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I) Safety

The purpose of gasification is to intentionally create H2 (~20%) and CO (~20%) which are the two main gaseous fuels that drives the chemistry of this technology. This chemistry works by reaching the combustion temperatures of wood around ~1200C. To minimize any risks, we have engineered the GEK to create producer gas in a negative pressure, closed, on-demand system.

Before running a gasifier, please remember the following . . .
-Review the health guidelines of carbon monoxide: http://www.osha.gov/SLTC/healthguidelines/carbonmonoxide/
A gasifier can be a dangerous thermo-chemical device. Like most useful tools, it will do damage if used incorrectly. A gasifier purposely generates carbon monoxide and other dangerous volatile organic gases as an interim step before combustion of the gas in a flare or engine. Carbon monoxide is colorless, odorless, and will quickly colonize your hemoglobin, leaving no sites left for oxygen to naturally attach. Acute exposure to carbon monoxide can be harmful or fatal. Exposure to other VOCs is similarly problematic. (In short, it is somewhat like smoking cigarettes, just exponentially worse.)

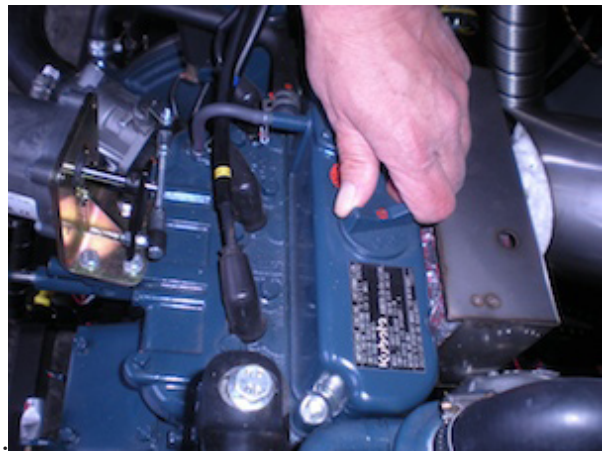
Always use a gasifier outdoors, and with extensive ventilation. Always stay out of the smoke and/or produced gas before it is combusted. This is NOT typical campfire smoke, even though it may smell similar. The carbon monoxide concentrations in gasifier gas are higher than in other "smokes". If you do not stay out of the smoke, you can get in trouble quickly, usually before you realize it, please be aware.

Always have a carbon monoxide meter in the area where you are working. Ideally, hang one on a tether around your neck. Carbon monoxide meters are included with the GEK Gasifier Kit and are also available at hardware stores in the smoke detector section.
STAY OUT OF GASIFIER GAS AT ALL TIMES!!!

TOOLS needed:
step stool
two hand held propane torches (ideally)
shop rag
adjustable wrench
1/2" wrench
~1/2" sifting screen
~2.5" sifting screen
allen key - 9/16ths
air compressor 4-8 cfm reference connection type (You will need an air compressor capable of a minimum of 4 cfm at 80psi. The air compressor is only used when flaring gas for start up and shut down of the GEK or when continuing to run the flare for other purposes).

II) Assembly and Preparation
The PowerPallet arrives at your door with some minor installation required as well as preparation of the system before running the unit. Please read all instructions first before starting, each interrelated action is critical for successful running of the PowerPallet.

A. Prepare Kubota Engine

a. 
b. 
c. 
d. 

Notes:

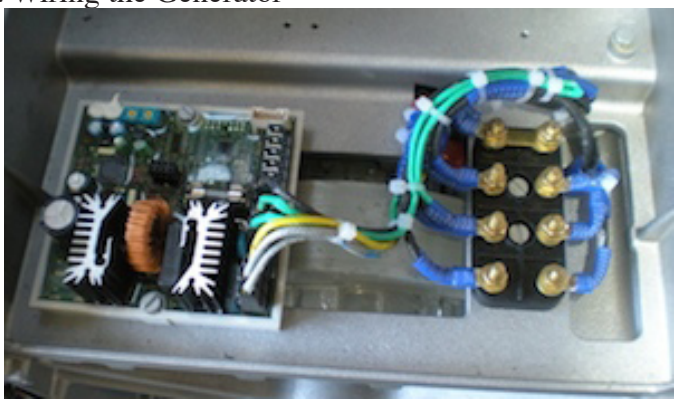
Because of shipping regulations, the engine on the PowerPallet does not come with its associated fluids. It is necessary to fill the engine with oil and coolant. For specifications and amounts for the Kubota engine consult the engine manual here: Kubota Workshop Manual WG DF DG972
The spec sheet for the Kubota can be downloaded here: http://wiki.gekgasifier.com/w/file/37064539/dg972_36.pdf

1. Fill the coolant via the coolant port on the radiator (photo a). (Note: if you are using this system for CHP add-ons, there may be additional actions needed for your system).

2. Open the oil cap and fill the oil to the appropriate level (photo b and c). Please consult the manufacturers manual for the oil type and amount.

3. Attach the filter condensate jar to the 1" plumbing tee on the air filter housing mounted on the generator (photo d). Make sure all connections are tightly sealed.

B. Wiring the Generator

a. 

Note: The generator either comes as 50 or 60Hz according to the request by our customers. Here is the current generator specs for our system.

50Hz: http://wiki.gekgasifier.com/w/file/37070947/ECP_2pole.pdf
60Hz: http://wiki.gekgasifier.com/w/file/37070943/ECO3N_4pole.pdf

1. The generator manual is sent with the PowerPallet package. Please read the generator manual for alternate wire configurations. According to the configuration option chosen, consult the manual to wire a break out box for electrical receptacles.

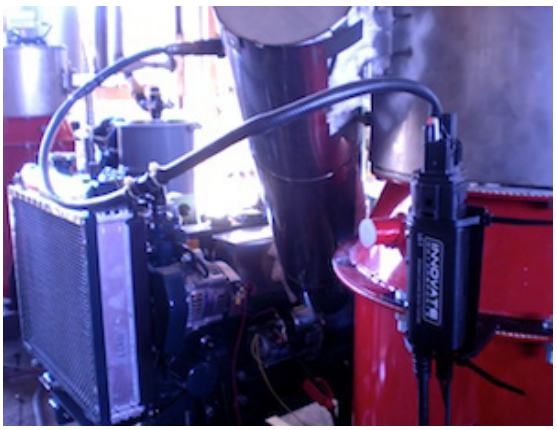
Wiring configurations page of the generator manual:
http://wiki.gekgasifier.com/w/file/38496510/meccalteGENwireconfig.pdf

C. Install Wideband Oxygen Sensor

a. 

b. 

c. 

d. 

1. The PowerPallet comes with an Innovate oxygen sensor module already wired into the main control panel. Locate the oxygen sensor module (photo A) and the sensor (photo B).

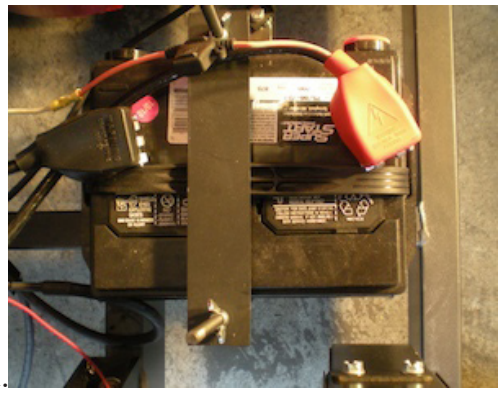
2. The sensor will thread into the insulated exhaust connection between the engine and the Pyrocoil (photo C). DO NOT touch the sensor head. The sensor has been calibrated previous to shipping, however, you may need to re-calibrate the sensor. To re-calibrate the sensor, please consult the manual referenced below.

3. Use two zip ties to attach the module to the black bracket protruding from the main reactor flange with the connector facing upward. Connect the sensor to the module (photo D).

Notes:
The oxygen sensor detects the ratio of oxygen to hydrocarbons and/or syngas in the exhaust stream. The signal from the oxygen sensor is used to control the air mixer servo actuated throttle body valve to monitor the air/fuel (woodgas) ratio.
Troubleshooting: if the servo valve is not hitting its target air/fuel ratio, the oxygen sensor may need to be re-calibrated. Consult the manual for instructions.
The Operation and Maintenance Manual of the LC-1 Wide-band Oxygen Sensor Controller is a available for download here: http://wiki.gekgasifier.com/w/file/37063828/LC-1_Manual.pdf OR <http://www.innovatemotorsports.com/support/manual/LC-1_Manual.pdf>

The oxygen sensor should always be on when running the engine to avoid damage to the sensor. The gauge is wired to the Internal Power bus, and will be on when the GCU is switched on. As the sensor warms up, the LED next to the gauge will flash, and in a few seconds the gauge should provide a read out. If there are errors with the sensor, the LED will continue to blink. If this occurs, consult the manual. A series of 8 blinks can indicate sensor overheating.
The oxygen sensor reading is also output on a digital display within the GCU enclosure. A reading of 14.7 on the display indicates a stoichiometric mixture, higher values indicate a lean mixture (more air than gas needed), and lower values indicate a rich mixture (more gas than air needed).

D. Source and Install Car Battery

a. 

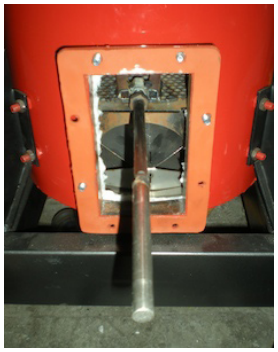
1. Because of shipping regulations, we can not ship a battery with the PowerPallet. You will need to source a 12vDC common car battery which supports the majority of the electronic controls, the PCU control board, as well as the starter motor for the Kubota engine. The battery box on the pallet has a 10.5" x 7" footprint. The car battery should be capable of 400 cold cranking amps (cca) minimum).

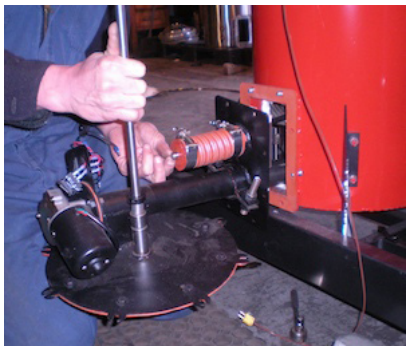
2. Capture the battery by using the wing nuts to tighten the band over the battery (photo a).

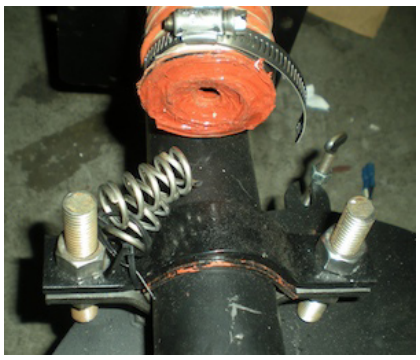
3. First connect the cable with the black terminal protector to the negative (-) terminal of the battery, then connect the cable with the red terminal protector to the positive (+) terminal of the battery (photo a).

Safety Note: Before connecting the terminals, make sure all switches on the control panel are set to the OFF position. Be sure carefully connect the negative terminal first, then the red terminal in that order.

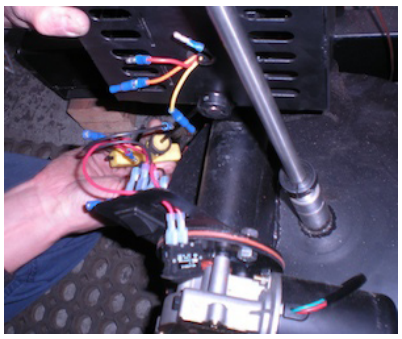
E. Install Ash Grate and Grate Shaker

a. 

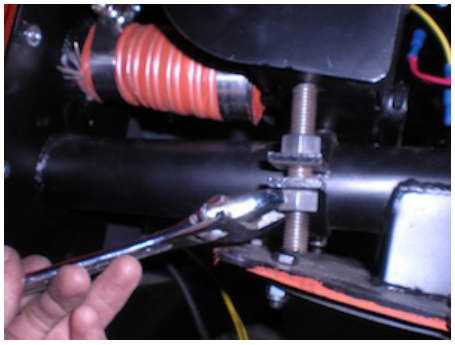
b. 

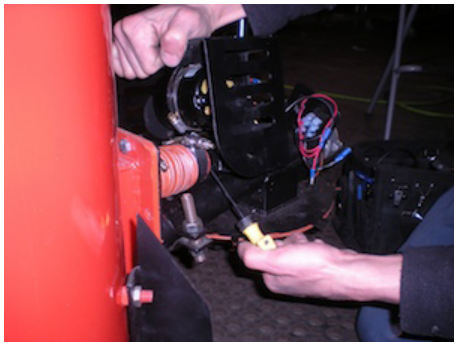
c. 

d. 

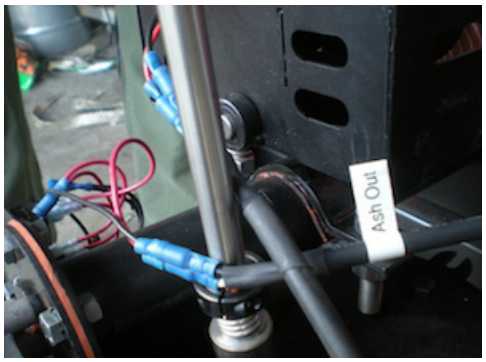
e. 

f. 

g. 

h. 

i. 

j. 

1. Locate the grate shake bar, ash auger motor and lid assembly, handle, eight 5/16ths bolts, 1/2" wrench, allen key for the shaft collars, two springs (attached to auger lid assembly), and ash bucket.

2. Thread the grate shake bar into the bolt of the ash grate (photo a).

3. Attach the ash bucket lid and auger motor assembly onto the side flange of the gas cowling. Slide the grate shake bar through the silicone port. Attach the door to the gas cowling flange with the 5/16ths bolts (photo b).

4. Remove the springs from the auger tube (photo c).

5. Install the grate shaker by passing the grate shaker bar through the ash grate motor. Make sure the grate shake bar passes through the shaft color of the motor assembly only 1/4" past the end of the shaft collar (photo d). Tighten the shaft collar (photo e).

6. The supporting clamp should be located on the auger tube so that it will support the ash grate assembly to the extent that it is able to move around (photo f and g).

7. Tighten the shaft collar between the ash grate motor and the ash port (photo h).

8. Attach the handle onto the valve shaft of the ash port. The standard orientation of the valve handle will be closed with the handle directed toward the GEK Gasifier, and open when pointing way from the GEK Gasifier. Look at the bottom of the lid to reference the valve direction before committing the direction of the valve handle (photo i).

9. Connect the wires labeled "Ash Grate" from the pallet to the the ash grate motor wires. Match the white wire from the pallet to the red wire on the ash grate motor. Match the black wire from the pallet to the black wire on the ash grate motor (photo j).

10. Note that the yellow and orange wires will not connect to anything.

11. Connect the wires on the pallet labeled "Ash Out" by matching the white wire to single red wire and black wire from the pallet to the single black wire.

12. Connect the green wire of the ash motor to the dual black wire on the forward/reverse switch and the red wire from the ash motor to the dual red wires on the forward/reverse switch.

13. Attach the ash bucket to the bottom of the lid assembly and tighten all of the hand bolts to the degree that they are gas tight.

14. Remember, the GEK Gasifier will get hot enough to melt wires if they are physically touching the surface of the gasifier body itself. Please make sure that these wires are not touching the surface of the GEK Gasifier.

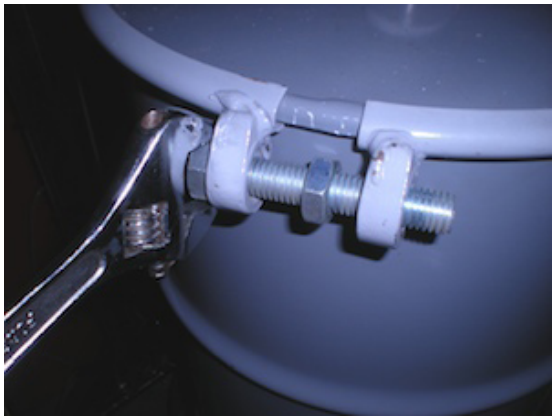
Safety Note: Be sure that all gaskets are seated properly, flanges are tightened and the hose is secured properly. The assembly of this component should be completed to the degree that all connections are gas tight. If any leaks are present, it will allow oxygen into the reduction zone of the reactor thus causing high exiting gas temperatures and low BTU value of the gas. High temperatures in the gas stream can damage downstream hoses. During shut down, wood gas can leak from negligent connections.

Safety Note: When routing the wires to the grate shaker and the ash auger, make absolutely sure that the wires are not touching the gasifier. Some wires may have shifted during shipment and/or your final assembly.

Remember, the GEK Gasifier will get hot enough to melt wires if they are physically touching the surface of the gasifier body itself. Please make sure that these wires are not touching the surface of the GEK Gasifier. If this occurs the system may not be able to have accurate feedback/control from the system to operate properly. It is worth to double check.

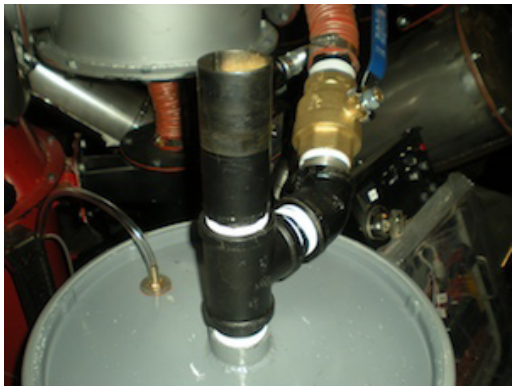
Note: You will want to remove the ash after about 4-5 hours or so (This greatly depends on feedstock and load). If the flare is having a hard time operating or the system is having a hard time pulling gas through the reactor (ie: reactor pressure stabilizes much lower than it was during start up) this can be an indication that the ash is clogging the reactor. In this situation use the ash take off to clear the reactor.

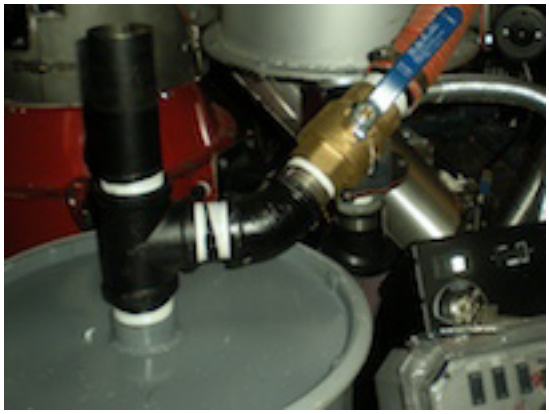
F. Fill Filter Barrel

a. 

b. 

c. 

d. 

e. 

1. Open the 16 gallon filter barrel (photo a), and pull out the two grates. (You may need to disconnect the orange silicone tube from the secondary filter attached to the generator. Do this by unbolting the four bolts attaching the square flange connection nearest to the secondary filter).

2. Place the grate with the larger holes down into the barrel. The grate will rest on the bolts protruding from the inside of the barrel wall toward the bottom (photo b).

3. Fill the 16 gallon filter housing with charcoal or saw dust. Use small particles smaller than 1/8th of an inch (photo c). Fill the filter about 5" from the top. For the last 2" for the top layer place a finer filter media (rags, old t-shirts, or another filter media) on top to keep the finer particulates from entraining in the gas stream (photo c).

4. Place the perforated filter plate with the smaller holes on top of the air filtering material to hold it in place so that it will not be sucked up into the gas exit port (photo b).

Warning: Only use natural fibers. Do no use nylon or synthetic fibers. Some synthetic materials have the potential to melt or release volatiles at lower temperatures that can possibly be introduced into the engine).

5. Attach the lid to the filter barrel. Ensure a tight seal. Reconnect the clear manometer tube to the brass barb on the 16 gallon drum filter lid (photo d).

6. Reconnect the square flange (downstream from the 1.5" ball valve) to the square flange of the secondary filter (photo e).

Note: A pressure reading between the reactor and filter exceeding a difference of 4" H2O or more is indicative of clogged or spent filter media. The PCU control board will display "“bad reactor P_ratio" which indicates that this is the case. To change the filter, remove the lid of the drum filter and disconnect the gas inlet line at the bottom. You will need to access the bottom of the filter stand-off grate, this is the location where most of the tars condense. The filter media could be mixed into the bulk of the feedstock. (Because the suggested sawdust filter media will typically be entrained with water and is below the suggested feedstock diameter, mix the filter media into the feedstock below 10%).

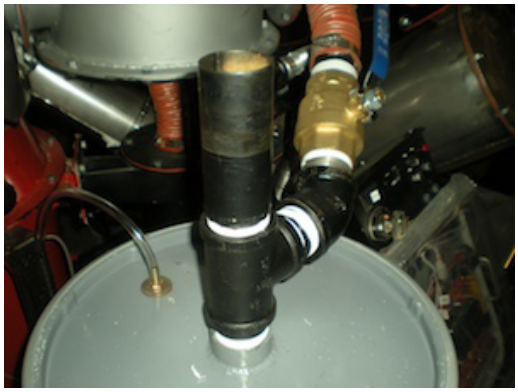
F. Ejector and Flare Stack

a. 

b. 

c. 

d. 

e. 

f. 

1. Make sure the burner is securely tightened to the stack (photo a).

2. Use four 5/16ths bolts to attach the square flange of the flare stack to the square Pyrocoil flange (photo b).

3. Assemble the plumbing according to photo c and f.

4. The orange flex tube will thread into the stack via the 1.5" ball valve and connect to the open pipe attached to the lid of the 35 gal. filter barrel.

5. Connect the square flange adapter of the silicone tube

5. Note: for all pipe threads, use the teflon tape provided with the PowerPallet accessories kit.

6. Make sure all connections are gas tight.

7. Locate the wiring on the pallet that is labeled "igniter". Connect these wires to the two leads of the igniter installed on the burner. Because this is a resistive heating element, the white and black wires can connect to either lead of the igniter.

Safety Note: When routing this wire upwards to the burner, make absolutely sure that the wires are not touching the gasifier or the burner stack. Some wires may have shifted during shipment and/or your final assembly. Remember, the GEK Gasifier will get hot enough to melt wires if they are physically touching the surface of the gasifier body itself. Please make sure that these wires are not touching the surface of the GEK Gasifier. If this occurs the system may not be able to have accurate feedback/control from the system to operate properly. It is worth to double check.

G. Hopper Barrel

1. The stainless steal hopper barrel will bolt onto the drying bucket by using the long 5/16th bolts provided in the PowerPallet accessories kit.

2. The bolts will thread into the nuts attached to the inside of the hopper barrel

3. Attach the lid making sure there is a gas tight seal.

II) Prepare the Reactor for First-Time Start Up

A. Fill GEK Gasifier with Charcoal
1. Obtain real wood charcoal between .5" - 2" in diameter. Do not use finer particles or dust, as that will restrict the flow rate in the reduction bell.

Safety Note: USE REAL WOOD CHARCOAL! It is important to use real wood charcoal, not Kingsford or the like, which is mostly pressed coal dust. Charcoal from a fireplace, fire pit, or mesquite BBQ charcoal will work. Make sure the charcoal is fully pyrolysed. To the degree that imcompletely pyrolysed charcoal is used, tar will be produced on start up. To the degree wet charcoal is used, steam will be produced on start up. Charcoal is hydroscopic so it is likely that it will be wetter than you imagine, however this is OK, it will vaporize quickly. You will see this as white smoke at the beginning of the start.

2. Start filling the reactor by adding charcoal through the port on the reactor lid. Allow charcoal through the reduction bell, then vigorously agitate the ash grate while filling the reactor. Repeat until the charcoal has been allowed to completely fill the space between the ash grate and the reduction bell.

3. Fill the reactor up to 1" - 2" above the ignition port/air nozzles (photo a).

4. Place the port cover back onto the port on the lid of the reactor. Tighten the wing nuts.

Safety Note: Make sure there is no large charcoal particles on the gasket when tightening the port lid cover. Wipe the gasket off to ensure that the gasket seals properly.

a. 

Note: The first time that the GEK gasifier is run, you will need to fill it with charcoal first before adding the feedstock. For the second start up, there will typically be left over charcoal in the bottom of the gasifier. You still may need to add charcoal to the level described here in step A.

B. Add Feedstock

1. Source your feedstock. For your first run, we suggest that you use ideal feedstock so that your will familiarize yourself with a successful first experience. Then you may move to more difficult feedstock characteristics. The ideal feedstock characteristics will be below 15% moisture content by dry weight, 1"-2" dia. particle size, low volatile carbon content and no saw dust. At the start of the run it is highly recommended to use dry feedstock (10% moisture content by weight) to ensure a quick start up. Once the reactor is up to temperature, higher moisture content feedstocks can be used.

2. Sift out the larger chunks/slivers of biomass (photo a). These can jam the auger or bridge over the reduction bell inside the reactor (photo b).

3. Sift out the smaller sawdust particles (photo c). The smaller particles limit gas flow, and fine particles also can interact with moisture in the drying bucket and become sticky which can prevent the solid flow through the hopper and drying bucket.

4. Use a step ladder or front loader to load the hopper barrel.

Safety Note: Make sure that wood chips do not fall into the PowerPallet equipment, such as the engine or electronics.

Safety Note: Do not stand on the components of the PowerPallet. Do not stand on the generator, engine, or GEK Gasifier.

5. Use the auger to introduce the feedstock into the reactor. To do this, open the enclosure for the control panel (photo d) and turn ON the

6. Use a ladder, and fill the hopper barrel.

7. On the main control panel inside the enclosure, turn the "MAIN" switch to "RESET/ON" (photo e), this is the main breaker for the system. Then turn the "INT" (for internal) switch to "RESET/ON" (photo f), this breaker switches power to the PowerPallet system. Next, turn "AUGER" to the "RESET/ON" position (photo

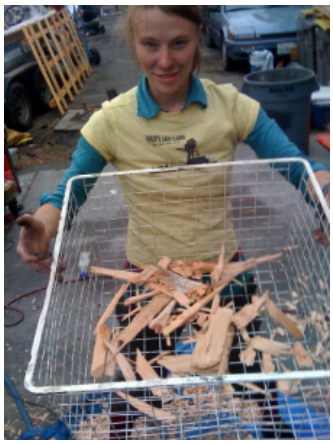
g), this will initiate the auger motor which will fill the reactor up with the feedstock from the hopper.

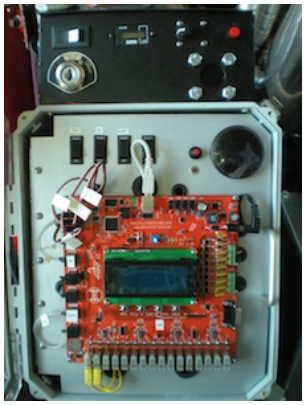
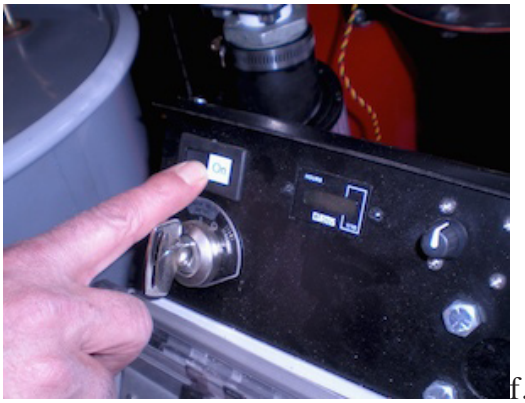
Note: The fourth breaker switch to the right in the series is an auxiliary button. It is currently not connected to anything but can be used for your development.

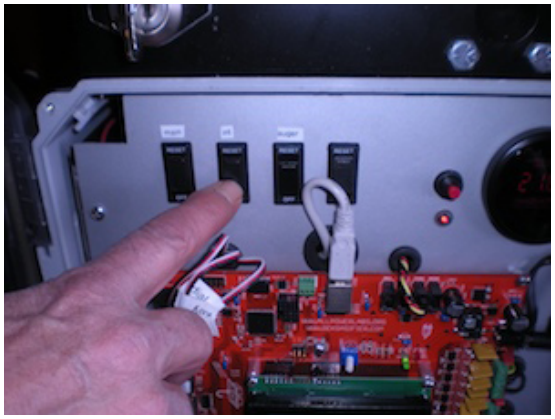
8. The fuel level switch on the reactor lid will switch off the auger motor automatically when the reactor is full. Open the port cover on the reactor lid to see the auger fill the reactor. Make sure the auger is performing properly with your chosen feedstock.

9. Agitate the ash grate and make sure all the feedstock has settled.

Note: There is an auxiliary adjustable potentiometric knob on the control subpanel. This is currently not connected to anything but can be used for development in controls.

a.  b.  c. 

d.  e.  f. 

g.  h. 

III. Start the GEK Gasifier Flare

Safety Note: Please read all the instructions completely before starting, some instructions are interdependent. Be aware, and remember protective eye equipment, when dealing with the combustion of fuels there is always a potential for explosion. With the GEK, there has never been any case of explosions more than a small cough of flame that may protrude out of the ignition port while the combustion zone is stabilizing initially. Proceed forward with awareness and caution.

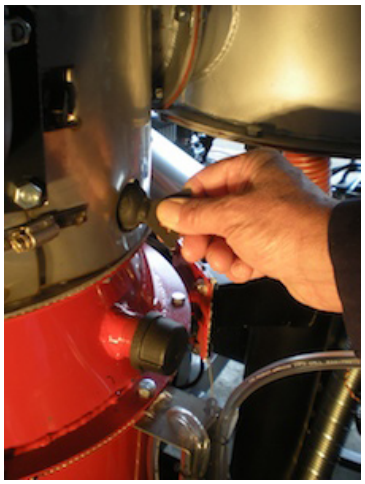
A. Start the GEK

a. 

b. 

c. 

d. 

e. 

f. 

g. 

h. 

1. Connect the air compressor line to the male quick connect attachment on the ejector venturi attached to the stack.

Note: The air compressor will most likely have the right female quick connect for the PowerPallet. The specifications of the common quick connect air connection that you will need can be referenced here: http://www.mcmaster.com/#6534k46/=be71lo

2. Open the gas line to the flare (photo a). Close the oxygen premix valve (photo b). Make sure the engine valve is closed (photo c). Make sure the 1" air inlet cap is closed on the GEK Gasifier reactor (photo d).

3. Open the 1/2" ignition port on the GEK Gasifier reactor (photo e).

4. Slowly open the needle valve on the ejector venturi (photo f, note the air compressor line is not connected in this photo, at this point in the instructions the air line will be connected). This will draw a vacuum on the system and will suck air through the ignition port on the reactor.
Turn the needle valve to reach a vacuum of 1 "H2O. Refer to the left channel of the manometer on the reactor (photo g) or the PCU control screen which will display the vacuum of "Preact" (Pressure Reactor) in negative tenths of an inch of water. ("Pfilt" on the LCD screen of the PCU refers to the negative pressure of the filter).

Note: Test to see if you can get upwards to 6 "H2O easily using your compressor. If not refer to the troubleshooting notes at the bottom of the page.

5. Double check that the igniter in the burner stack is on. If it is on it will be glowing red.

6. A squirt bottle with a red top is included, fill the squirt bottle with diesel fuel. Squirt about 10-20 ml of diesel into the ignition port of the reactor (photo e).

Safety Note: It is highly recommended that you use diesel. You may use other liquid fuels such as kerosine, biodiesel, ethanol, methanol, gasoline, etc. WARNING: Liquid fuels with lower partial pressures will start to evaporate, fumes could become explosive, this is why diesel is recommended above the more volatile fuels with quicker combustion rates. Make sure the container of fuel is well away from the GEK while lighting and during operation! Please be careful not to drip any fuel in or around the PowerPallet system. While we have done this with great success in the past, USE CAUTION and USE AT YOUR OWN RISK).

7. It is easiest to light with a propane torch. Hold the propane torch an inch away from the ignition port so the flame is pulled into the opening (photo g, note: this picture is of an older version, refer to photo e for the location of the ignition port). Notice that shortly after the reactor is lit, there will be a white "smoke" released from the stack. This is water vapor boiling off from inside the system and feedstock. Use a second propane torch to flare off the gasses as they will range from water vapor to wood gas during start up. While the igniter is intended to keep the flare lit, the earlier gasses during start up will need flare support to ensure that no CO or smoke is escaping from the stack without being combusted.

Note: If you do not have a propane torch you may use other ways of lighting the reactor (for instance lighting a rag and dropping it on top of the charcoal layer of the reactor before adding raw feedstock on the top).

8. Refer to the temperature of the reactor by the LCD screen on the PCU in the main control enclosure. The temperature in degrees C is displayed as "Ttred" for the temperature of the top of the reduction bell, and "Tbred" for the temperature of the bottom of the reduction bell.
Watch the temperature of "Ttred" increase to 80-100C. At this point open the 1" cap on the air inlet port (photo d). Continue lighting with the propane torch.

Note: Place the 1" cap remember where you place the cap. You will need this 1" cap for shutdown. If misplaced, proper shutdown will be difficult and smokey. Please remember to place the cap in a place known by the operator at all times.

9. Once the temperature raises to 180-200C, slowly increase the flow rate by turning the needle valve to for the ejector venturi (photo f).

10. Once the temperature of the top of the reduction bell "Ttred" reaches 300 C, you may stop lighting the reactor via the propane torch through the ignition port (photo e). Close the ignition port using the 1/2" plumbing cap.

Safety Note: At this point the ignition port is obviously hot. Be careful.

11. The flare should light when the temperature of the bottom of the reduction bell is in the ~300-450C range.

12. At a reading of 5 "H2O pressure on the reactor with ~1" diameter feedstock of 10-15% moisture content by dry weight, you should expect to have temperature readings of about 650-750 at the bottom of reduction and a reading of 700-800 at the top of reduction.

Note: Do to a host of variables the temperature ranges referenced in steps 11 and 12 can fluctuate. Use these as a general reference.

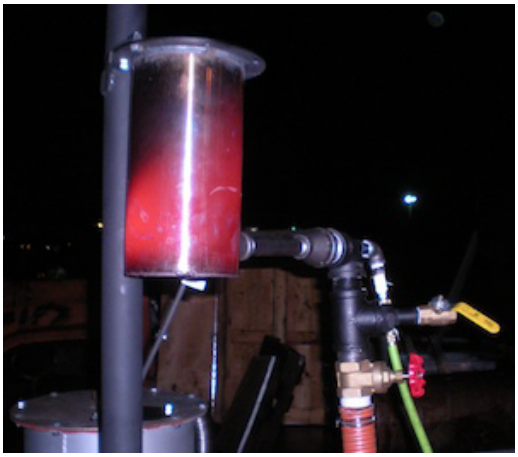
B. Controlling and Sustaining the Flare

a. 

b. 

c. 

d. 

e. 

1. While the reactor is coming up to temperature described during step III,A above, you will want to keep the propane torch in the flare to ensure combustion of the gasses in the flare stack.

2. As stated in the last step, when the reactor reaches 100C, the water in the system will turn to steam and escape through the stack. As the temperature of the reactor rises, it will get closer to a combustible gas, keep the propane torch in the flare until it has lit (photo a).

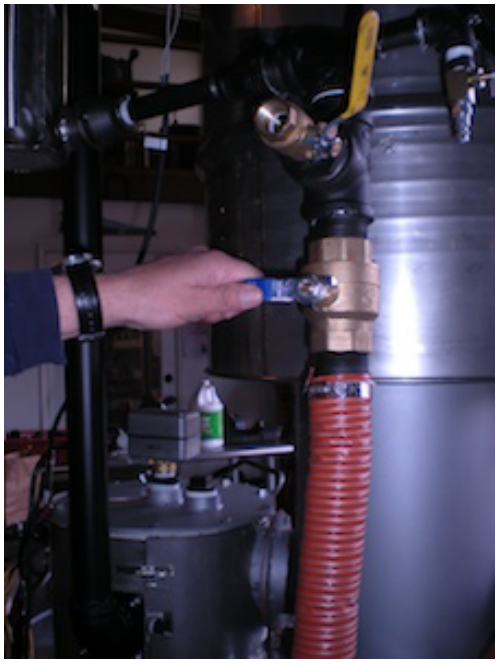
2. The gas mixture must be producing a combustible gas and be near stoichiometric for the burner to sustain a flare (photo e).

3. Adjust the air pre-mix valve (photo b) back and forth until the flare is lit. Depending on how much moisture is in the fuel this can take from 1-5 minutes from a cold start. Sometimes for a first run, start up time can be longer due to settling of new charcoal. Start up time will also depend on what kind of liquid fuel you have used for start up.

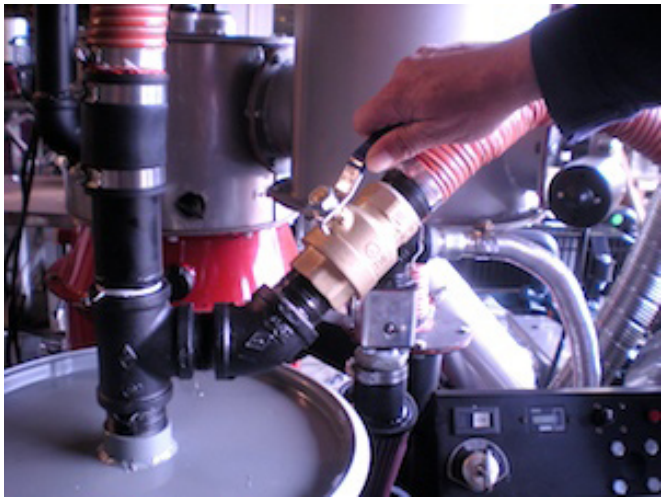
4. Make sure the flare is steady in the swirl burner. The flare should be down inside the swirl burner with the flame terminating before reaching the top of the burner.
Notice: As the air pre-mix valve is closed, the flare will rise upward out of the burner as it requires more oxygen for a complete combustion (photo c). In this case, there may not be enough oxygen to completely combust the gas allowing the hydrogen and carbon monoxide to be released. As the air pre-mix valve is opened, the flare will lower into the burner (photo d). In this case, all of the wood gas is allowed to combust before exiting the burner. This ensures a complete and clean combustion.

Notice: When the air pre-mix valve is opened, the suction from the ejector venturi is divided between the reactor and air pre-mix valve. This will lower the total vacuum across the reactor (and vice versa) as indicated on the manometer reading. Make sure that the reactor is kept in range of the proper pull rate. The compressed air valve may need to be opened/closed to control the flow across the ejector as the air pre-mix valve is adjusted to keep the reactor pressure within range.

C. Run the Engine off of Wood Gas

a. 

b. 

c. 

d. 

Note: This section assumes that testing has been performed to find the optimal temperature/vacuum range in which the system will produce a clean producer gas given the biomass characteristics used for the run. If you introduce tarry wood gas into your engine, it will damage your engine by sticking the intake valve(s) and piston rings. To ensure this does not happen, use dry biomass, make sure that you are within the proper temperature and pressure range in the reactor, double check seals on the gasifier, and make sure filters are not spent.

1. Close the ejector venturi gas valve (photo a). Your flare should go out.

2. Close the air compressor needle valve (photo b).

3. Open the engine valve (photo c), and crank over the engine very soon after (photo d).

4. Because there is air in the line between the engine ball valve and the engine itself, the starter motor will have to crank the engine until the air in the line has purged. The engine will crank when the wood gas has reached the engine and the automatic air pre-mix servo valve has reacted to deliver the correct air/fuel ratio to the engine.

D. Electrical Power from Biomass.

a. 

1. Plug appliances into the PowerPallet!

Notes:
For more sensitive electrical equipment, it is recommended to use a UPC.
Ideally temperature readings in the gasifier should be Ttred>850C and Tbred>750C. Running the reactor at cooler temperatures will produce more wood tar which will spend the filter media faster and could possibly run the risk of introducing wood tar into the engine. An increase in the electrical load placed on the generator will increase the temperatures in the reactor.

E. Shutdown

a. 

b. 

c. 

d. 

e. 

f. 

1. When shutting down the system, switch the wood gas back over to the burner.

2. Close the engine valve (photo a) and turn the key of the engine to the "OFF" position (photo b).

3. Open the gas valve to the ejector venturi (photo c), open the air compressor valve (photo d), and adjust the air pre-mix valve (photo d), while keeping the pilot light over the burner to ensure ignition of the flare.

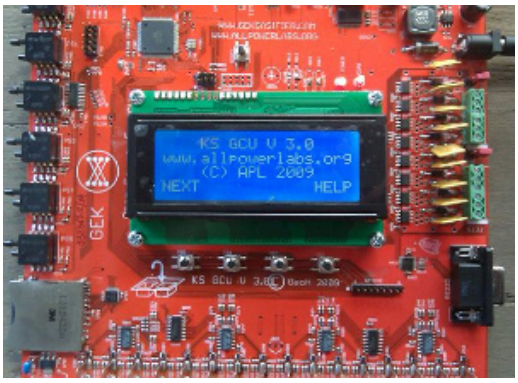
4. Over the course of about 5-10 minutes, slowly turn down the compressed air valve while adjusting the air pre-mix valve to keep the flare lit at lower and lower flow rates.

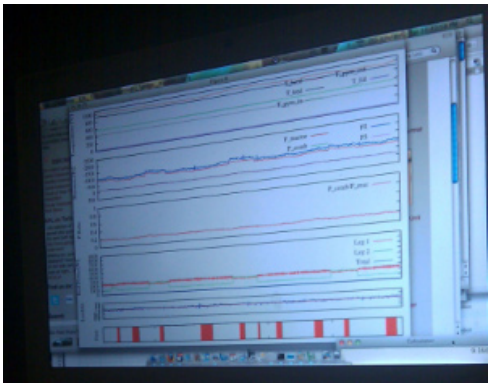
5. When the gas is no longer able to sustain a flare, close the gas valve to the ejector venturi, place the 1" cap on the air inlet of the reactor (photo e), and close the valve to the air compressor.

UNDER CONSTRUCTION-- Please read the instructions, but note they are currently (3/11/11) under construction. If you have questions, and you might, please do not hesitate to contact Jay at support@allpowerlabs.org

V) Communicating with the GCU
The GCU is a flexible platform for control and automation of the Power Pallet. With it, various components can be controlled and automated, including grate shaking, mixture control, pressure and temperature monitoring and alarms, etc.
Gasifier Control Unit (GCU) Operation Manual <http://gekgasifier.pbworks.com/Gasifier-Control-Unit>.

1. Automation
a) Air Mixture Control
The ratio of wood gas and air is controlled with a Bosch wideband oxygen sensor and servo actuated butterfly valve under closed-loop PID control.
The Bosch wideband sensor controller (LC-1) outputs a 0-5V signal which is read via an analog input on the GCU. This valve is input into the PID controller which provides a response to changing mixture by smoothly opening and closing the air intake valve as needed. The PID loop is always in operation when the GCU is on.





Oxygen Sensor Gauge

The oxygen sensor should always be on when running the engine to avoid damage to the sensor. The gauge is wired to the Internal Power bus, and will be on when the GCU is switched on. As the sensor warms up, the LED next to the gauge will flash, and in a few seconds the gauge should provide a read out. If there are errors with the sensor, the LED will continue to blink. If this occurs, consult the Operation and Maintenance Manual of the LC-1 Wide-band Oxygen Sensor Controller <http://www.innovatemotorsports.com/support/manual/LC-1_Manual.pdf>. A series of 8 blinks can indicate sensor overheating.

Operation of the PID loop can be proved by exposing the sensor to uncombusted propane. When exposed, the valve should close. When the engine is off or not started, the display should read 21.7 and the servo valve should be in its closed position.

VI) Maintenance

1. air filter on air mixer throttle body

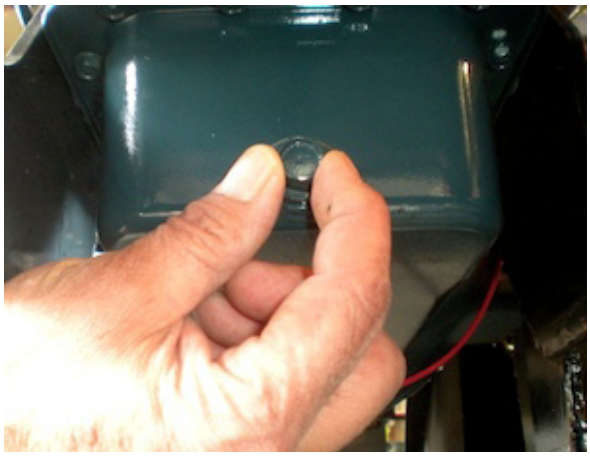
1. GEK Gasifier
Warning: Remember, the system is full of hydrogen and carbon monoxide. Purge the system of wood gas before any maintenance is done on the gasifier. Any maintenance should be conducted outside or in a highly ventilated area.

i) Before doing any maintenance on the gasifier, wait until the reactor has completely cooled to room temperature. Refer to the temperature reading from the internal thermocouples. Warning: Opening the GEK gasifier before allowing it to cool, could allow enough air across existing hot charcoal which could re-start combustion inside the reactor.
ii) Open the top of the hopper.
iii) Open the gas valve to the ejector venturi. Warning: If the temperatures in the reactor start to increase, the reactor will need to cool off further until there is no more activation energy left to re-light the reactor.
iv) Open the valve to the compressed air. Vacate the area (or allow the gas to escape well above the operating level) until the wood gas has been completely purged through the system and allowed to dissipate. (If you have propane hooked up to the ejector, light the flare and burn the wood gas).

c) Ash Grate
If the gas flow rate seems low, the ash grate may need to be cleared.Open the grate door on the side of the reactor to access the ash grate. Clear out charcoal and reattach the door.

2. Engine
We are currently using a Kohler Command Pro engine (CH980 for air cooled 10 kW pallets). We recommend checking the oil and the air filter after shutdown of the unit. For further assistance, consult the Kohler engine service manual: <http://www.kohlerengines.com/manuals/landing.htm>
a) Check oil.
b) Check air filter. Make sure the filter is not clogged.
c) Check the spark plugs.





a) Filter

Troubleshooting:
1. Bridging in the hopper or the reactor.

The long slivers and broad particle size ranges and the like are historically a difficult fuel due to the fact that they tend to interlock in a manner that causes bridging. If you have any bridging problems (indicated by high temperatures near the top of the lid ~500C, or high temperatures around 1000C at the top of the reduction bell temperature) then you may have bridging occur. What will happen is the gas quality will become weak in the flare or your engine will stall. To recover from this, take a long stick and poke the feedstock to break the bridge that may occur in the hopper or the reactor.

2. Blockage of gas flow.
You will want to remove the ash after about 4-5 hours or so. If the flare is having a hard time operating or the system is having a hard time pulling gas through the reactor ie: reactor pressure stabilizes much lower than it was during start up, this can be an indication that the ash is clogging the reactor. In this situation use the ash take off to clear the reactor.