The IPRO 310 Project Plan

Spring 2006

Conversion of a Commercial-Grade Riding Lawnmower to Hydrogen Fuel in conjunction with John Deere and the Chicago Parks District

Advisors: Said Al-Hallaj and Francisco Ruiz

Objectives

This semester, the IPRO 310 team is continuing the work started by the previous semester's team. Our work will build off of the previous team's work and many of our objectives will be an extension of their original objectives.

This semester, the team has set forth the following objectives:

- Finish benchmark testing on the lawnmower including gas emissions
- Further research the safe storing and usage of hydrogen as a fuel
- Develop guidelines to create and maintain a safe laboratory area
- Investigate avenues to decrease overall conversion cost
- Perform the engine conversion
- Write a step-by-step conversion manual keeping in mind safety and Occupational Safety and Health Administration (OSHA) standards

Although the team's main objective is to provide a safe way to convert a gas-powered lawnmower to a hydrogen-power lawnmower, the team will strive to create an environment in which team collaboration, the application engineering knowledge and ability, and individual passion for the project can flourish thus providing a rewarding and educational experience for all of the participants.

Background

Over the past few decades, many performance standards have been placed on automobile emissions and fuel consumption but these standards have not been extended to gas-powered recreational vehicles such as lawnmowers. The Chicago Parks District (CPD) is responsible for over 7300 acres of trim green parkland. According to last semester's testing, with the blades engaged and a full 10-gallon tank of gas, a lawnmower can operate for less than 6 hours and according to eNature, per hour of operation, a lawnmower emits 10-12 times as much emissions gas as does a typical automobile. With increasing gasoline prices and increased evidence for global warming being caused by vehicle emissions, CPD figured something had to be done! They charged this team with investigating the costs, benefits, and procedure associated with converting CPD's brigade of lawnmowers to run on a fuel with higher energy density and lower noxious emissions: hydrogen.

John Deere © donated the riding lawnmower that the team will eventually convert and is always interested in improving upon current designs and offering new and improved products to its customers.

The team will run into a few problems as the conversion process continues. The problems primarily surround safe storage and refueling of the hydrogen fuel tanks, decreasing conversion cost such that it is not prohibitively expensive, and how to mount the fuel tanks safely on the lawnmower.

Methodology

The final product of the team's efforts will be a riding lawnmower that has a hydrogen-powered engine and is an improvement upon its gas-powered former self by way of less noxious emissions and cheaper fuel costs. Right now, however, the team has just assembled and has many roadblocks on the way to the ultimate goal.

The following steps were developed and will be followed procedurally by each member of the team to reach the goal:

- **Become familiar with conversion methodology, equipment and necessary precautions.** Each member of the team will need to understand the basics of hydrogen properties, storage techniques, and integration into an internal combustion engine. This includes reading research papers and reviewing the previous semester's results. The team members actually completing the testing and conversion sill need to become familiar with the laboratory equipment. The lab safety group will need to verify and implement safe hydrogen containment and a safe testing environment.
- **Complete the preliminary conversion research.** The team still needs to complete emissions and other benchmark testing, continue researching and agree on satisfactory conversion materials and costs, comply with OSHA standards when working with the hydrogen, develop a conversion procedure, and find a satisfactory way to mount the hydrogen tanks on the lawnmower.
- **Perform the conversion**. Following the conversion procedure developed previously and revising as necessary, the team will install the necessary materials and actually convert the engine.
- **Execute performance testing on the new lawnmower**. The team will perform tests to compare with the benchmarks established before.
- **Analyze the data**. The team will compare the benchmark data with the data in the previous step to determine performance and emissions improvement.
- **Report results to CPD and John Deere.**

This model is necessary as so much research needs to be completed before the actual conversion takes place. Research into the technical aspects needs to be extremely extensive as there is only one available lawnmower and a capped budget so the team needs to get the conversion right the first time. A similar amount of research needs to be completed on the financial aspects because CPD is looking to save money and if the conversion is so expensive that if it does not actually save money then a different avenue will have to be pursued.

Expected Results

The expected result of the team's work is a safe working riding-lawnmower whose engine runs completely on hydrogen gas and is more fuel- and emissions-effective than an identical gasoline-powered model based on data comparison. The team will also have a safe laboratory testing environment and produce a step-by-step manual detailing the conversion process.

Budget

Table 1 shows the projected cost of conversion.

Item	Part Number	Quantity	Unit Price	Amount
From Swagelok, Gas Technologies				
Union Elbow	SS6009	4	$16.50	$66.00
Union Tee	SS6003	3	$24.50	$73.50
Tubing	SST6S04920	20 feet	$4.53	$90.60
Flex Metal Hose	SSFM6TA6TA636	1	$210.30	$210.30
Flex Metal Hose	SSFM6TA6TA618	4	$178.30	$713.20
Regulators	KPR1JRF417A20010	4	$399.50	$1598.00
Valve	SS43GS6	1	$67.90	$69.70
From Luxfer Composites				
3000 psi Tank	N200	4	$333.00	$1332.00
From IMPCO Systems				
Lock-Off Solenoid	4004A12V	1	$29.83	$29.83
Low-P Regulator	T60G	1	$93.23	$93.23
Venturi	2001532	1	$36.13	$36.13
Connection Bolts	42EA	1	$8.65	$8.65
			Total:	$4329.71

Table 1: Projected Budget

The total of $4329.71 is expected to go down to $1966.62 (as was presented by the previous group to CPD). This decrease in projected cost can be attributed to the possibility of reducing the number of regulators from four to one and renting the hydrogen tanks, thus reducing the two largest projected expenses. However, as these two avenues are not absolute and still need to be confirmed, $4329.71 is the worst case conversion cost.

Tasks and Milestones

Although the team is already armed with the objectives, a more detailed breakdown of tasks, deliverables, and milestones is necessary. Table 2 shows a list of IPRO deliverables, their due dates, and those responsible for the deliverable.

Deliverable	Due Date	Responsible Parties
Project Plan	Feb 3	Team Leader, Sub-Team Leaders, Advisors
Mid-Term Report	Mar10	All Groups, Mid-Term Report Group
Website (Optional)	Apr 28	Team Leader
Presentation	May 3	All Groups, Presentation Group
Exhibit Poster	Apr 28	All Groups, Poster Group
Abstract	May 1	Team Leader, Advisors
Final Report	May 5	All Groups, Final Report Group
Deliverable CD	May 5	Team Leader

Table 2: IPRO Deliverables Information

Note: Since the website is optional, the team will evaluate its available time and resources closer to the website's due date to see what, if anything, will be done with the website.

Table 3 shows a breakdown of sub-team deadlines for each of the milestones in the research methodology. It shows the milestones, the projected date of completion, a more specific task for each team, and the projected number of hours to complete the task, per person, per group. For sections in Table 2 where '----' was entered as a due date, it means that that team does not play a large role in that step and the students in that group will join other groups to further contribute to the overall project.

Milestones	Date of Completion	Task Breakdown Per Group	Hours
Familiarization			
*Testing Team	Feb 4	Learn equipment	4
*Conversion Team	Jan 26	Review papers and research	6
*Lab Safety Team	Feb 11	Research safety codes, find equipment	15
Preliminary Research			
*Testing Team	Feb 21	Dyno. and gas analyzer, engine mapping	20
*Conversion Team	Feb 10	Develop thermodynamic model	15
*Lab Safety Team	Feb 14	Write safety codes	5
Conversion			
*Testing Team	----		
*Conversion Team	March 12	Convert the engine	30
*Lab Safety Team	March 1	Order/install safety equipment	10
Post Conversion Testing/Analysis			
*Testing Team	April 7	Test new motor and compare results	30
*Conversion Team	----		
*Lab Safety Team	----		
Presentation of Results	April 18		

Table 3: Milestone Breakdown by Sub-Team

<u>Individual Team Member Responsibilities</u>
Advisors: Said Al-Hallaj and Francisco Ruiz
Team Leader: Steffany Evanoff

Conversion Team
Daniel Taulbee - Leader
Preeti Abraham
Steffany Evanoff
Yewon Gim
Shawn Shoulders

Lab Safety Team
Joel Fenner – Leader
Jason Neale
Minsuk Jung
Minjoong Kim
Chungyun Kim

Testing Team
Nate Gates - Leader
Nathan Knopp
Melissa Lemons
Jim Nihei
Karen Sedacki
Frank Costanzo

Deliverables Groups
Mid-Term Report: Preeti Abraham, Jim Nihei, Karen Sedacki
Final Report: Melissa Lemons, Nate Gates, Nathan Knopp, Joel Fenner
Poster: Chungyun Kim, Minjoong Kim, Frank Costanzo
Presentation: Yewon Gim, Dan Taulbee, Minsuk Jung