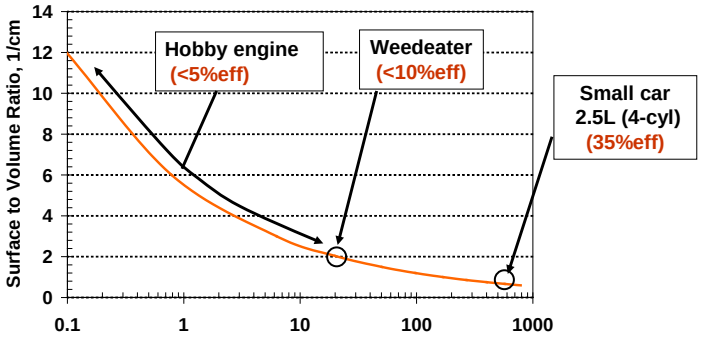
Very Small Units, e.g. 2 kW will Require Unique Approaches

- Perhaps this is a chance to develop an innovative architecture, e.g. free piston with an integrated linear alternator



Source: SAE paper 2014-01-1203 (Toyota)

- Challenges:
  - Wall heat losses more pronounced as the cylinder size is reduced thermal barrier coatings can help



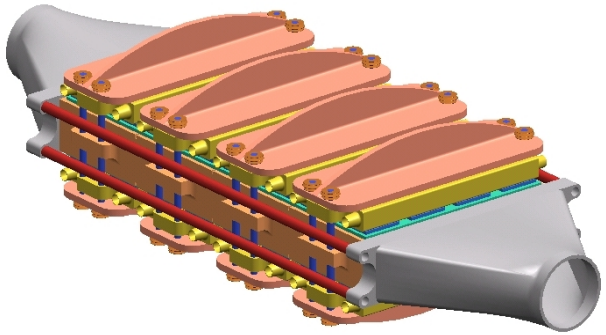
Courtesy M. Kass, ORNL

Zirconia coating applied to the piston top, Filipi et al.

  - Ignition, reliable and long lasting
  - Durability , novel materials & lubricants

System Integration, Waste Heat Recovery, Controls

- Integration and control will be critical:
  - Ultimate goal is not as straight forward as in ICE for propulsion, overall efficiency includes power to electricity and heat
  - Physics based models of components, integrated into a comprehensive CHP simulation will be necessary to address system integration, optimization of design and control
  - Duty cycles will have to be defined, and they will depend on the application and season (winter/summer)
  - Thermoelectric materials provide a very attractive option for waste heat recovery. Recent progress promises higher ZT, as well as longer life. Integration will require both heat transfer expertise and control



Courtesy : Terry Tritt
Clemson University,
automotive application