Increasing Engine Efficiency through Extreme Compression

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Motivation
One of the most substantial loss mechanisms in current, simple cycle, unstrained, reactive engines is combustion irreversibility. A large fraction (~20%) of the exergy of the fuel resource can be destroyed during the combustion process. The goal of this project is to substantially reduce the combustion irreversibility thereby increasing the overall efficiency.

Basic Design
New design choices are required to construct a device capable of these high compression ratios. Post-combustion pressures are greater than 1000 bar, while post-combustion temperatures are greater than 3000 K. A few of the obstacles and their design implications include:

- Typically the higher temperatures lead to greater heat transfer losses
- Increase expansion speed to extract work before it is transferred out at heat
- High pressures lead to high forces
- Use two pistons to balance the forces and increase expansion rate

Experimental Data
The apparatus contains:
- A fast (~20 ms opening time) air-driven poppet valve to allow repeatable, controllable introduction of driver air to cylinder
- A free-piston architecture that allows for high piston speeds
- An ~2.5m long cylinder bore to achieve low surface to volume ratios at TDC, reducing the effects of heat transfer
- A high-pressure combustor attached to the end of the cylinder to withstand the high pressures at TDC

Operating space of device as well as more recent operating space given constraints due to piston acceleration.

Future Work
- Assess Combustion Performance
- Extent of turbulent mixing vs. laminar flow
- Injector spray performance at high densities
- Ignition delay imaging
- Install window to visualize spray dynamics and combustion
- Install exhaust gas analysis system for measuring NOx and reaction efficiency
- Analyze and experimentally test ring design to understand and reduce blowby losses as well as combustion inefficiency.

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