THE HAITIAN SUNSATION

EDSGN 100, Section 12, Fall 2011

Professor Correll

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The Haitian Sunsation

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A Design for Emerging Markets: Solar Cooker

Abstract

Solar energy is a very effective energy source when adequate sunlight is available, especially for Developing Countries. In countries such as Haiti, they receive adequate sunlight and do not use this potential energy to benefit any part of society. With more and more people displaced from the recent earthquake and struggling to make ends meet, a simple, easy to use solar cooker would be very helpful. This design project looked at developing a simple, frugal, and functionally designed solar cooker for a Developing Country such as Haiti.

In order to create our product, we had to carefully follow the design process. We set our target market to be Haiti because we all wanted to help an area that is struggling with product development because of a recent catastrophe. After generating three different designs, we chose the most economical and effective way which was a square base built up and then four flaps fanning out from the base and a rectangular attachment to help direct the sun. We built two prototypes and found that our design would not, in fact, be able to boil a half cup of water. Our final product is able to heat water to one hundred and ten degrees Fahrenheit in thirty five minutes.

Problem Statement

Engineers have the potential to design almost anything, but in recent years, not only have they been assigned to grandeur projects but they have also been asked to consider ecological and environmental sustainability. The National Society of Professional Engineers defines sustainable development as the challenge of meeting human needs for natural resources, industrial products, energy, food, transportation, shelter, and effective waste management while conserving and protecting environmental quality and the natural resource base essential for future development. The idea of the Design for Emerging Markets (DEM) project is to incorporate sustainable development into every aspect of the building process to create the most economical, environmentally friendly and efficient product that is ideal for those at the base of the economic pyramid. There are many ways in which engineering can involve unsustainable practices. Engineers can use byproducts that are harmful to life, they can further societal inequities, and use valuable resources that are nonrenewable. It is through hard work and dedication that engineers produce the best possible design without these unsustainable practices.

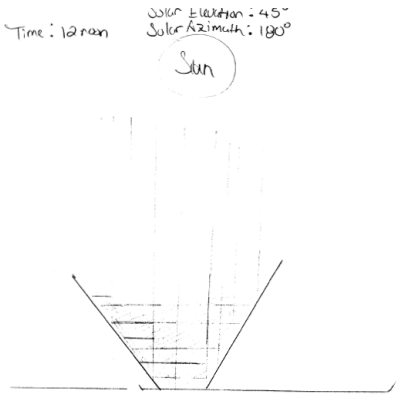
For our Design for Emerging Markets project, we were asked to create a solar cooker that had a frugal and appropriate design that would be ideal for a Developing Country. In order to achieve these two design factors, we had to consider many other ideas. Other ideas that we had to consider were that our product could be massed produced in Developing Countries, that our product is easy to maintain and clean, that our product is safe, that our product is aesthetically pleasing, and that it is an ideal design for those living in the economic base of the pyramid.

When the idea of an ideal design for those living in the economic base of the pyramid is mentioned, there are certain standards that are expected to be followed according to Paul Hudnut. For one, the project that is at hand should not do any harm to the environment. The project

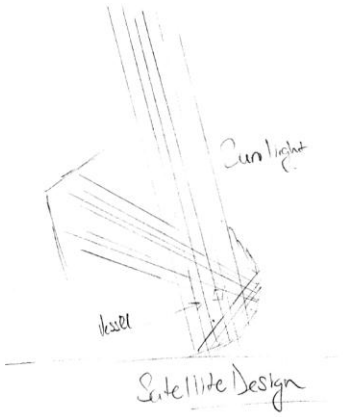
should also be a positive shock to the economy meaning that it creates local jobs as well as boosts the local economy. The project should fix something that is a common problem for the area. Finally, the project should deliver a sustainable solution that is a benefit to every part of the society. In Haiti, our final product, “The Haitian Sunsation,” is a sustainable product that uses renewable energy to benefit every part of society.

Concept Development (Prototype Number One)

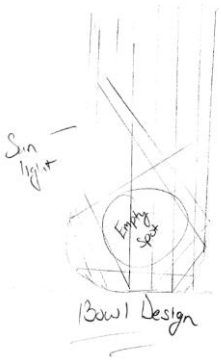
When it came to developing concepts for our first prototype, we knew that we wanted a design that would provide the optimum performance. While researching concepts on the Internet, we came across three design ideas that caught our eyes. They were a bowl shaped design, a trapezoid design, and a satellite shaped design. After observing some possible ways that the sunlight could enter and be utilized in the possible cookers, we figured that the trapezoid design would be the best for us. Being that we wanted to focus on the design factors of frugality, safety and ease of manufacturing, such a design could be made from very cheap and easy to find materials in a short period of time with no skilled labor required.



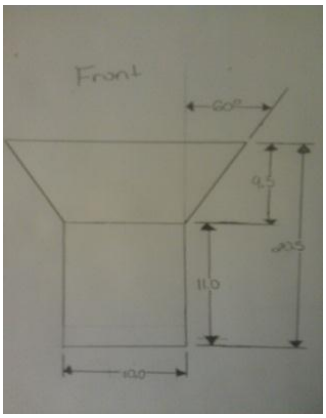
Trapezoid



Satellite



Bowl



Soon after finalizing our design, we set out to find a suitable target country that our cooker would work best for. We took to the Internet once again and looked up the top ten most impoverished countries in the world. Not only did we want to consider impoverishment, but we also were interested in how the society is using the resources that they had available to them, specifically sun light.

Taking these factors into consideration, we chose Haiti. Haiti is the most impoverished country in the Western Hemisphere. Sixty one percent of Haiti's population is classified as undernourished and furthermore, twenty eight percent of all of their children under the age of five are underweight and one third of those children are stunted in growth. On top of that, Haiti is recovering from a recent earthquake that devastated their capital city, Port-Au-Prince. With the people of Haiti struggling to make ends meet and the ideal location for an ample amount of sunlight, we thought that Haiti was the perfect place to design our product for.

Finally, we had to name our product. We wanted a name that was catchy as well as incorporated our target country. After throwing a few concepts like "The Suntastic Cooker" and the "Haitian Heat," we finalized our name as "The Haitian Sunsation." We really liked the idea of incorporating the "sun" into our name and this seemed appealing to us.

AHP Pairwise Comparison Chart to Determine Weighting for Solar Cooker

We used this chart to determine our most important design factors for the solar cooker. Our three most important design factors were cost, safety, and efficiency, but we chose to use ease of manufacturing for our third design factor as this Pairwise Comparison Chart was for the solar cooker in general, not for our Haitian product. We believe that for Haiti specifically, ease of manufacturing is almost as important as cost and safety since they need to be able to build this quickly.

	Cost	Efficiency	Durability	Portability	Amount of food cooked	Safety	Ease of Manufacturing	Aesthetics	Total	Weight Percent (%)
Cost	1.00	3.00	2.00	1.00	4.00	1.00	2.00	5.00	19.00	18.28
Efficiency	0.33	1.00	0.50	3.00	5.00	0.50	1.00	5.00	16.33	15.71
Durability	0.50	2.00	1.00	2.00	4.00	1.00	0.50	5.00	16.00	15.40
Portability	1.00	0.33	0.50	1.00	3.00	0.50	0.50	5.00	11.83	11.38
Amount of Food Cooked	0.25	0.20	0.25	0.33	1.00	0.20	0.33	2.00	4.56	4.39
Safety	1.00	2.00	1.00	2.00	5.00	1.00	1.00	5.00	18.00	17.32
Ease of Manufacturing	0.50	1.00	2.00	2.00	3.00	1.00	1.00	5.00	15.50	14.92
Aesthetics	0.20	0.20	0.20	0.20	0.50	0.20	0.20	1.00	2.70	2.60
								Total	103.92	100.00

Design Factors

When thinking about important design factors, the first idea that came to mind was to create a cost effective design. For our prototype, the materials that we used consisted of a cardboard box, duct tape, aluminum foil, wood, black paint, and a small metal vessel. Total, we projected that this would cost between seven and eleven dollars. In Haitian currency, this is 277.28 Gourde to 435.73 Gourde which is very affordable.

The second most important design factor we chose was safety. There is no fear of getting hurt from the cooker. It has a very strong base to prevent toppling and it can even withstand moderate strength gusts of wind. Since there is no open fire and it uses the suns reflection to heat the food, there is no chance that the solar cooker itself will catch on fire. Finally, it is beneficial for the environment as some of the materials that we used were recyclable materials.

The third most important design factor we chose is ease of manufacturing. No skilled labor is required to build the Haitian Sunsation. In fact, it takes about two hours to build from scratch. Our cooker is mainly made of cardboard and aluminum foil, and therefore it is very cheap and light weight, making it the ideal design for a Haitian woman, who traditionally does the cooking.

Testing – Prototype Number One

	Date	Weather Condition	Temperature Outside (Degrees Fahrenheit)	Test Start Time	Vessel Used	Time to First Bubbles on Water Surface	Temperature of Water (Degrees Fahrenheit)	Time to Rolling Boil
Test #1	9/25/11	Partly Cloudy	74	12:10 pm	Metal bowl	1:10 pm	90	N/A
Test #2	9/26/11	Sunny	72	10:20 am	Metal Bowl	11:40 am	95	N/A

The testing results for prototype one was pretty good, but there was plenty we could work with to improve upon. We were able to produce small bubbles along the bottom of the cooking vessel in the water. The water also reached a temperature of ninety five degrees Fahrenheit, which is not bad for a first attempt but still is not as high as we would have liked. These results made us change a few things in our design, as we definitely wanted to receive better results.

Design Refinement

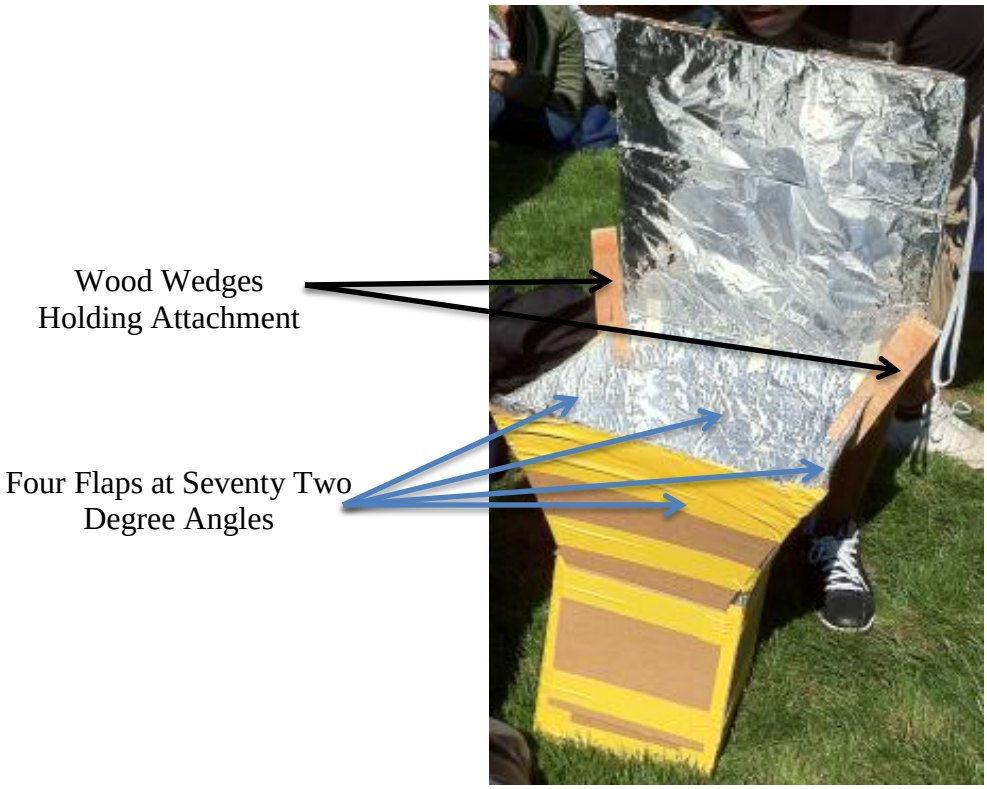
The first change that we made was creating wood wedges. We created the wood wedge so that the attachment itself would not fall off of the main body as well as to allow us to change the angle of the flap depending on where the sun is in the sky. If we move the wood wedge down, the angle is smaller which is ideal for when the sun is lower to the ground. If we move the wood wedges up, our flap will be at a greater angle which is ideal for when the sun is high in the sky.

The next changes we made included putting a wood plank painted black underneath our cooking vessel, and painting our vessel black and adding saran wrap to cover the top of the vessel. All of these changes are for one purpose and that is to increase the absorption of heat from the sun. Increasing the amount of heat absorbed, will decrease cooking time which is one of our main goals, making the Haitian Sunsation more effective.

The final change that we made to prototype one is that we changed the angles of our four side panels. Originally they were each coming out of the base at an angle of sixty degrees. After looking at the solar charts for Haiti, we determined that during the Spring, Summer and Fall, the solar angles are greater than sixty degrees. So we decided to change our panels to seventy two degrees in order to maximize efficiency during the Fall, which is our current season. When the sun is at a high angle of elevation, the side panels need to be more open so that a lot of the sunlight can be reflected toward our cooking vessel.

Prototype One: Haitian Sunsation

Prototype Two: Haitian Sunsation



Not Pictured: Vessel painted black, plank below vessel painted black, saran wrap on top of vessel

Prototype Number Two Testing

	Date	Weather Condition	Temperature Outside (Degrees Fahrenheit)	Test Start Time	Vessel Used	Time to First Bubbles on Water Surface	Temperature of Water (Degrees Fahrenheit)	Time to Rolling Boil
Test #1	10/06/11	Sunny	75	1:45 pm	Metal bowl Painted Black	2:20 pm	110	N/A

The results for testing prototype two were more promising than those for prototype one. The temperature of the water reached one hundred and ten degrees Fahrenheit in a time of thirty five minutes. Prototype two reached a temperature twenty five degrees higher in forty five minutes less time which is a very good improvement. The changes we made definitely helped our solar cooker work more effectively without compromising any of our important design factors of cost, safety, and ease of manufacturing.

Lessons Learned

Although we were happy with our accomplishments with The Haitian Sunsation, if we were to build a third prototype, we would make several changes that we believe could improve the functionality. The main change that we would like to make is where we place our cooking vessel. One flaw in our first two prototypes is where the focal point was in our structure as compared to where our cooking vessel was. We calculated that the focal point is, in fact, four inches higher than where our cooking vessel was actually placed. We believe that this could help make the water a significantly higher temperature. One of the other changes that we would make for prototype three is to make the Haitian Sunsation more portable. For the first two prototypes, we were more concerned with the functionality and did not really consider aesthetics or portability. If we were to do this project again, we would like the base of our solar cooker to fold up as well as add paint to the outside of the structure to make the solar cooker more aesthetically pleasing.

Looking back at this project, many things went well for our team. We believe the thing that went the best for our team is that we were able to bond throughout this project. When we were put together as a group for the first time, we did not really talk to each other. But as time went on, we became closer and were able to figure out each other's strengths and weaknesses. If we were to do this project again, one thing that we would definitely want to change is how we schedule times to meet and work collaboratively. We had a lot of difficulty scheduling times that would work for all of us so sometimes certain people were assigned to more work than others. We would also like to share our ideas more, because sometimes we got stuck on one idea and did not really explore our other options. For our next project, we are going to work ahead and actually already decided as a group that we will schedule a time a week in advance to meet

up so that we can avoid procrastination. We also will keep our same roles but will collaborate more before just acting on our initial ideas. Overall, we all agreed that this DEM project was very well organized. We liked how it made us spend a lot of time together, how we had to collaborate, and how we all were dependent on each other. We all mutually agreed that it would have been better if we would have had a live demonstration of a successful solar cooker. It was hard to get an idea from just looking at pictures from the Internet. We also all agreed that this project would either be better to do earlier in the semester or wait until later in the spring semester to do testing. Having cool weather while testing negatively affected our water temperature even when the sun was out. Overall, though, we believe that this was a very beneficial project and that we all learned a lot from the beginning when identifying customer needs until implementing our final product.

Resources

https://www.cia.gov/library/publications/the-world-factbook/geos/ha.html

http://www.foodbycountry.com/Germany-to-Japan/Haiti.html

http://www.nationsonline.org/oneworld/index.html

http://www.everyculture.com/Ge-It/Haiti.html

http://www.foodbycountry.com/Germany-to-Japan/Haiti.html

http://www.caribbeanfoods101.com/haitian-food

http://www.theworldmappictures.com/haiti-world-map/

http://www.numismundo.com/pm/hti/2001/

http://www.physicsclassroom.com/class/refln/u13l3a.cfm

http://ants-and-grasshoppers.blogspot.com/2011/06/true-economics-sleepytime-stories-6511.html

http://www.nspe.org/index.html