Yeast Biodiesel And Petroleum Diesel Comparison Testing On The Bonneville Salt Flats

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BioEnergy Center

Abstract

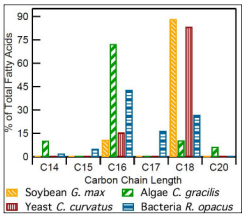
In 2006 faculty from multiple departments at Utah State University began collaborating in an effort to create biodiesel from CO_2 and sunlight using microalgae. In early 2012 the team was successful in creating biodiesel from a microalgae (*Chaetoceros gracilis*) in sufficient quantities to test using a diesel engine and dynamometer setup. The team had also created biodiesel from a bacteria (*Rhodococcus opaqus*), and a yeast (*Cryptococcus curvatus*) grown utilizing a waste carbon stream from a cheese making plant, to test along with the microalgal biodiesel. The fuels were successful and performed nearly identically to commercial soybean biodiesel, and were comparable to petroleum diesel. With successful testing of the biodiesel the team set out to test the fuels in a vehicle. Over the course of 10 weeks in the summer of 2012 the team along with industry partner Utah Chassis and Machine in West Valley City, Utah created the USU Aggie A-Salt Streamliner. The car featuring a V-twin direct injection diesel and a continuously variable transmission ran at two events at the Bonneville Salt Flats in Wendover, Utah setting a land speed record in its class using petroleum diesel and successfully demonstrating yeast biodiesel in a vehicle by performing nearly identically to the petroleum diesel run without any modifications to the vehicle. The car is part of an ongoing senior design project for the Mechanical and Aerospace Engineering department for both aerodynamic and drivetrain performance design. For 2013 the car will feature a carbon fiber body and a Harley-Davidson 5 speed transmission. The car is also part of the biofuels project and will run algal biodiesel in 2013.

The Team

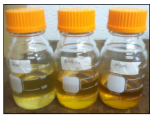
The USU Aggie A-Salt team consists of faculty, staff, and students from the Mechanical and Aerospace Engineering(MAE), Chemistry and Biochemistry, and Plants, Soils, and Climate departments, as well as an industry partner with Chassis and Machine. The MAE team members are focused on continually upgrading the car in order to minimize efficiencies with senior design teams working on improving the car each semester through a design and build phase. The Plants, Soils, and Climate team members are working to understand better the physiology and growth parameters to optimize microalgal growth with increased biodiesel creation potential. The Biochemistry team members are focused on creating more efficient extraction methods along with continued testing of biodiesel properties in creating liter quantities of biodiesel from multiple microorganisms . Industry partners Utah Chassis and Machine assist in testing and building of components for the race car bringing with them decades of racing experience.

The Fuel

1) Graph 1. Carbon chain lengths of each microbial biodiesel and soybean biodiesel.



3) Figure 3. Microbial Biodiesel



Biodiesel can be created from oleaginous, or oil containing, microorganisms. Utah State University has been able to successfully create biodiesel from yeast, bacteria, and microalgae in sufficient quantities to test the chemical properties and performance properties using chemical analysis and dynamometer testing with a small diesel engine.

2) Figure 2. Dynamometer and emissions setup with a Kubota Z482 to test the fuels.

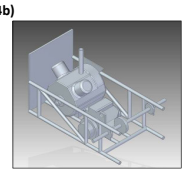
Initial testing of the fuels showed that the microbial biodiesel fuels performed similar to soybean biodiesel and comparably to petroleum diesel fuel. The algal biodiesel had lower NO_x emissions than all fuels including petroleum diesel.

The Powertrain

4a)

Figure 4. The Powerplant.
4a) The engine is an 836cc v-twin direct injection diesel. The engine produces 22 hp and 30 ft-lb of torque. 4b) A pictorial representation of the proposed layout for the engine placement with a new Harley-Davidson 5 speed transmission

4b)



A small diesel engine was chosen in order to minimize fuel consumption. The engine is a 22 hp air cooled V-twin direct injection diesel. The engine features 19:1 compression and a maximum rated RPM of 3600.

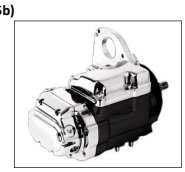
The engine was rebuilt within a few minutes of run time due to an error at the manufacturer leaving errors which caused engine failure. The engine was then reassembled utilizing improved parts.

At the second event it was determined that one injector was not performing correctly and that the valves were not seating properly. After the event the heads had the valve seats resurfaced and the heads were extensively ported to improve performance. Dyno testing has shown increased performance that will be utilized for the 2013 season.

5a)

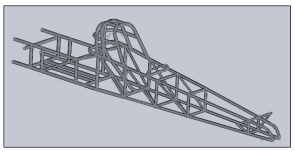
Figure 5. The Transmission.
5a) The initial design utilized a Polaris snowmobile continuously variable transmission or CVT.
5b) For 2013 the car will be featuring a Harley Davidson 5 speed transmission with a hand clutch and shifting mechanism

5b)



The Chassis

6) Figure 6. CAD model of the chromoly chassis



The chassis is built to meet the specifications of the land speed racing sanctioning bodies associated with the Bonneville Salt Flats which are the Southern California Timing Association (SCTA) and the Utah Salt Flats Racing Association (USFRA). The two main groupings for special construction category are 175 mph and above and 175 mph and below. The Aggie A-Salt Streamliner is built to the 175 mph and below group. To meet the technical specifications the main cage structure is crafted from chromoly steel with an O.D. of 1.5" and a wall thickness of 0.095".

The Body

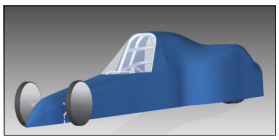
7) Figure 7. Initial streamliner design used for 2012 season

To meet the streamliner body requirements of the SCTA and USFRA two of the wheels must enclosed for a minimum of 120°. Due to build time constraints the original body was made from aluminum and the front two wheels were covered for convenience. An required inner body skin was also crafted from aluminum for driver protection.

As part of the ongoing senior design projects for MAE a team of students is crafting a carbon fiber body for the streamliner with features that have shown favorable in creating a lower drag coefficient for the car utilizing computational fluid dynamics (CFD). Those features include:

- Continuous body from front to rear to direct airflow
- Enclosed cockpit utilizing a canopy
- Rear wheels enclosed and front wheels uncovered

8) Figure 8. 2013 MAE students carbon fiber body design



Conclusions

Microbial biodiesel created at Utah State University is a viable replacement for petroleum diesel. When tested against commercial soybean biodiesel and petroleum diesel fuel the microbial fuels performed favorably when using a dynamometer and emissions testing equipment. The yeast biodiesel was then tested in a vehicle on the Bonneville Salt Flats. With back to back runs using petroleum diesel and yeast biodiesel the yeast fuel was again shown to perform nearly identical when used in a vehicle without any modifications to the vehicle. Microbial biodiesel is a viable alternative to petroleum diesel fuel and will continue to be tested on the Bonneville Salt Flats.

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Utah State University Land Speed Project

Accomplishments

- Streamliner was constructed in 10 weeks
- Passed inspection at first event attended
- Set a land speed record at first event attended
- Increased performance at each event attended
- Received international attention for biofuel use
- Published microbial biodiesel results in Energy & Fuels

References

Acknowledgments: US DOE Grant No. DE-EE0003114; USTAR (Utah Science Technology and Research Initiative)

Slide 1

RMW1 Minimize or maximize?
Robert Malone Willis, 1/22/2013

RMW2 consider rewording, you use error twice in a row and that can be somewhat redundant to a reader
Robert Malone Willis, 1/22/2013

RMW3 Consider saying something like "have been shown favorable in reducing the drag coeficient"
Robert Malone Willis, 1/22/2013