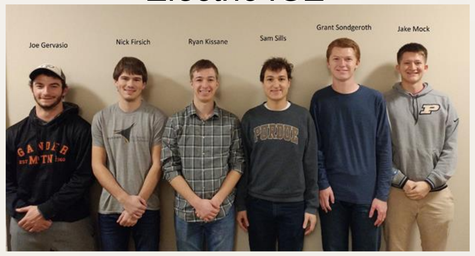
PURDUE UNIVERSITY
Mechanical Engineering

Solenoid Engine

Capstone Senior Design Project • Spring 2019

Electric ICE



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Mission Statement

To implement an auxiliary system to propel the piston of an internal combustion engine during non-powered strokes

Problem Statement

Four-stroke internal combustion engines only produce power during one stroke, with some of this energy being used to complete the other 75% of the cycle. The low efficiency of ICE vehicles in the market results in high fuel consumption and costs to the consumer.

Problem Solution

An electronic solenoid surrounding the cylinder uses magnetism to help propel the piston through the three non-power strokes. This creates an integrated hybrid system using an auxiliary electrical power supply.

Benchmarks

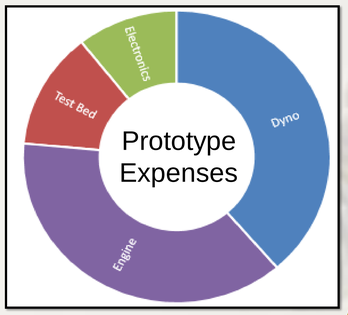
Dynamic Fuel Management (DFM)
- Engine deactivates some of the cylinders to manage fuel consumption under low load

Hybrids
- Use electric motors in addition to IC engine to decrease fuel consumption

Business Case

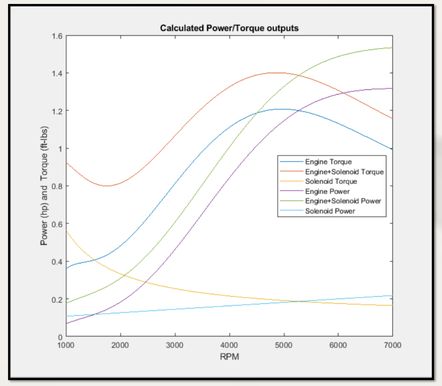
Prototype Cost	Engine Cost	Engine Price	Profit Margin	Annual Profit
$361	~$130	~$260	7%	$780K

- US car sales in 2018 were ~17.2 Million
- 2.5% of US vehicle sales (430,000 cars) in 2018 were hybrids
- **Market Share of 0.25% represents 43,000 cars**
- Engine only represents 38% of prototype costs



Mathematical Modeling

Solenoid Calculations
- 14 AWG magnet wire
- N = 245-283 turns
- R = 0.5 ohms
- I = 24 A
- Max current of 14 AWG wire = 32 A
- Peak power: 292 W



- Mean effective force from solenoid = 46.8 lbs.
- Mean effective force from combustion = 150 lbs.

Manufacturing

Base Engine: Honda GX35

Custom Piston
- 304 stainless steel
- Chosen for maximum magnetic permeability

Output Assembly
- Output flange and shaft
- Bearing and bearing mount
- Encoder mount

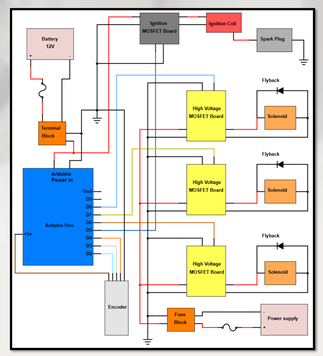
Stock Piston vs. Custom Piston

Solenoid Wrap
- Cooling fins machined off
- 3 parallel circuits (250 total turns) to reduce inductive time constant

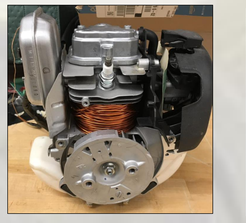
Engine and Dyno Mounts

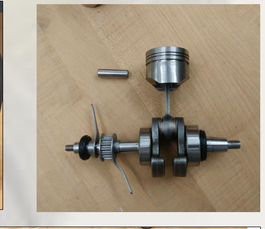
Electronics & Controls

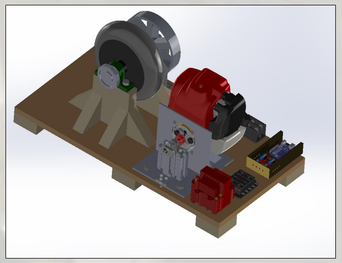
Engine Control System
- Encoder mounted to output shaft
- Arduino UNO controller and timing code
- MOSFET-gated ignition coil and solenoid
- Power distribution and fuse blocks

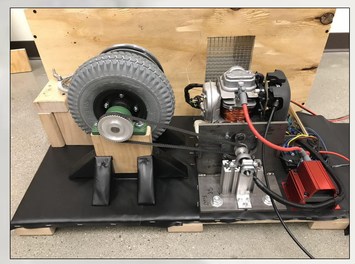


Final CAD / Prototype









Testing

- Successfully ran engine with ignition control system, solenoid wrap, and custom piston
- Successfully measured magnetic field within cylinder during stroke (projected 606 Gauss)

Piston Position	Magnetic Field (Gauss-Proportional to Force)
Top Dead Center (TDC)	361
Midpoint	12
Bottom Dead Center (BDC)	440

- Test plan could not be completed due to undersized factory carburetor
- Efficiency improvements unconfirmed

Going Forward

- Fine-tune ignition timing at higher RPM
- Adjust for proper air-fuel mixture (new carburetor)
- Design a piston with lighter, magnetic material
- Further analyze fuel consumption and efficiency

Acknowledgements

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