

Final Report

Biodiesel Education Project

Submitted to:

Ravi Malhotra, *i*-CAST

Julie Vanlaanen, Sr. Design Faculty Advisor

Team Members:

Lina Anelauskaite

Keanan Harrold

Allen Kuhn

Shamim Monjazeab

Gage Soehner

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Introduction

This report is intended to serve two purposes. The first of which is to provide an easy to use manual that can be used to administer a presentation about Biodiesel using the educational cart built during this project. The second purpose is to wrap up the design and construction aspects of the Biodiesel Education Project.

Educational Cart

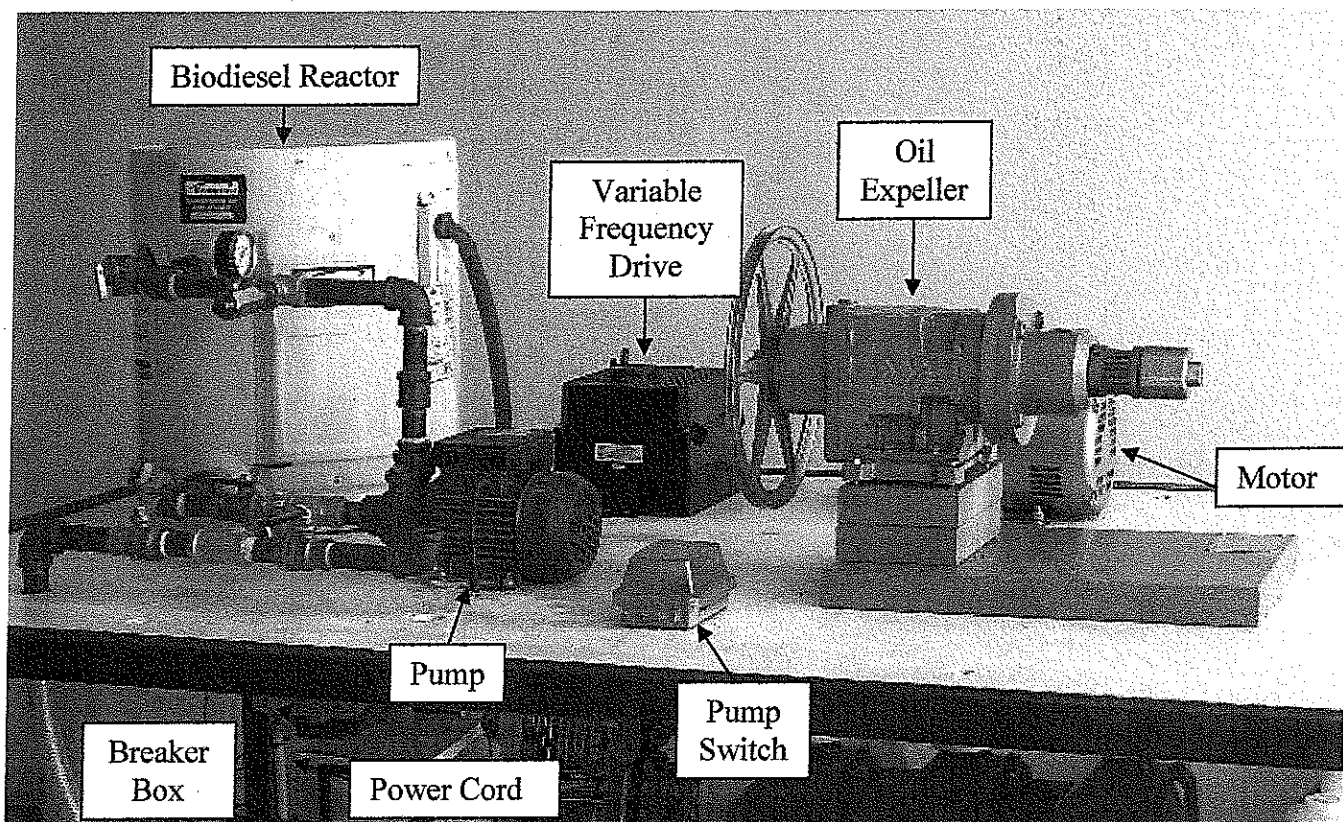


Figure 1. Educational Cart

This cart can be used to press oil from seeds and also produce biodiesel. The procedures on the following pages outline how to use the cart in an educational setting.

Recommendations for the biodiesel education class

- It is recommended that the display board showing examples of seed to biodiesel provided to you by the CSM students be placed in a visible location. This will allow farmers to see all of the inputs and products involved in the biodiesel production process.
- Biodiesel production can take a long time even on a small scale. It is our recommendation that the biodiesel batch be prepared and mixed beforehand.
- The class could be started with the Educational Presentation provided by the CSM students to teach farmers the basics of biodiesel production. The presentation is about 20 minutes long.
- After finishing the educational presentation it may be useful to reiterate the production process by completing the Hands-on Demonstration (see separate procedures). This demonstration could be done with the whole group making a small batch, but it would be easier and much safer to just have a few people make a batch, while being sure to show the whole group. We recommend that only one or two people perform the hands-on portion at a time.
- At the completion of the hands-on demonstration it would be useful to allow the mixtures to settle. You can move on to the rest of the class and come back to see the separation at the end.
- While waiting for the hands-on batches to settle you can move on to the SID unit.
- Begin by demonstrating the seed crushing process (see separate procedures).
- Then the biodiesel can be drained out of the reactor*(see separate procedures). This will give the farmers a chance to see production on a larger scale and present a perfect chance for a question and answer session regarding large-scale production.
- At this time you can also go back to the hands-on batches to check for separation.
- The educational handouts and FAQ report should be handed out after the class. The farmers can take these products with them to hopefully keep everything they have just learned fresh in their minds. These products can also be distributed in public (independent of the class and presentations) to help increase biodiesel awareness.

Please carefully read the MSDS sheets for safe chemical handling as well as all user manuals before performing any procedures.

*Complete settling can take up to 12 hours. We recommend the biodiesel be fully mixed and allowed to settle for the class begins. Then it would be possible for the farmers to get a better look at the separated biodiesel as it comes out of the reactor. However, mixing could be done during the class and previously made biodiesel could be shown to the group to demonstrate the separation of biodiesel and glycerol. There are several ways to structure the presentation of materials. This is just our recommendation.

Hands-on Demonstration

Materials needed

- Mason jars (two for each experimenter)
- Crock-pot
- Rubber gloves (at least one pair for each experimenter)
- Safety glasses
- MSDS sheets for each chemical (KOH, methanol and biodiesel)
- Fire extinguisher
- KOH
- Methanol
- Filtered vegetable oil
- A glass or plastic measuring container
- A digital scale
- Zip lock bags
- A common spoon (preferably plastic or stainless steel)
- Paper towels
- Long-sleeve shirt, full shoes and trousers are recommended while performing this experiment
- A running water source close by.

Recipe

250 mL oil
55 mL methanol
4 g KOH

Preparation and Production

Perform this experiment only in a well lit and well ventilated area.

Fill up the provided crock-pot with water (about ½ way) and turn on low 15 minutes before starting the experiment.

Plan for spills by spreading paper or plastic on your work surface.

Please read MSDS sheets provided and familiarize yourself with methanol, lye and biodiesel handling and safety. Do not inhale any vapors!

Put your safety glasses and gloves on before opening any chemicals.

Make sure that there is a fire extinguisher with the portable biodiesel reactor unit.

Add 250 mL of oil to desired number of mason jars and place them in the crock-pot so that oil warms up. At higher temperatures the reaction proceeds much faster.

Measure 4 grams of KOH using the digital scale. It is recommended to have measured amounts of lye prepared in zip-lock bags before hand.

Measure 55 mL of methanol using a marked glass container and add to a clean mason jar. It is recommended to have measured amounts of lye prepared in the mason jars before hand.

Slowly add KOH to methanol to get a mixture called "sodium methoxide." Place the lid tightly on the jar and shake the mixture. Note: the temperature will rise. After about 2 minutes of shaking the jar the KOH should be completely dissolved into the methanol.

Add the warm 250 mL of oil to the sodium methoxide mixture.

Reattach the lids and shake the mixture for about 5 minutes.

Let the biodiesel settle.

Check if biodiesel reaction is complete by looking for a clear line between biodiesel and darker colored glycerol (it will settle at the bottom). Please see picture below for reference.



Figure 2 Light-colored biodiesel is on the top and dark colored glycerol is settled at the bottom of the jar

Dispose of used chemicals properly. The byproduct is laden with methanol. Pour it into 5 gallon buckets, leaving no air gaps at the top and dispose of it at a landfill.

Oil Expeller Operation

1. Before any expeller operation be sure that the expeller has been properly cleaned (see Operators Manual in Appendix A for proper cleaning procedures).
2. Plug the main power cord into a non-GFCI outlet (see Electrical Recommendations).

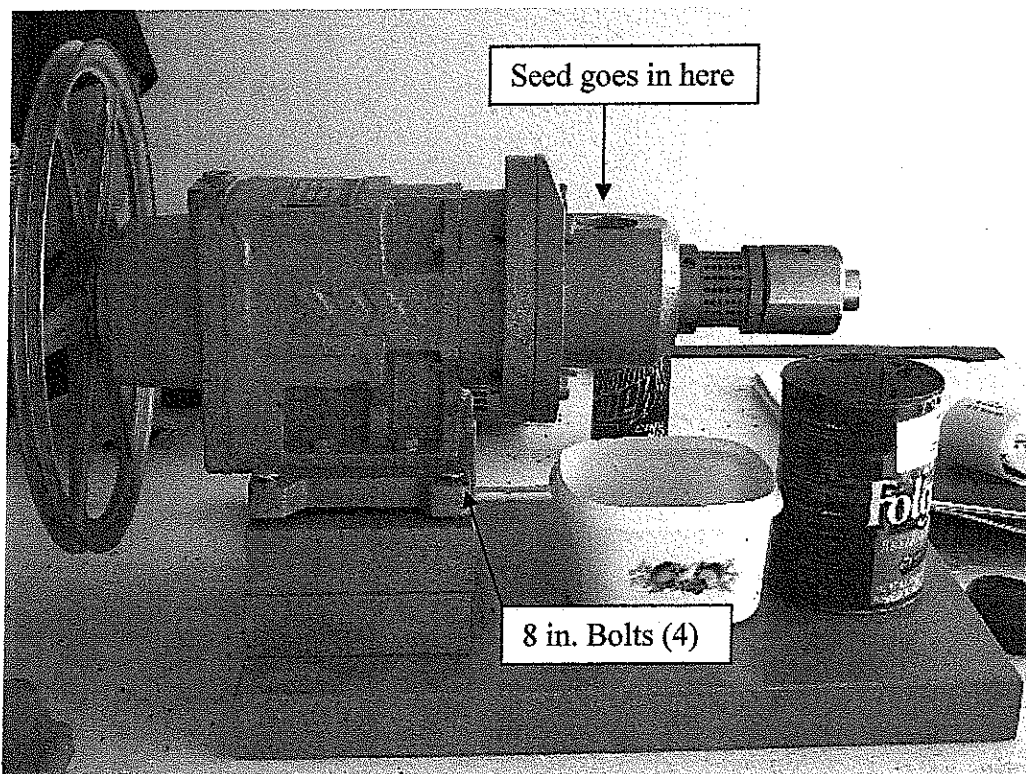


Figure 3. Expeller Unit

3. Turn the breaker (located in the green breaker box) labeled "Expeller" to the On position.
4. Make sure that the belt connecting the expeller to the motor is tight. If there is slack in the belt, loosen the four bolts holding down the motor and slide it to tighten the belt. Be sure to retighten all 4 bolts before running the motor.
5. If it is desired to run the expeller by hand cranking, remove the belt. Loosen the set-screw on the 12" pulley and remove the pulley from the expeller. Place the 12" pulley, belt, and the shaft key in a safe location. Loosen the 4 – 8" bolts (see Fig. 3) and remove. The top portion of the expeller can now be lifted off of the base. Lift the top portion and rotate the base 180 degrees. Reorient the top portion of the expeller on the base and bolt down. Attach the hand crank provided with the unit (It should hang off of the edge of the cart). Tighten the Allen-head set-screw on the hand crank. The expeller is now ready to be used.
6. Add oil seed to the expeller hopper (big hollow container not showed). Place catch bowls under the expeller outlet. With the set-up shown in Figure 2 the oil would drip into the white container and the oil meal would fall into the coffee can.
7. Flip the Power switch on the Variable Frequency Drive (see Fig. 4 on next page) to ON.
8. Make sure the indicator dial is not set above 25%. Flip the Start/Stop toggle switch to start.

- Adjust the indicator dial to the desired speed (15 to 20% is recommended).

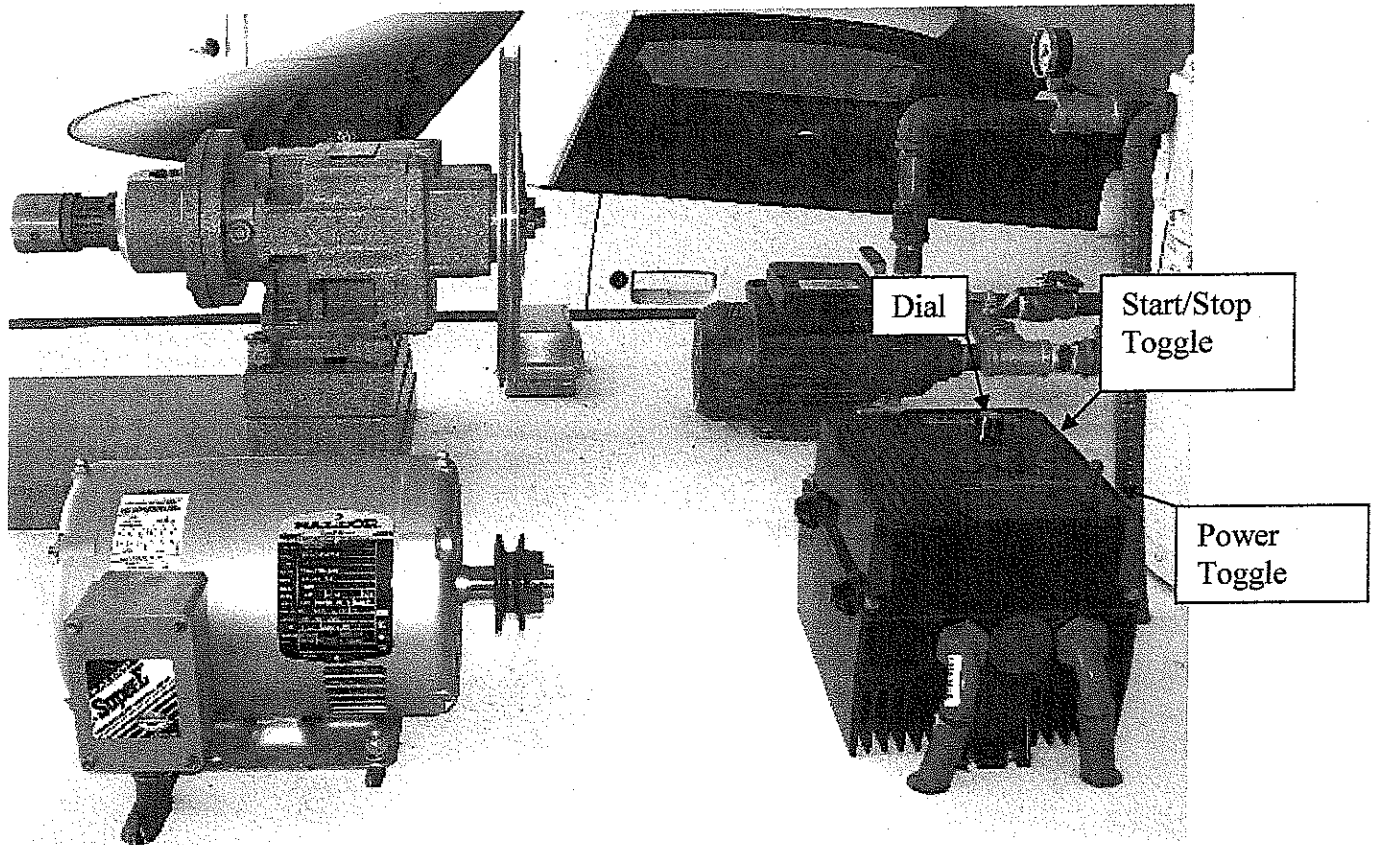


Figure 4. Expeller System

- Press the desired amount of seed.
- Flip the Start/Stop toggle to stop and turn the Power toggle to OFF.
- Turn off the "Expeller" breaker to protect the Variable Frequency Drive.
- Clean the expeller unit according to the procedures mentioned in the expeller User's Manual in Appendix A.

Batch Process using Reactor

Materials needed

- Rubber gloves (at least one pair for each experimenter)
- Safety glasses
- MSDS sheets for each chemical (lye, methanol and biodiesel)
- Fire extinguisher
- Lye (KOH)
- Methanol
- Filtered oil
- A measuring container for the liquids (preferably 1L in volume)
- A digital scale for measuring the Lye
- Zip lock bags
- A common spoon (preferably plastic or stainless steel)
- Paper towels
- Long-sleeve shirt, full shoes and trousers are recommended while performing this experiment
- A running water source close by

Recipe (per L of Oil)

1 L oil

220 mL methanol

12 g KOH

* 12g assuming store bought canola oil. Different oils will require a different amount. Titrations will be necessary for different oils.

Preparation

Perform this experiment only in a well lit and well ventilated area.

Plan for spills by spreading paper or plastic on your work surface.

Put your safety glasses and gloves on before opening any chemicals.

Please read MSDS sheets provided and familiarize yourself with methanol, lye and biodiesel handling and safety. Do not inhale any vapors!

Make sure that there is a fire extinguisher with the portable biodiesel reactor unit.

Production

1. Measure out the required amount of KOH using the digital scale. If performing the process during the presentation then it is recommended to have a measured amount of KOH prepared in the zip-lock bag before hand.
2. Measure proper amount of methanol using a marked glass container. . If performing the process during the presentation then it is recommended to have a measured amount of methanol prepared before hand in one of the utility jugs.
3. Slowly add the KOH to the methanol to get a mixture called "sodium methoxide." This should be done in one of the 5 gal. utility jugs. Shake the jug until the KOH for two minutes or the KOH is completely dissolved. Note: the methoxide must be used right away to make

biodiesel because it loses its potency over time. It is normal for the methanol temperature to increase substantially during mixing.

4. After the sodium methoxide is prepared, pour it into the jug that will be used for addition to the reactor (this jug will have a hole poked in the black overflow on the handle, and a lid with a quick-disconnect nipple).
5. At this point the methoxide can be added to the reactor, or the proper amount of oil can be added to the “addition jug.” If the oil and methoxide are not added together, the oil will have to be added separately (still using the “addition jug”).

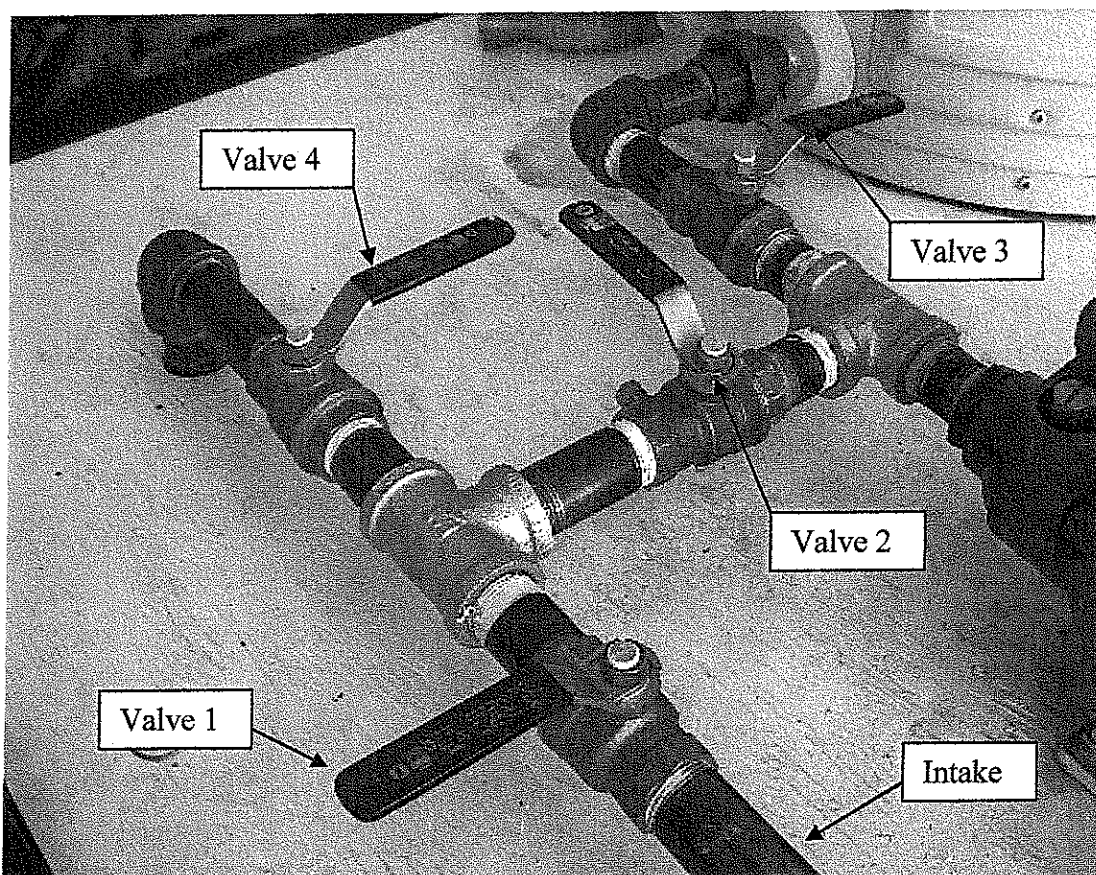


Figure 5. Valve System

When the chemicals are in the “addition jug” it should be connected to the intake using the quick-disconnect valve threaded into the intake. Be sure to remove the plug from the intake.

For chemicals to be added to the reactor **Valve 1** and **Valve 2** should be **open**. All other valves should be closed. Elevate the “addition jug” above the intake so the chemicals will begin flowing into the system. After chemicals are flowing in turn on the pump using the switch located near the pump.

When all chemicals have been added **close Valve 1**, then **close Valve 2**, and then you can **open Valve 3** to allow for circulation. Let the reactants circulate for about 2 hours. The system will probably circulate at about 6 psi according to the gage mounted on the top side of the system. Disconnect the “addition jug” from the intake and place a plug in the intake to prevent any foreign objects from entering the system.

After 2 hours of mixing turn off the pump and let the biodiesel mixture settle in the reactor. After 6 to 12 hours of settling the biodiesel will rise to the top of the mixture while the glycerol will settle at the bottom. The biggest distinction between biodiesel and glycerol is that glycerol is much darker.

To drain the system **open Valve 3, Valve 2, and Valve 4**. If the mixture is allowed to settle in the reactor the glycerol can be drained into a jug and Valve 4 can be shut off when biodiesel starts coming out. A biodiesel jug can be placed under the drain hose and the valve can be reopened to drain the remaining biodiesel from the system. This allows for easy separation of the two chemicals. However, when mixing is finished the whole mixture can be drained into a jug and the settling can be done in the jug.

Electrical Operating Instructions

- Powering the Bio-Diesel Educational Unit
 - To power the educational unit plug the main (yellow) service cord into a standard wall outlet.
 - The main (yellow) service cord shall not be connected to a Ground Fault Circuit Interrupter (GFCI) protection device due to the electrical properties of the Variable Frequency Drive (VFD).
 - Each electrical device is protected locally by circuit breakers located in the gray service box. For operation of electrical devices the corresponding breakers need to be placed in the ON position.
- Operation of the Mixing Pump
 - The breaker in the gray service box labeled 'Mixing Pump' needs to be placed in the ON position. The switch located near the pump needs to be placed in the ON position for the pump to operate and placed in the OFF position to stop operation.
- Operation of the Water Heater
 - The breaker in the gray service box labeled 'Water Heater' needs to be placed in the ON position. The switch located on the Water Heater need to be placed in the ON position for the heating element to operate and placed in the OFF position to stop operation.
- Operation of the Outlet
 - The breaker in the gray service box labeled 'Outlet' needs to be placed in the ON position for electrical devices connected to the outlet to operate.
- Operation of the Expeller
 - The breaker in the gray service box labeled 'Expeller' needs to be placed in the ON position for the motor to operate. Refer to the Variable Frequency Drive instruction booklet (Appendix B) for further instruction on operation of the VFD.

Electrical Schematic

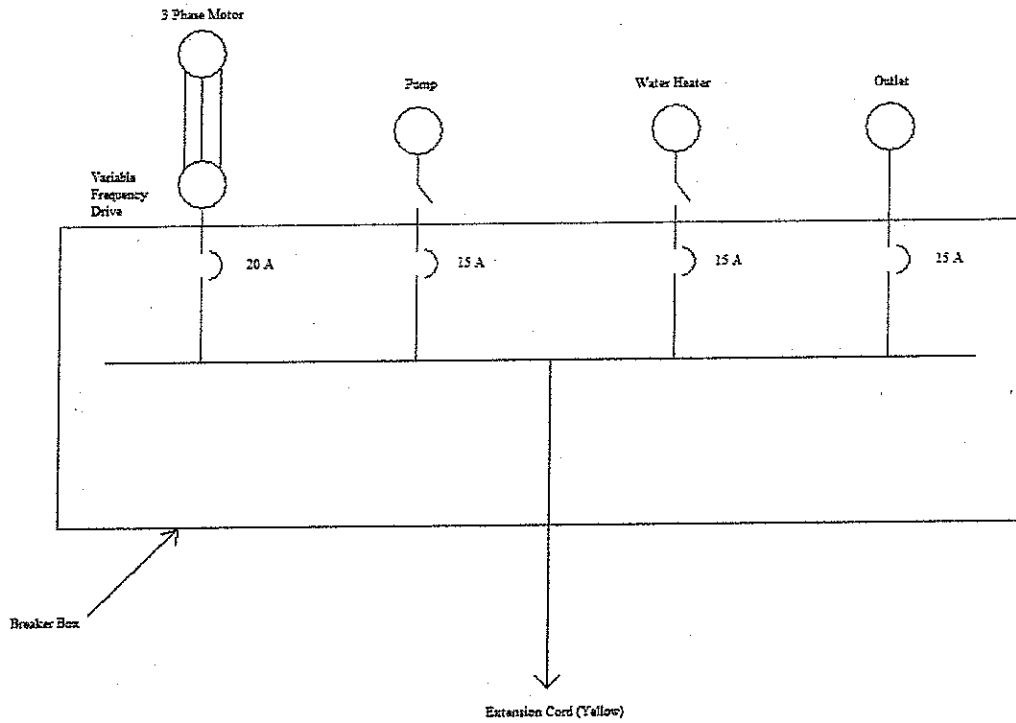


Figure 6. Cart Electrical Schematic

- Pictures are shown on the following pages, which depict the internal wiring of the pump and the Variable Frequency Drive (VFD).

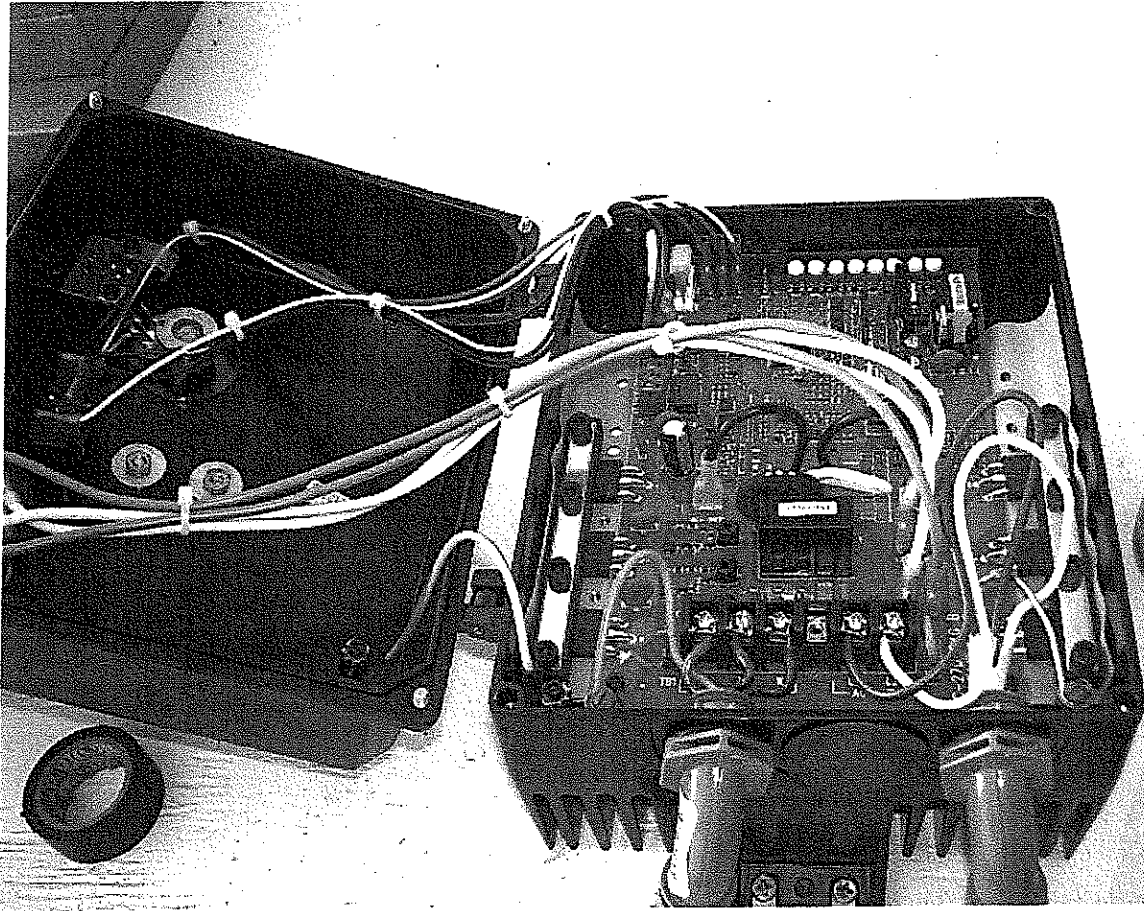


Figure 7. Variable Frequency Drive Wiring

- The three lines for the motor are the blue, red and black wires and any two leads may be switched to reverse direction of the motor.

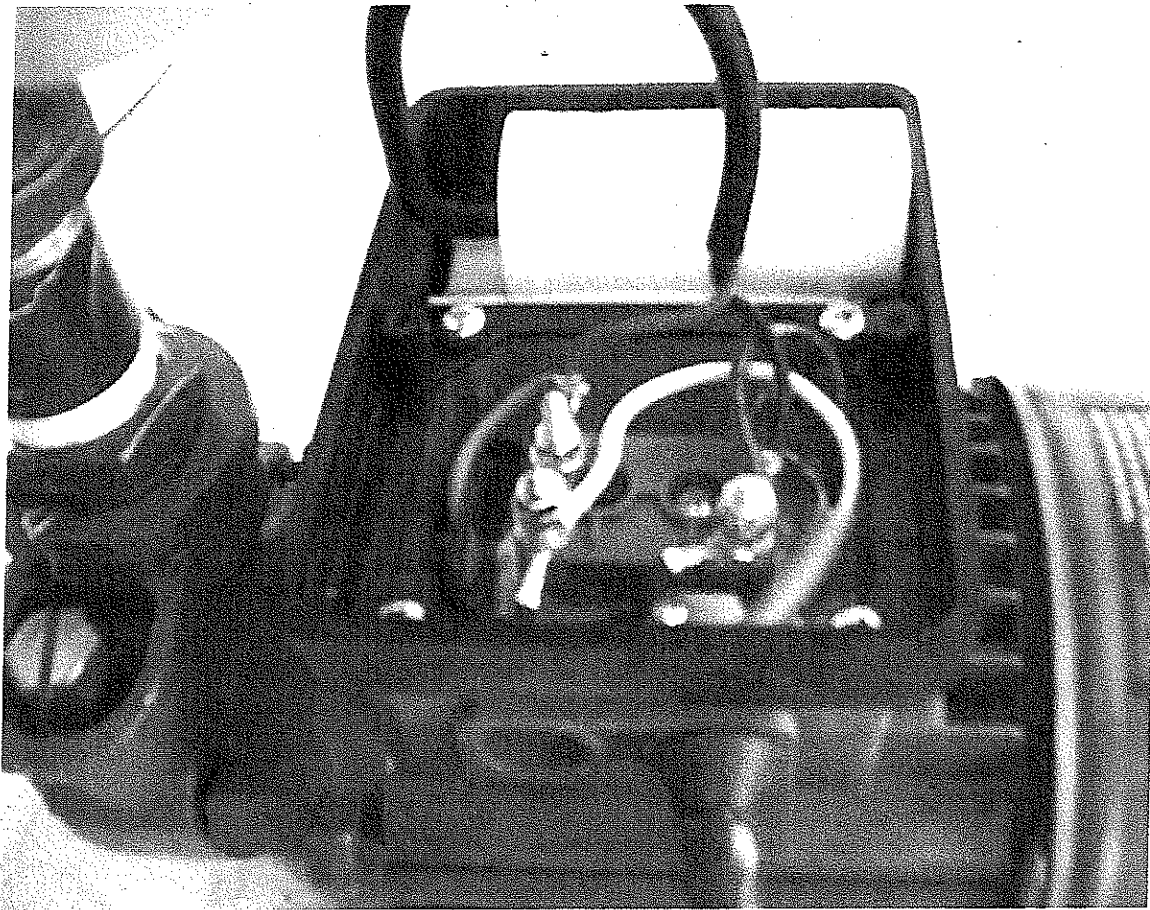


Figure 8. Pump Wiring

- The hot incoming line is connected to the brown/red wire terminal and the neutral incoming line is connected to the black wire terminal.

Conclusion and Recommendations

In total the team applied approximately 800 man-hours to this project. We feel that we have successfully completed the original scope of the project, and we hope that this cart and other materials will be useful in promoting biodiesel.

We have a few recommendations for proper use, and also recommendations for future projects:

- If a variation of oils are going to be used to make the biodiesel then *i*-CAST will have to invest in titration equipment in order to accurately gauge the free fatty-acid content of the various oils. This content will determine the proper amount of KOH per liter of oil.
- If *i*-CAST intends to use the pressed oil in biodiesel production then a filtering device will have to be used on the pressed oil. Two options are a small plumbing system that includes a pump and filter, or invest in a filter-press unit.
- If ASTM Grade Biodiesel is the goal then it will be necessary to set up a washing system for the fuel.

In the end we feel happy with the final product. This project was very useful to us, from an educational perspective, because it forced to adapt from just making things up in the class to trying to design something that could actually be built. We were also able to get increased exposure to working as a team and working with deadlines. The whole team is grateful to have the chance to help promote biodiesel. We do feel that is a great alternative fuel. Maybe if enough people get educated about it, and the right people apply themselves biodiesel could be the diesel of the future.