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ABT 289: D-Lab II
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Kornbluth

Guatemalan Temazcal

Background and Design Brief:

This quarter, our team designed an efficient wood burning stove meant to heat the 6m3 of space in a temazcal while minimizing smoke production and fuel requirements.

A temazcal is a "house of heat" or a sweat lodge constructed from cement used for bathing. It is approximately 2x2x1.5 meters in length, width, and height. The people of Santa Catarina Palopo in Guatemala currently use an open fire pit to heat the interior of the temazcal as well as the water used to create bathing steam. The main issues with using an open pit are wood consumption/monetary cost and smoke production within the enclosed space. The Universidad de la Valle de Guatemala (UVG) designed and built a burner that used significantly less wood and produced far less smoke. However, the burner did not produce enough heat, according to the locals, so community members went back to using the open pit despite the monetary and health costs. With this in mind, we knew that our design had to meet temperature requirements or else it would not be used.

In order to gain further understanding of the project, our team looked at barbecue smokers, as they burn wood for the production of heat just as the temazcal burner does. The design of barbecue smokers is heavily reliant upon airflow. With greater airflow, the fire will burn cleaner (i.e. less particulate matter in the smoke) and hotter, one of our main goals. On every smoker are air intake ports and smoke stacks for "exhaust." We then analyzed the UVG design and found that there were no air intake ports besides the where fuel can be added. We hypothesized that lack of intake ports resulted in a cooler fire and that the addition of these ports would increase the temperature inside the temazcal.

Our goal this quarter has been to recreate the design by UVG and modify it in order to test the effectiveness of the addition of the intake ports.

5 Design Considerations: (*most design consideration were achieved by the previous design, modifications do not change the considerations)

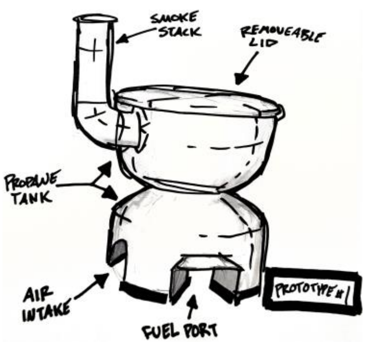
- Cost*: <$50 (in parts, does not include labor)
- Construction*:
  - Materials: readily available
  - Tools: generic tools
  - Skill/ability: easily replicable
- Performance: must heat temazcal while limiting the amount of smoke produced and wood required

*Our design is based upon modifying the previous design, which proved the feasibility of four out of our five design considerations. The previous design that was built in Guatemala with the village locals was under $50, was built with available materials using generic tools, and is easily replicable. Our prospective modifications do not change this.

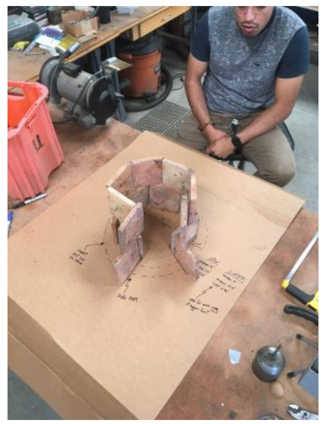
Design Criteria:

Criteria	Qualitative/ Quantitative	Testing procedure	Target Value	Metric
low smoke	quantitative	measure	60	ppm
fuel	quantitative	burn test	1	kilogram
prep time	quantitative	measure	20	minutes
budget	quantitative	count receipts	<50	dollars
temperature	quantitative	measure	90-100	°F

Build:



This is the design for our first prototype using a propane tank that is cut in half. This design was without air intake ports for baseline testing and then modified to open airflow at the base of the burner for further testing.



This is the design for our second prototype. The design functions the same as prototype #1, the main differences are that this prototype uses an old oil drum rather than propane tank for increased scale and includes tiles around the fire for increased insulation.

Our testing procedure is as follows:

- Install measurement devices into cabinet
- Weigh out 1 kilo of wood
- Set burner in cabinet and fill with wood and newspaper, light with lighter, start timer
- Close cabinet doors
- Watch devices and fire until the flames are out, stop timer
- Record data (weight of wood, Δ ambient temperature, relative humidity, and time elapsed)

The procedure is the same for both prototypes before and after intake modifications.

Results:

	Weight of Wood (kg)	Δ Temperature (°F)	Δ Relative Humidity (%)	Time Elapsed

				(min)
Prototype 1 (no modification)	1	+135.79°F (91.2-225.01)	-59.38% (63.8-4.42)	36
Prototype 1 (modification)*				
Prototype 2 (no modification)*				
Prototype 2 (modification)*				

*Testing To Be Completed at a Later Date

Discussion:

We conducted our first test using 1 kilogram of wood. Only half of the wood fit into the burner at once, so the other half was steadily fed into the fire chamber one piece at a time every 2-3 minutes until all wood had been put into the burner. The fire was started with a crumpled handful of newspaper. With the burner inside a metal cabinet, which served as our temperature containment unit, the burner got the interior of the cabinet up to 225°F over 36 minutes. This was an overall increase in temperature of 135°F from the beginning of the test where the temperature inside the cabinet was around 91°F. The relative humidity percentage inside the cabinet dropped over the course of the test. It started out close to 64% and bottomed out at 4.4%.

Conclusions:

This quarter our team recreated and modified a previous temazcal burner in order to achieve higher interior temperatures of a containment unit while minimizing smoke production and fuel requirements. Our modifications consisted of the addition of air intake ports along the bottom sides of the burner to allow for the fire access to more oxygen for more efficient combustion.

In measurement, we have tested for temperature of the unit and time elapsed based upon the weight of wood used. All of these measurements are quantitative. These are measured using gauges, timers, and scales. One of the main constraints that could affect our results is the outside environment where we test. The environment in Davis in June may have a different temperature and humidity than that of Santa Catarina Palopo in Guatemala. The testing equipment we have will be placed in the metal cabinet we are using to localize and contain our testing.

Our tested prototype is the same design as the one created by UVG. Based on a rocket stove, the burner by UVG, which served as one of two prior art examples for our project, worked as an efficient burner in our test. The design localized and contained heat in a small area, maximizing heat transfer to the stones placed in the top section of the burner. Had we been able to test the same prototype with air intake ports, it would have related to barbecue smokers, our second prior art example. These intake ports in conjunction with the chimney would resemble the air intake and smoke stacks of barbecues that enhance the fire's temperature output and cleanliness. In addition, from some minor research, the addition of more oxygen to combustion leads to less CO production, a beneficial aspect for the enclosed space within the temazcal.

Our team was able to measure the temperature achieved by one prototype based upon the weight of the wood burned, relative humidity inside the containment unit, and time elapsed after lighting the fire. The first test with prototype #1 worked well in the sense that the design of the burner achieved a very high ambient temperature (225°F) in less than 36 minutes. The first test did not work well in the sense that the burner melted one of our HOBO data loggers set inside the containment unit so the remainder of our tests was put on hold. This sets our team back until acquiring high temperature thermocouples and an IR camera. The setback also means that our team was unable to record an average baseline from which to measure the effectiveness of our modifications, which we were also unable to test.

Recommendations:

Due to the few number of tests carried out and the lack of success with the HOBO data loggers, our next steps with this project would be to acquire thermocouples and an IR camera and then to commence testing once again to determine changes made in temperature, time, and humidity based upon our modifications and changes in prototype scale. In addition, during further testing we would measure the presence of particulate matter and CO within the containment unit before and after modification to see if the addition of air intake ports, and there fore more access to oxygen, would lower the amount of these harmful byproducts. The larger data sample size achieved from more tests will provide us with more accurate data averages, by which we can determine if our modifications made a significant difference in increasing temperature and decreasing particulate production, CO, and fuel required.

Prior Art Bibliography

https://www.idin.org/sites/default/files/resources/ReportefinalIDDS-energia.pdf

https://www.engineeringforchange.org/news/five-sustainable-home-solutions-co-designed-with-guatemalan-villagers/