Small Scooter Engine Testbed for Advanced Combustion Research

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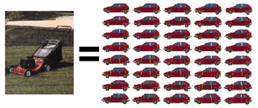
Background

- Small internal combustion reciprocating engines (ie. Less than 50cc displacement) are one of the major power plants for portable power generators, small power equipment (ie. Lawn-mower) and transportation across the globe (especially in developing regions).
- Yet very few standards exist to regulate the emissions from these small engines and are thus a substantial contributor to global air pollutants.
- New advanced combustion technology such as homogeneous charge compression ignition (HCCI) have the power to greatly reduce harmful emissions and improve fuel efficiency.
- However, very little research has been done on the potential application of HCCI to engines of this size.



Goals and Objectives

Goal

- The purpose of this project is to create a small scooter engine testbed that can be used to refine small engines in order to improve their efficiency and to reduce their production of harmful emissions.

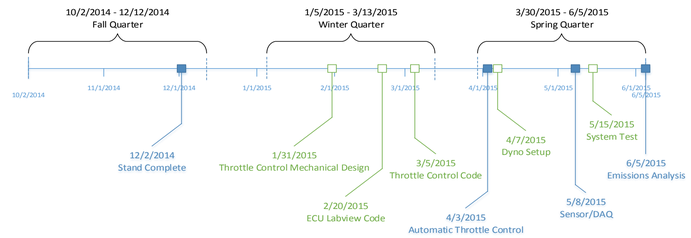
Objectives

- Design and develop a chassis support structure for the scooter and dyno system
- Re-wire, organize and instrument engine with sensors
- Design automatic throttle control system
- Collect baseline emissions data

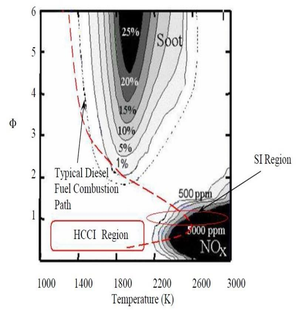
Budget-2014/2015

Project Expense	Comments	Est. Amount ($)
Bicycle Stand	To hold front wheel upright	$60
Battery Trickle Charger	Maintain battery charge	$20
Fabrication materials	For brackets and connections	$50
Arduino/Servo & Servo Shield	Automatic throttle control	$96
	Total	$226

Timeline



Innovation



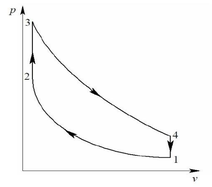
HCCI

- Novel combustion concepts being explored for high-efficiency, low pollutant emission engines are based on strategies for achieving Low-Temperature Combustion (LTC). LTC requires the formation of reacting mixtures in an engine that are dilute enough to not produce the high temperatures that lead to NOx and that have well-enough mixed fuel and air to avoid soot formation.
- Traditional SI gasoline engines and CI diesel engines have to operate at unfavorable combinations of temperature and fuel-air ratios for the formation of NOx, and in the case of Diesels, soot.

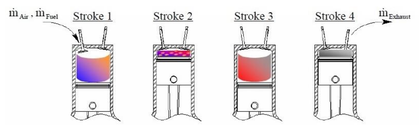
- The simplest form under which LTC operations can be realized is homogeneous charge compression ignition (HCCI) operation.
- This engine offers the opportunity to achieve high thermodynamic efficiency and sharply or completely eliminate production of soot and oxides of nitrogen (NOx). It accomplishes the low NOx emissions by operating at very low product temperatures.

How it works

- A four stroke HCCI engine may be thought of as a CI and SI engine combined into one.
- During the intake stroke a uniform (homogeneous) mixture of air and fuel enters the combustion chamber.
- The compression stroke gives enough energy input to the charge, so that the temperature reaches an autoignition condition for the fuel. This combustion process occurs without help from a spark plug.

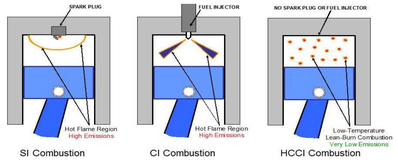


$p - v$ **diagram for ideal HCCI cycle**



Charge path in a 4-stroke HCCI engine

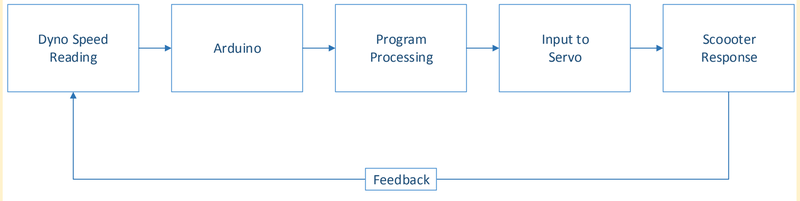
- Due to the homogeneous nature of the charge and by running at very low fuel/air equivalence ratios ignition begins at many points simultaneously and occurs at a significantly lower temperature because there is no flame propagating throughout the chamber.



Comparison of SI, CI and HCCI engines

Current Status

Automatic Throttle Control Feedback System



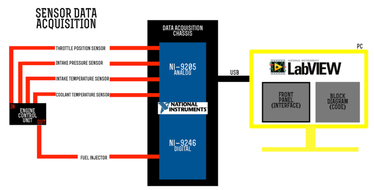
Mounting Assembly

```
#include <Servo.h>

Servo myservo;  // create servo object to control a servo

int val;    // variable to read the value from the analog pin

int pos = 0;   // variable to store the servo position

int desiredVoltage = 2;

void setup() {
  // initialize serial communication at 9600 bits per second:
  Serial.begin(9600);
  myservo.attach(9);
}

// the loop routine runs over and over again forever:
void loop() {
  // read the input on analog pin 0:
  int sensorValue = analogRead(A0);
  // Convert the analog reading (which goes from 0 - 1023) to a voltage (0 - 5V):
  float voltage = sensorValue * (5.0 / 1023.0);
  if (abs(voltage -desiredVoltage)<= 0.01 ){
   delay(5000);
  }
  if (voltage < desiredVoltage && pos <180 ){
   pos = pos+1;
   myservo.write(pos);
  }
   if (voltage > desiredVoltage && pos >0 ){
   pos = pos-1;
   myservo.write(pos);
   }
  }
```

Throttle Control Code

Next Steps

- Finalize engine instrumentation
- Finish/de-bug LabView code
- Collect baseline emissions data
- Test the effects of different fuel additive



DAQ Sensor Interface

The Big Picture

- HCCI engines have the power to greatly reduce harmful emissions and improve fuel efficiency
- However, research concerning the potential of smaller HCCI engines is sparse
- This testbed will be used to research and explore the viability of small HCCI engines as a better alternative to the current CI and SI operated small scale engines