**Unit Overview**

This unit begins with a lesson that first summarizes the problems we are facing with using fossil fuels as our primary energy source and then introduces the use of biofuels in transportation as one potential solution to these problems. Two NSF Educational Web Modules through the Sustainable Futures Institute at Michigan Technological University are used for this overview.

Following are three lab activities in which the students investigate the formation and combustion of a biofuel. First, the students actually convert two types of biomass into ethanol and compare the amounts yielded by each. Next, they conduct an experiment in which a fossil fuel and a biofuel are combusted and perform calorimetry to compare the amount of energy released by each. In the third experiment, they combust a fossil fuel and a biofuel and measure the byproducts (particulate matter and carbon dioxide) of each for comparison.

**Assessments**

1. Students conduct a silent, written argument on the subject of biofuels being a worthwhile transportation energy resource to pursue.
2. Students create technical reports of all three experiments including all methods, results, and conclusions.
3. Using what they have learned, students discuss the advantages and disadvantages of converting from fossil fuels to biofuels as a transportation energy resource.

**Bioethanol Production**

Early in the research experience, we learned the mechanics of converting plant biomass into bioethanol. Current bioethanol production is primarily from corn and sugar cane sources, but research is being done on the viability of converting woody materials like aspen trees into ethanol - hence the Wood in Wood-to-Wheels!

Using bioethanol as a source for automotive fuel could result in a net reduction of carbon dioxide in the environment, allowing progress towards a sustainable energy source, and becoming more energy independent. Using woody materials as a source for ethanol allows us to move beyond competing with food sources and using agricultural lands. This gives a lot more flexibility in meeting ecological concerns with growing and harvesting our feedstocks.

**Combustion Analysis**

Research being conducted at the AERB lab in Hancock studies the fundamentals of fuel combustion in engines. A high-speed camera capable of capturing 30,000 frames per second films fuel being ignited by a spark and fuel being sprayed through different types of injectors in a specialized combustion vessel with sapphire viewing windows.

The test we observed modeled the combustion in an auto engine that is using Exhaust Gas Recirculation. Running EGR reduces nitrogen oxide (NOx) emissions but leads to more engine misfires. Various spark energies were tested to try to reduce these misfires, with the camera recording if and how the fuel combusted.

**Emissions Analysis**

The research we were involved with in the MEEM labs focused on reducing pollutants in vehicle exhaust. Studies were done on two actual engines - one being a Cummins heavy engine diesel and the other a Ford EcoBoost small truck engine.

One heavy engine test analyzed the results of varying the amount of urea being added to the chemical converter in the exhaust stream (adding urea reduces the amount of NOx exiting the tailpipe). The second heavy engine test analyzed the effectiveness of a new type of radio wave sensor used to measure particulate matter amounts in the exhaust stream. The small truck engine lab tested the effectiveness of making hotter and longer sparks to prevent misfires while running EGR.

**Conclusion**

The Wood to Wheels Research Experience for Teachers included laboratory activities and collaboration with MTU faculty to create teaching units that incorporate content knowledge, research, science, and engineering.

In the IC engine labs...

we gained a great experience in technology & research. It allows us to introduce a greater degree of "real life" engineering into our classes.

As Dr. Shonnard said, "...so they know it doesn’t exist just in a textbook."

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