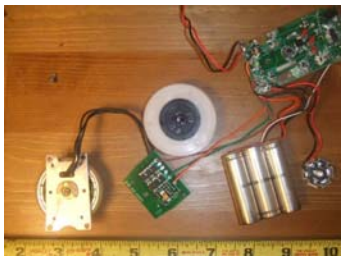
Experiences Using a Hand Crank Generator for Fan Stoves

Charlie Sellers and Brad Ballard

January 2008

For about four months I have had a hand crank powered LED flashlight that I have been *very* impressed with (http://www.freeplayenergy.com/products/illumination/jonta, and other retailers such as REI sell it for less - ~$50) – it can either be charged by its AC adapter or by turning a hand crank, the high performance LED is *extremely* bright, the flashlight has several intensity settings, it lasts longer on a full charge than I can easily measure, and my model is heavily rubberized for ruggedness and waterproof characteristics. It is *by far* the best of the many LED flashlights that I have tried, including both moving magnet and straight battery powered ones – this one seems very bombproof and efficient; several of us have been very pleased with it.



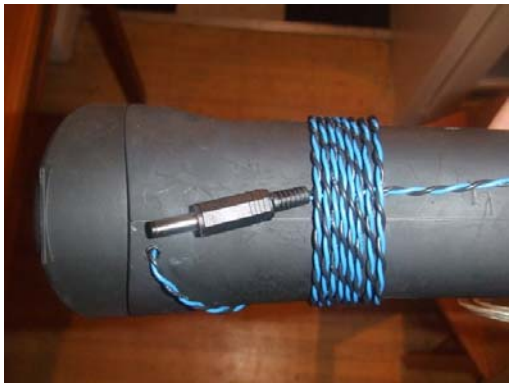
Brad's flashlight broke after it was submerged in water so we had the opportunity to disassemble it and both investigate its construction and measure its electrical characteristics, and then use it to power the commercial WoodGas campstove. A very successful experiment showed that we had plenty of power for the fan - this is all contrary to my previous comments, because it uses a well designed generator that is well matched to this particularly efficient stove fan – it supplies the correct voltage and it has enough battery life,

Upon opening the broken unit we were very impressed with most of its construction – the 2 beautiful circuit boards were ruined by the exposure to water, the LED turned out to be the very high intensity 1 watt Luxeon Star warm white model (http://www.luxeon.com/pdfs/DS23.pdf, with a forward voltage rating of 3.42 V, 350 mA – USD $9 each when purchased separately), the batteries were **very** low capacity (three 1300 milliamp-hr NiMH batteries with a total parallel rating of 3.6 VDC, while good rechargeable AA batteries have 2500-2700 mA-hr of capacity each, at the same 1.2 VDC) but adequate, the generator was a nice sintered NdFeB magnet version somewhat like those used to drive HDD and CD/DVD drives in computers, and all the electronics were surface mounted (the most modern method); there was nothing to complain about except for the 2 nylon gears, that might wear out too quickly with hard use.

We removed the obviously ruined main circuit board (which contained somewhat unnecessary control/indicator functions like switches and status LEDs) and then rewired it so that we had access to the unadulterated output from the generator's alternator – this is a 3 phase motor connected to a resistor bridge circuit board, which then produces a simple DC output. We could then use the manual crank to produce an incredibly bright light output, or connect it directly to other loads. At the leads we measured a voltage of ~4 VDC and ~250 mA at ~1 turn per second – approximately supplying the 1 watt that the LED is rated at (and we could power the LED without the

removed circuitry – from the bridge we got a smooth 4 VDC for the LED or for other purposes). We don't know yet how many mA-hrs of energy each turn of the crank generates.

The commercial TLUD WoodGas's stove fan also requires only about 1 watt at 2.5 – 5 VDC (quite efficient - it is designed for 2 AA alkali batteries, but I usually use 3 NiMH AA batteries to achieve a similar voltage, or alternatively I sometimes use for testing a variable voltage power supply for up to 5 VDC – above that the motor sounds unstable). We used the simple hand crank mechanism (with just the 3 phase power converted to single phase) to power the WoodGas fan, both with and without the LED in series (together, for amusement only and to limit the voltage). Lo and behold, this hand crank generator powered the fan beautifully! Fortunately the voltage was approximate matched to that needed by the WoodGas fan. At ~1 crank/sec we got good flame (no smoke) from the stove and easily cooked quesadillas quickly. When we got down to the "charcoal stage" (after the obvious yellow flame disappeared) we inserted a device to occlude all of the secondary air holes at the top (a trimmed stainless steel hose clamp, spring fit – doubling the primary air flow at the bottom of the stove) and again easily cooked another batch of quesadillas. We thought that the mostly constant cranking was a little tedious, and that a treadle powered mechanism (like an old sewing machine) would work better; this company also sells a foot generator for 12 VDC power output to any device.
http://www.freeplayenergy.com/products/portable-power/weza



Now that we had prowled the interior of one, we could hack my own functioning one to power a commercial WoodGas stove – I just took the necessary screws out, attached wires to the LED, used 6 ft. of wire to allow for powering the stove from a distance, burned a hole in the flashlight casing to pass the wires out, and soldered a new power plug on the end. Now I can use the 3 intensity settings with the fan (the setting pulsing the power might just work to save energy using a fan stove…), and the batteries charge if there is extra cranking. Trying it on a stove with wood pellets it performed beautifully, with the voltage/power evened out by the battery circuit – always constant and just enough. One minute of cranking from completely discharged batteries seems to yield from 1 to 14 minutes of fan time, depending on the setting. With a full charge (from the AC adapter, or an unknown amount of time spent cranking) we can expect to get many hours of operation, and by installing a simple switch we can turn off the LED while the stove is on

Initial experiments put the stove fan in series with the LED, then in parallel, but finally the best circuit is to isolate the fan from the LED with a simple switch (single pole, double throw) so that the two can be operated independently – a full charge then powers the fan at very high rpms for +2 hours, and with this particular flashlight we have more fan speeds than the WoodGas stove has usually. This stove is designed for 2 AA alkaline batteries and has 2 settings, but the 3 AA rechargeable NiMH batteries that I normally use with a speed controlling rheostat are better (a PWM controller is even better - both environmentally, and it permits both a higher fan speed and a longer run time – though the motor is not

designed for these rpms) – and this flashlight approach permits even more variations (including the pulsed mode).

It is still unknown how many turns of the crank it takes to power this stove for a meal – if you charged it fully (AC or by hand), the 3 AA batteries are somewhat anemic (you can easily buy ones with **twice** the energy capacity of these) so few hours of operation result – you can calculate this, and maybe my flashlight version is just outdated. And remember that you cannot extract all of the energy from any battery: http://en.wikipedia.org/wiki/Nickel_metal_hydride_battery.

Charging with the AC adapter was a tad curious – it seemed to take too many hours before it indicated that there was a full charge. Further experience showed that a one hour charge (from a dead discharge state) resulted in 30 minutes of full fan power – any project would want to analyze the situation further, since every load is different.

An ultimate WoodGas batch of fuel might be 400 g of wood pellets (as are used in North American pellet stoves), which requires ~20 minutes to burn completely at the full fan speed (firepower is generally correlated with fan speed) – several hours of energy then corresponds to a number of batches of fuel with this stove, a very considerable amount. More typically, batches of ordinary fuels (wood chips, pine cones, nut shells, etc.) are closer to 100-150 g so this same amount of battery energy would not result in nearly as much total energy output – the denser the fuel (in g/cm^3) the better this type of stove performs for the user.

In conclusion, an *efficient* and *rugged* hand cranked generator can easily power an *efficient* fan motor for biomass cooking stoves – provided that they are electronically voltage matched and that the generator is of this quality. Other applications can similarly be supplied with power, but a decent knowledge of the requirements – e.g. volts, amps, watts, LED lumens, and mA-hrs of energy storage – is recommended.