IPRO 310

Conversion of a Commercial-Grade Riding Lawnmower to Hydrogen Fuel

Presenter: Steffany Evanoff, Team Leader

Teaching Assistant: Kris Kiszynski, Graduate Student

Advisors: Dr. Said Al-Hallaj and Dr. Francisco Ruiz

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IPRO Team

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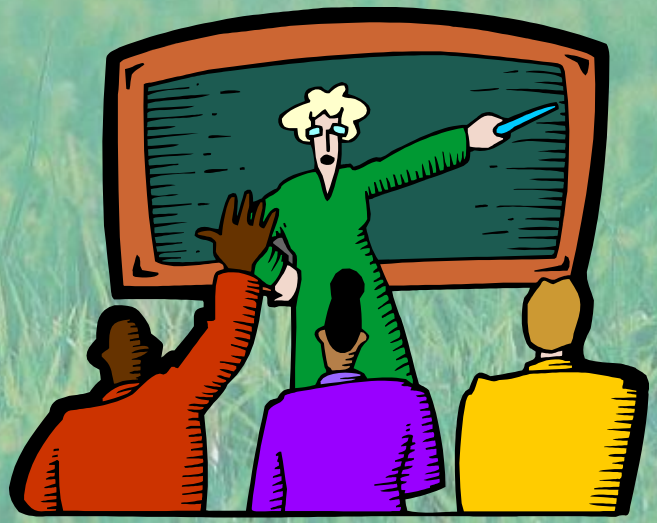
Team Structure

- Advisors
  - Teaching Assistant
  - Team Leader
  - Lab Safety Sub-Team
  - Testing Sub-Team
  - Conversion Sub-Team

Presentation Outline

- Project Introduction
- General Hydrogen Safety
- Testing Methods and Results
- Conversion Methodology
- Conversion Costs
- Further Study and Actions



Project Overview

IPRO

Presenter:
Preeti Abraham
Conversion Team

Purpose

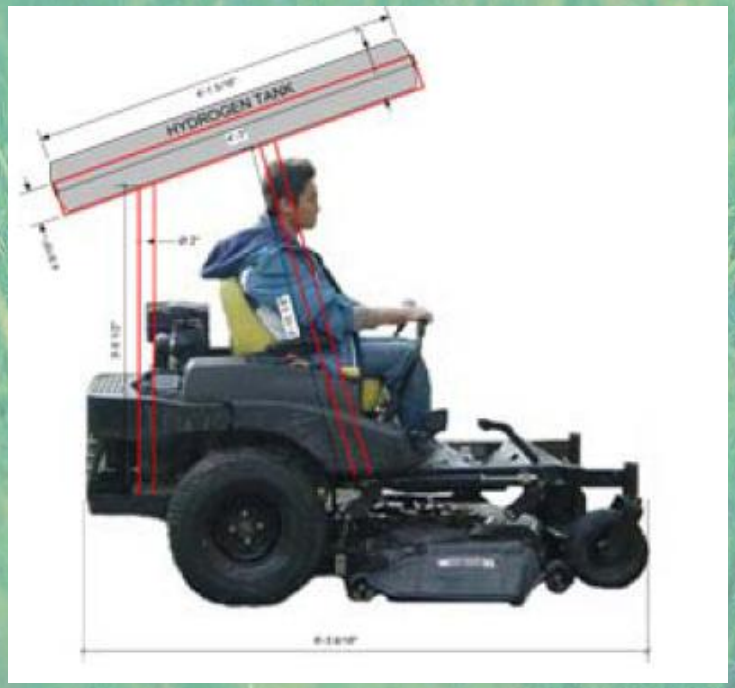
- The Chicago Park District charged the group with finding an alternative fuel source for their lawnmowers that satisfied the following criteria:
  - Reduced emissions
  - Was as or slightly less powerful than a typical lawnmower
  - Was economically feasible

IPRO Objectives

- Perform benchmark testing
- Research and development of hydrogen safety guidelines
- Design a tank mounting system
- Develop a detailed conversion methodology
- Perform engine conversion
- Retest converted engine
- Assemble prototype lawnmower

Contributions from Previous Team

- Estimated thermodynamic model
- Performed preliminary testing
- Located vendors for parts
- Proposed hydrogen delivery system
- Suggested mounting structure



Hydrogen Safety

Presenter:
Joel Fenner
Lab Safety Team Leader

Safety Codes

- NASA (National Aeronautical and Space Administration)
- OSHA (Occupational Safety and Health Administration)
- ICC (International Code Council)
- NFPA (National Fire Protection Association)

General Hydrogen Safety

- 4.7% by volume (LFL) in air to pose combustion hazard
  - Most standards recommend 25% of LFL, i.e. 1% hydrogen by volume in air

- Involved personnel and tank must be grounded

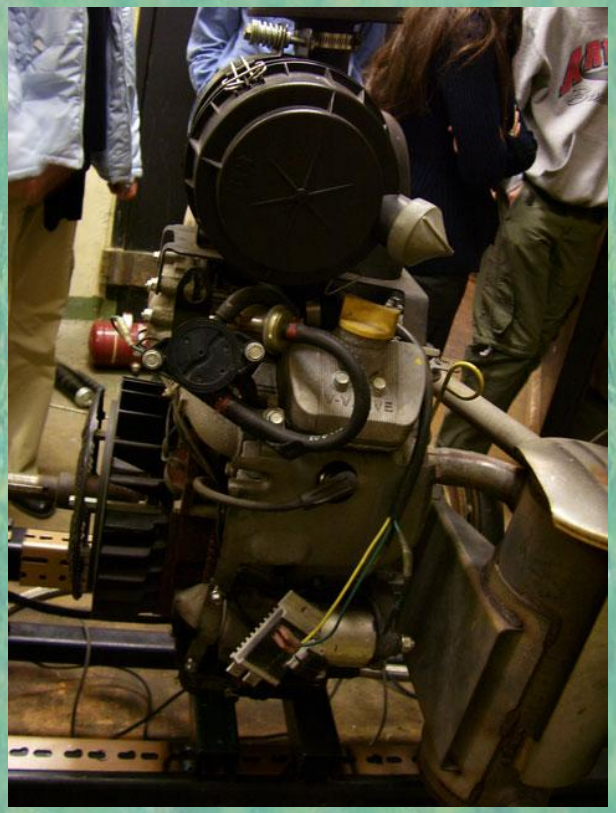
- Monitor tank material for embrittlement

General Hydrogen Safety

- Hydrogen quantity in lab controlled
- Welded fittings preferred over mechanical fittings
- Slight leakage unavoidable through seals and fittings
- Hydrogen detector triggered at 1% v/v
  - Must cause visual and audible warnings
  - Must enable ventilation system and cut off heat sources

- In case of emergency, cut off hydrogen supply

Testing Methods

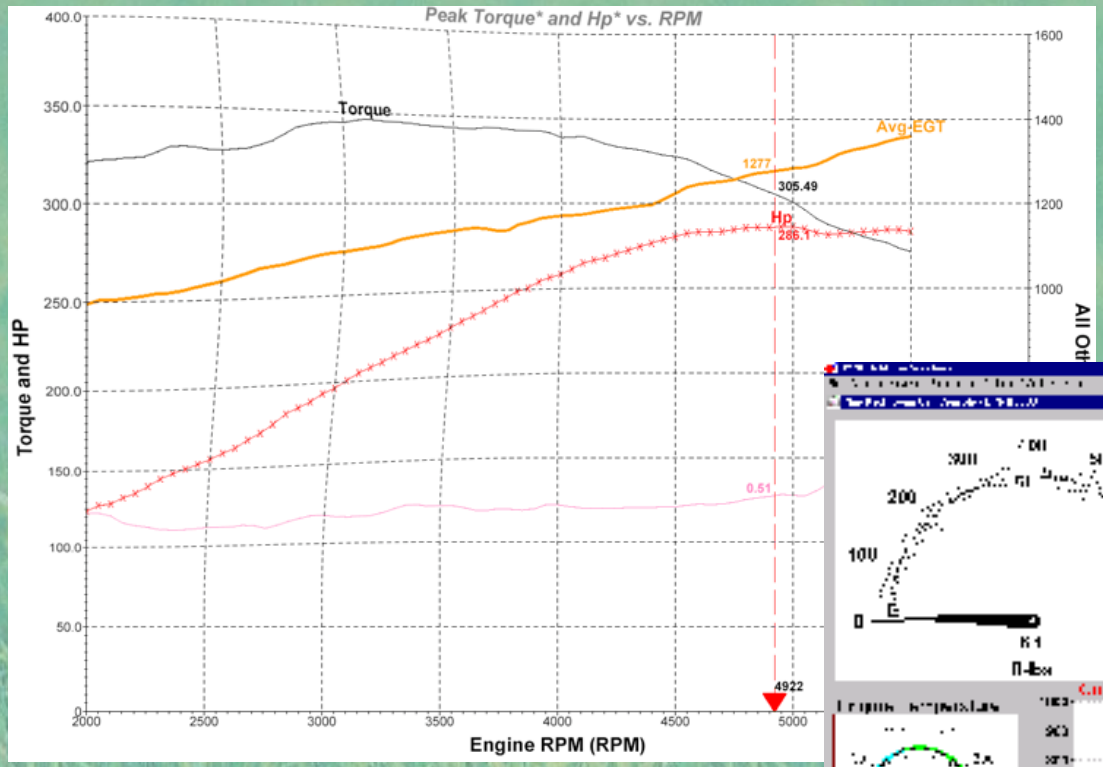


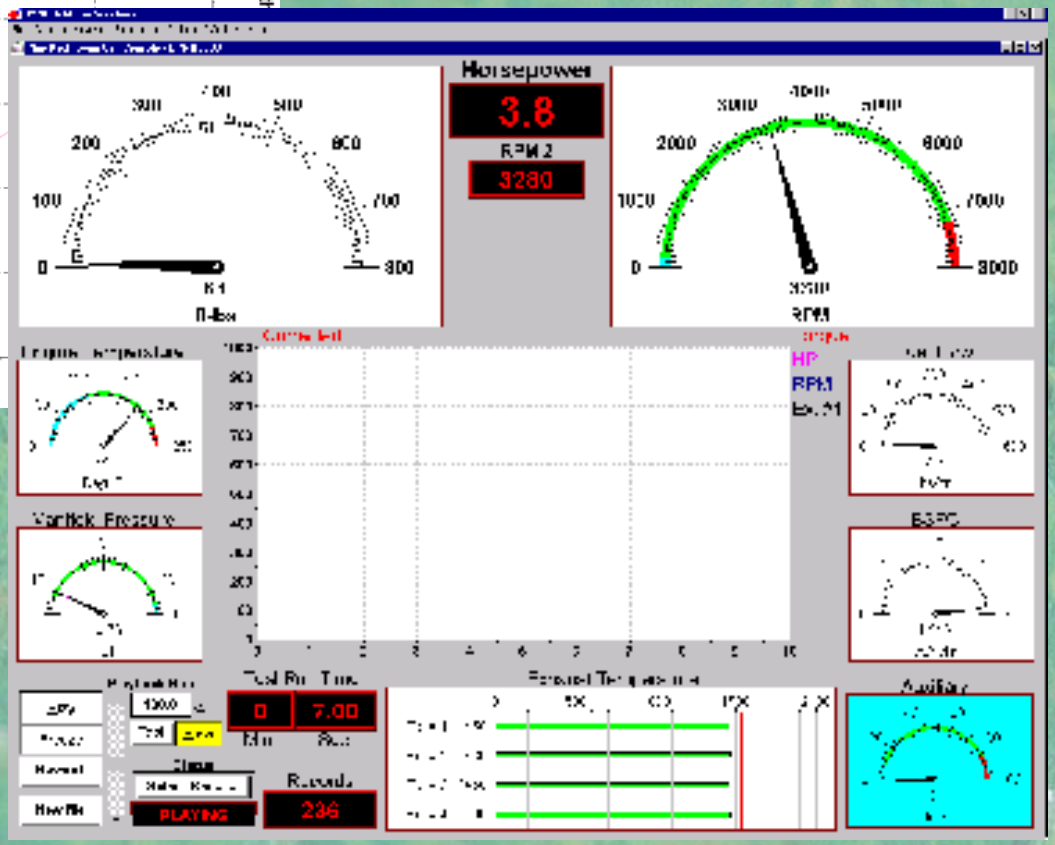
Presenter:
Nate Gates
Testing Team Leader

Progress To Date

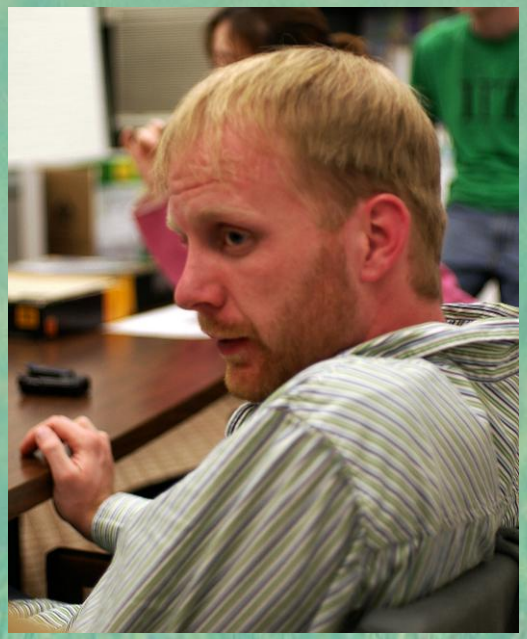
- Refurbished laboratory and testing equipment
- Mounted and started engine
- Prepared laboratory and procedure for benchmark testing

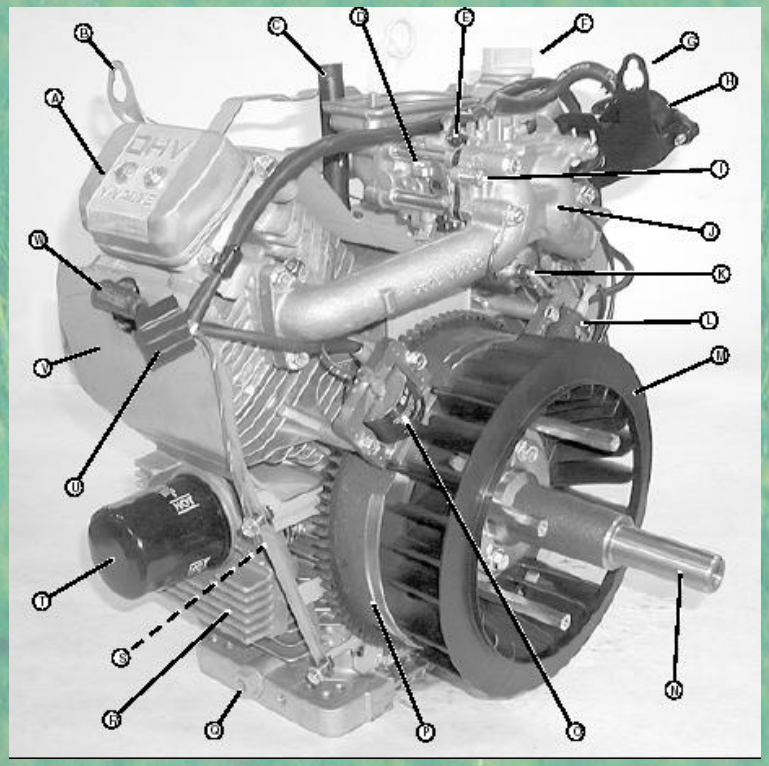
Engine Mapping





Conversion Methodology





Presenter:

Dan Taulbee

Conversion Team Leader

Thermodynamic Model

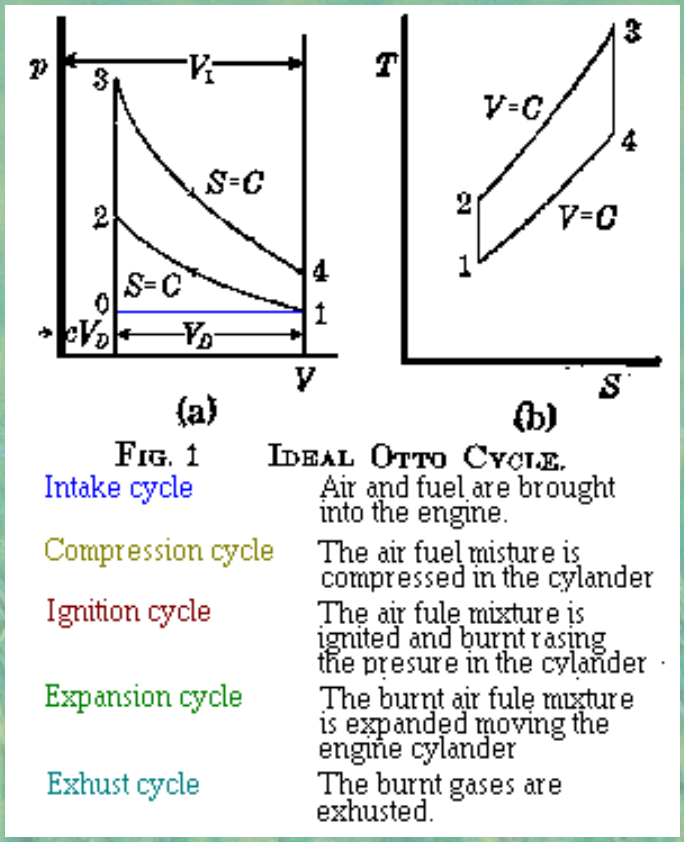
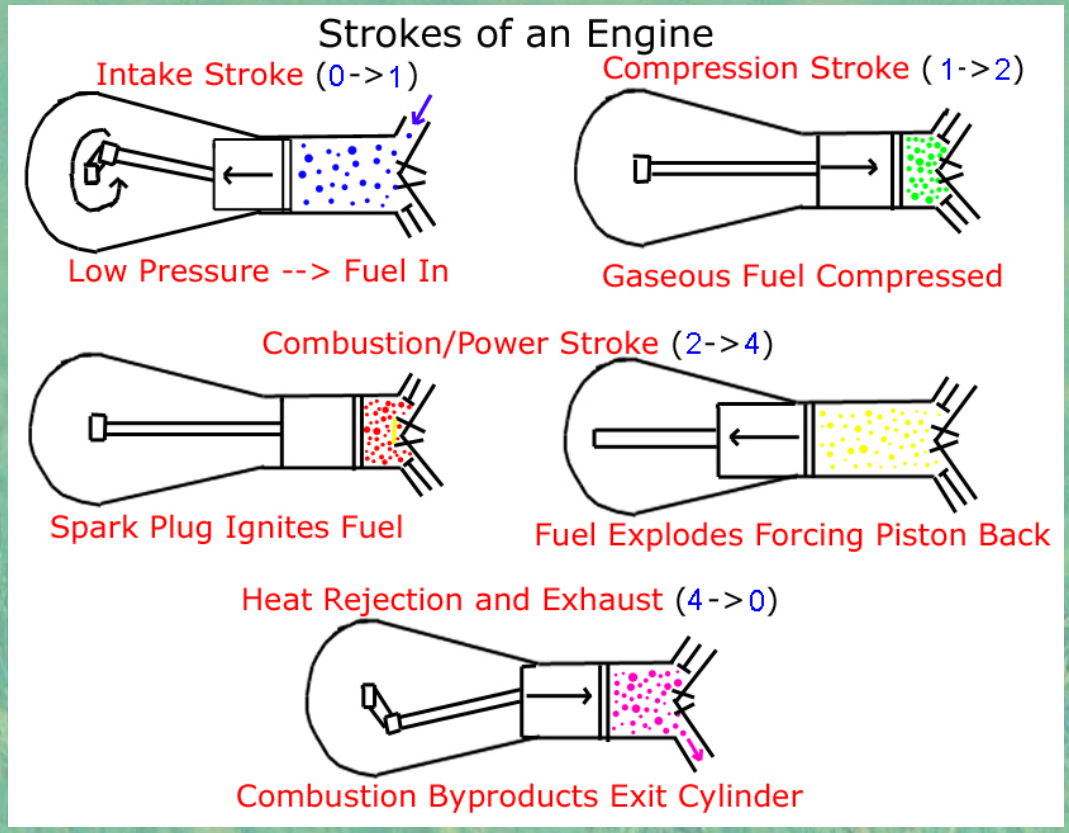


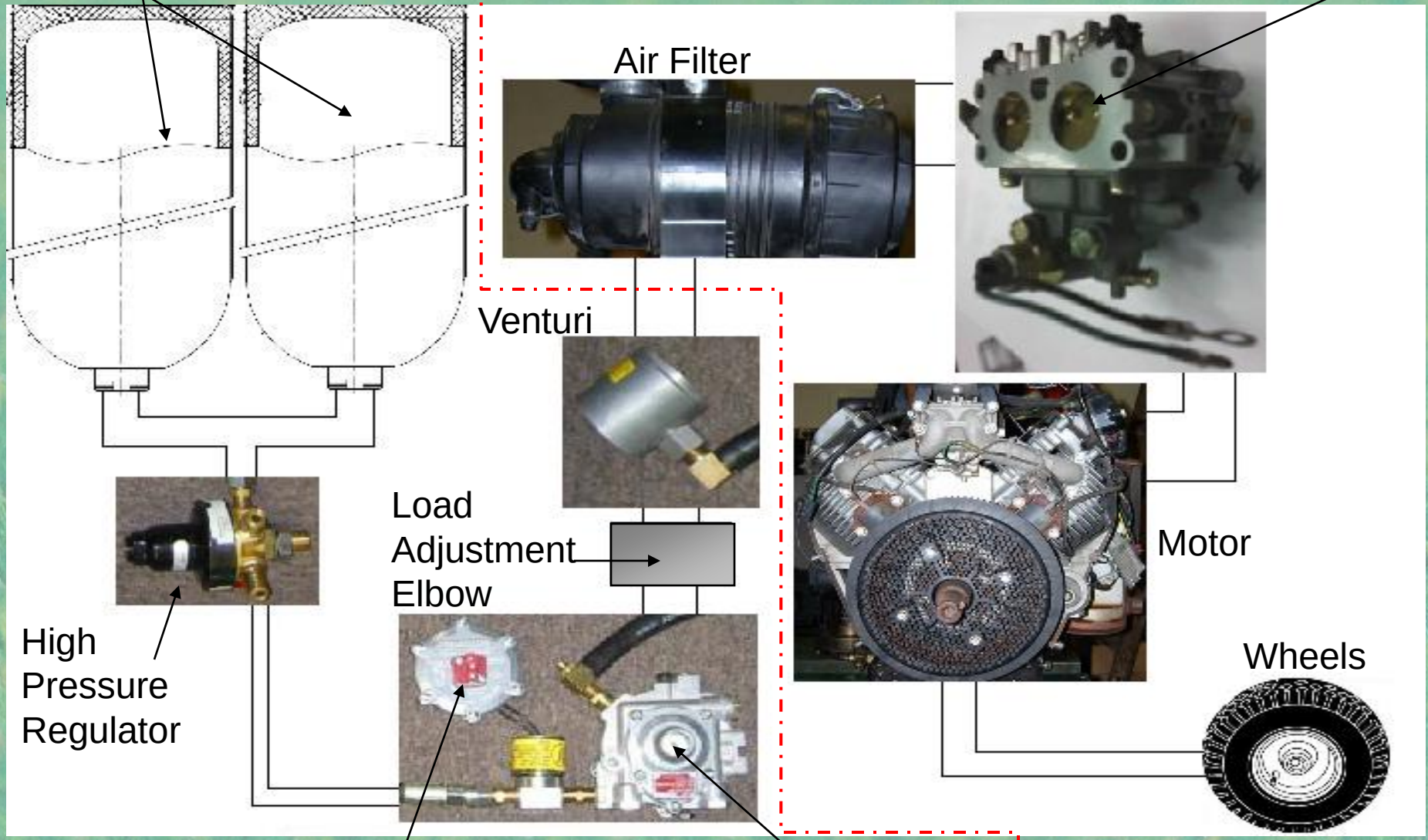
FIG. 1 IDEAL OTTO CYCLE.

Intake cycle	Air and fuel are brought into the engine.
Compression cycle	The air fuel misture is compressed in the cylander
Ignition cycle	The air fule mixture is ignited and burnt rasing the presure in the cylander
Expansion cycle	The burnt air fule mixture is expanded moving the engine cylander
Exhust cycle	The burnt gases are exhusted.



An analysis of the Otto Cycle as an approximation of the real engine yielded 23-27hp for the gasoline-powered engine and 20-25hp for the hydrogen-powered engine.

The Hydrogen System



Proposed Mounting System

Conversion Costs

- Conversion necessities:
  - Tubing and hosing from Swagelok
  - Fuel delivery system from AcmeCarb
  - Composite hydrogen tanks from Luxfer
  - Hydrogen from Mittler (IIT's supplier)
- Prototype Conversion Cost: $2,677.94
- Cost of Hydrogen: $0.30/liter
- Total Cost with 6 hours of runtime for testing: $3,937.94
- Cost increase of 27%

Conclusions and Further Study

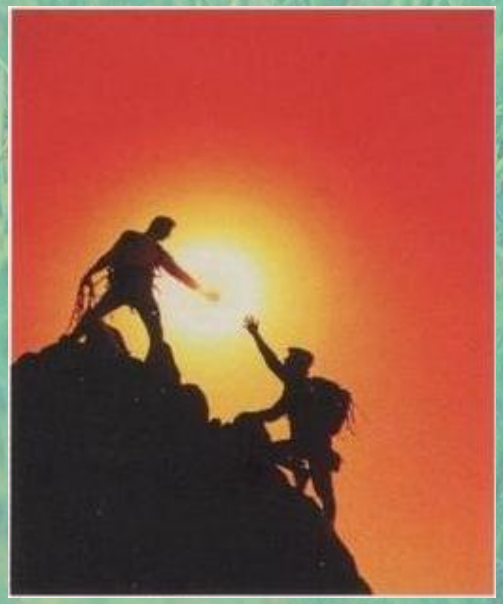
Presenter:
Jason Neale
Lab Safety Team

Further Study and Action

- Perform the conversion
- Perform complete cost to benefit analysis
- Test hydrogen engine for comparison
- Work to reduce conversion costs and increase performance
- Investigate alternative fuels – fuel cells, ethanol, etc

Conclusions

- Accomplishments
  - Overhauled testing equipment and laboratory
  - Developed procedure and ordered all parts for conversion
  - Documented safe handling and usage of hydrogen
- Knowledge Base



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Questions?