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Service Learning Without Borders – Turning Peanut Shells to Fuel Briquettes in the Gambia

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Service Learning Without Borders
– Turning Peanut Shells to Fuel Briquettes in The Gambia

Abstract

The need of firewood in the Gambia is leading to rapid deforestation. An engineering student team in our program was founded to convert peanut shells, an abundant agricultural waste from the country, into fuel briquette. By consulting the local contacts, the students developed a series of pressing devices and processes for the purpose. Then they compared the strength, burning rate and duration of burning of the briquettes, as well the difficulties to obtain binder and process the material. They finally settled to an easy to follow recipe and a very simple device to press the loose shells to briquettes. In the January of 2012, a student team went to 8 remote villages in rural Gambia. They demonstrated the briquetting process to the local people. The team was warmly received and all villages agreed to try out the method so they could preserve the dwindling forest while supporting the growing community.

1 Introduction

The Gambia is a small country located at the tip of West Africa. A relatively peaceful life in the past decades brought rapid growth of the population (372 thousands in 1960 to 1.77 million in 2011 [6]). However, as in many parts of the developing world, most Gambia people cannot afford the gas or electricity. They rely on trees and firewood for their cooking needs. The practice leads to a significant deforestation rate at about 6% per year, which makes the continued use of firewood unattractive [8]. Meanwhile, since the wood sources are getting further away from the villages, collecting firewood is becoming an increasingly time consuming and dangerous process. It often prevents people, especially women and children due to the culture preferences, from conducting more productive activities.

At the meantime, peanut is a major cash crop for the country, accounting for about 6.9% domestic GDP. While the peanut products are exported, the shells are left behind (Figure 1). In many villages especially those we visited, corns are also grown. The agricultural rejects like corncobs and leaves are often burned to clear the room for the new crops.

Facing this simultaneous fuel shortage and abundant bio-waste, many organizations have started biomass briquetting projects [1]. However, unlike those projects conducted in China and India, where government incentive and more sophisticate industrial infrastructure are available [4], the almost non-existing industry makes it hard to process the peanut shells or corncobs in large scale. One effort of a local NGO group called Concern Universal was to build a small factory to make the briquettes from wood and other material. However, they require a special type of stove and continuous purchase of the briquettes. Their strategy is to start from the relatively wealthier families along the coastal area and let them lead the trend. Unfortunately, for the major population living inland, it will take years or decades before they can catch the trend because of the lack of road and transportation methods [1, 2].

Another approach to the problem was proposed by an engineering student in our program at 2009. She found these pressing problems in the Gambia when the students were asked to conduct engineering ethic and sustainable engineering study. As a member of Engineering Without Border, the student and her peers presented the problems and proposed their solutions to the faculty. That is, they wanted to develop a device and a process that can convert the peanut shell to fuel briquettes at the village level. So the local people can burn the briquettes instead of the firewood for heating and cooking. According to their calculation, the peanut shell can provide up to one third of the total fuel needs of the country.

The idea was supported by the faculty and further funded via an EPA's People, Prosperity and the Planet (P3) grant. A team was formed to implement the idea. They studied corresponding documents, contacted people familiar with the area, and conducted an engineering development with a clear goal. The result was an easy to find tool set and an easy to follow instruction. The team further collaborated with a local group of Gambia students and visited 8 villages in the remote area of the Gambia to promote this environment preserving technology.

Figure 1: (Left) In the past 10 years, the forest has retreated from right next door to about half hour walking distance from the village where we visited. (Middle) Tons of discarded peanut shells are piled outside a town of the Gambia. (Right) A typical pile of refused corn leaves in the middle of the field.

2 Developing the Technology of turning peanut shell to fuel

In early tests of the project, the team found that calorific value of the peanut shells is even higher than that of the oak. However, loose peanut shells are hard to store, transport, or burn. It is desirable to densify and solidify them into briquettes [3, 6]. Developing an easy and systematic way of pressing peanut shells at the family level is a great engineering exercise for the students. However, it is different from the traditional engineering projects. The design will be built and used by individuals or families who had no machinery experience at all. The goal is to make the process as easy as possible yet still meet the necessary engineering criteria. Therefore, some unique design constraints were imposed:

- Briquettes must be suitable for use with a traditional three stone cooking fire.
- The briquette press must be able to be built using materials that are affordable and easily accessible in The Gambia.
- The briquette press must be able to be easily built and maintained by local artisans, or better yet, by the villagers themselves.
- The briquette press must be manually operated.
- The briquette making process must be easy to follow and require no special skill.

2.1 Preparation of the peanut shells

Although not realized at the beginning, it is considered the most important step of the whole process. To compress the peanut shells to a briquette, people need to prepare them to small pieces and use binders to keep the pieces from falling apart.

In the first trial, the student team followed the practices of industrial briquette making by grinding the peanut shells. However, they later realized that it was impossible for the local villagers to obtain grinders. A quick solution was proposed to use the mortar and pestle that are commonly seen in the Africa. A bucket and a 2-inch PVC pipe with an end cap were used to simulate the equipment (Figure 2 A & B). The peanut shells are reduced to the size of a thumbnail. The size is selected by balancing the effort of crushing and the easiness of pressing.

The student team also spent a long time to look for a suitable binder. The industrial binder was clearly not an option. They tried cornstarch and rice starch since they were the local staple food. It was considered as the necessary evil of the project for quite a while. After numerous trial and error, they found that by leaving the wet crushed peanut shells in the container for a few days (depending on the weather), the natural fermentation will make the peanut shells mushy and sticky but still not sour and smelly as completely composted. Using this technique, the shells can be easily pressed into briquettes without help of any binder.

2.2 Stoves burning the briquettes

(A) (B) (C) (D)

Figure 2: (A) A student was practicing the use of mortar and pestle. (B) A pipe and bucket simulation. (C) A typical three stone stove. (D) Used tin cans are good substitutes to stones.

In the Gambia, especially in the countryside, almost all cooking are conducted outdoor using the traditional three-stone stove (Figure 2 C & D). That is, they will put three stones or similar objects to form a triangle base. Then a stove will be put on top of the stones. Firewood or fuel will then be put into the stove to cook meals. Sometime, people put corncob directly into the stove. However, it is very slow and inefficient. In one evening, our host family took about twenty minutes to boil a small pot (about 300ml) of water by using entirely the corncob. It will be also difficult and tedious to constantly shovel loose peanut shells to keep the fire burning.

2.3 Tools and processes of converting the peanut shells

A series of tools were developed to compress the peanut shells. The first approach was to modify the Legacy Foundation briquette press [5]. After consulting a former Peace Corp member who had been to the area, the students compiled a list of what were available from the local market. It was assumed that the villagers had access to wood stocks such as 2”x4” and some basic hand tools such as knife, saw, screwdriver, and nails. This information turned out to be inaccurate though. During our visit to the villages, we found that it was true that these tools were available in the capital and large trade towns, but were very rare (except knives) in the villages. It is nearly impossible for the normal villagers to obtain 2”x4” or to prepare the wood stocks to such conditions.

Another version of press (middle of Figure 3) developed by the student group was based on a car jack. The reasoning was that although the regular people in the Gambia cannot own a car, there must be some discarded cars lying around beyond repair and the jacks would have no use to the owners. Meanwhile, the jack-based design is more compact, powerful, easy-to-use, and last longer. Therefore, it would be more suitable for the villagers with entrepreneurship to start a business, make a profit, and then help energize the local economy. Unfortunately, the area we visited was so poor that there was no metal object left unclaimed.

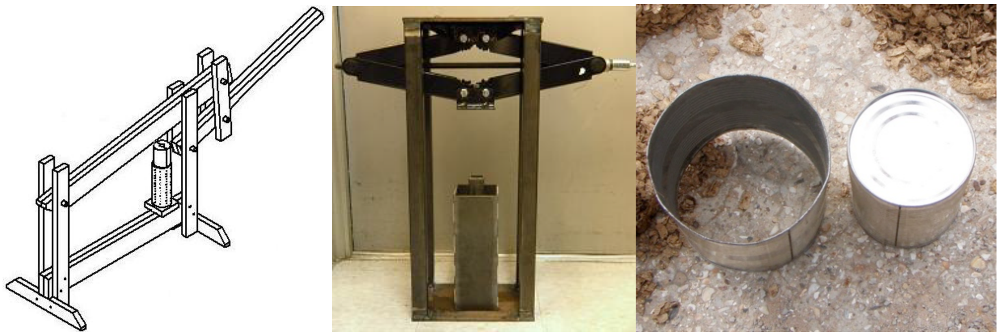

Figure 3: Press tools. (Left): Legacy Foundation briquette press. (Center) Car-jack based press. (Right) Can press.

After rounds of design improvement and briquette tests, it became evident that pressure was not the most critical factor for small-scale production of the peanut shell briquettes. It was on the contrary to the industrial practice where the pressure could reach as high as 5MPa[3]. The students performed an experiment by varying the pressing force from 400lb (1780N) to 50lb (220N) on a fixed area of about 12in^2 (~80cm^2). The critical point was found to be 70lb (300N). When the pressure is below this threshold (~0.04MPa), the water will not be able to bind the shells with the existing preparation method. Nevertheless, this pressure is easily obtainable with manual force without any special tool.

After testing a few lever-based designs, which still required fabrication with hand tools, the pressing method was ultimately simplified to using two used tin cans. As shown in Figure 3, one was slightly larger and with both ends removed. The other one was slightly smaller such that it could just slide through the larger can. At least one end of the smaller tin can was kept intact. One could easily push the smaller tin with hand and press the prepared peanut shells to a round briquette.

This ultra simple design was warmly received by the local residents when we visited them. Several tools or designs were introduced to them in the past for various purposes. Because of the limited knowledge base and restricted material supply, to make a lever device by them was almost as difficult as to build a car by someone in an industrial country. However, the seemingly ridiculous approach with two used cans makes it easy for them to replicate the technology. Although considered as some kind of luxury, the canned foods were readily available in the local market. Indeed, the 20L petrol cans and used tin cans were the most ubiquitous industrial products in the region. For example, as shown in Figure 2, some people even used tin cans to build a three-stone stove. From our limited interaction, we also observed local people using the cans to feed chickens, drink water, or store loose objects.

2.4 Briquette making

With proper preparation and 2 used tin cans, one can easily compress the crushed and soaked peanut shells to a round briquette. An adult can press by hand and a child can simply step on it. They need to keep the pressure while counting to 10. For the industrial briquette with very fine particle and high density, a center hole is necessary to keep the air flowing during the burning process. However, with the less dense homemade briquette, a center hole will be beneficial but not mandatory, especially when it is completely dry.

Figure 4: (Left) The briquettes made by the local students from the University of the Gambia. (Middle) Starting a fire with dry grass. (Right) A half burnt briquette.

A series of tests were developed to test the properties of the peanut shell briquettes. The student team tested the density, durability [7], combustion rate, and calorific rate of the briquettes at various stages, such as with different binders, pressing pressures, moisture levels, compost levels, shapes and sizes.

After a year and half of research and engineering design, combining the above-mentioned development from preparation to fabrication, the team eventually finalized a simple yet effective process of making peanut shell briquettes using locally available material and skill. They prepared a visual instruction (see attached) and provided it to a group of local students from the University of the Gambia. With some trial and error and without further intervention from us, they successfully made several dozens of briquettes themselves (Figure 4). The burning tests also proved to be satisfactory.

3 Promulgate the technology

3.1 Collaboration with the University of the Gambia

In late 2011, the team identified a cluster of 8 villages in the Niamina East district of the Gambia and extended the contact to a group of local college students from the University of the Gambia. The goal of collaborating with the Gambia students is to bridge the culture and knowledge differences between the villagers and the American students. The Gambia students were majored in Physics or Education. Though not engineering students, they all had basic trainings on math and physics. They also were deeply concerned with the deforestation of the rural areas of the Gambia. One of them even came from the area that we were targeting.

The briquette making guideline together with other project documents were sent to the Gambia students. Without too much difficulty, the students quickly followed the instruction and made their own peanut shell briquettes. They also started to add their own inputs such as using sawdust (there was a wood cutting factory near their campus), corncob, and other locally available materials.

In early January of 2012, the team from US flew to the Gambia and met their local counterpart. The travel was partially funded by the EPA P3 grant and partially funded by the student chapter of Engineering Without Border (EWB) through fund-raising activities. Then they traveled together to the villages in order to promote the technology to the local residents. In the following week, the joint team visited all 8 villages one by one.

During the interview with the villagers, it became clear that the local people were aware of the damaging consequence of the deforestation. The water from the well started to taste bitter and salty so they had to rely on the deep wells drilled by outside aid groups. The time they spent on collecting the firewood was getting longer every year. This was especially painful to the women and children since they were in charge of the job. Unfortunately, the villagers had to choose between getting by today and protecting the environment for tomorrow.

When the idea of making briquette was mentioned to the residents, their first responses were mostly negative. Several external aid groups had been to their villages and promoted various technologies to help them improve productivity or life quality. However, the technologies tended to be too complicated to them and not sustainable. For example, some solar pumps were installed to help them get continuous supply of water inside the village. However, frequent breaking down of the motor and inverter drained their anemic cash reserve on repair. Many of them have to wait for fresh donation or switch back to hand pump or open well. They were afraid that the briquette making machine would be another white elephant introduced to them.

However, quickly after the team took out the two tin cans, demonstrated the briquette-making technologies, and burned a premade one on-site, the villagers started to get convinced and excited. It is within their understanding and approach. Some villagers quickly learned to make the briquettes themselves. Some of them even started to brainstorm other applications. For example, one elder pointed out that he could use a damped briquette to repel flies and other insects from his livestock.

4 Impact of the project

Originated from a class project on sustainable energies, developing peanut shell briquettes had grew to a worthy project that provides trainings on engineering, communication, and social awareness.

The project was a great example of developing suitable technology to the targeted population. From the project, the students learned that the best technology is not necessary the most advanced technology, but the most suitable one. They did not need to use state-of-the-art components and materials. On the contrary, they are limited to the most primitive means. Nevertheless, they still need to apply their engineering skills to solve demanding problems. For example, they had to build a bomb calorimeter to test the calorific value of the briquette. They also need to develop a systematic way to find out the minimum pressure of making a usable briquette. They also learned the importance of having proper assumptions and constraints to succeed on a project.

The project also improved the communication skills of the students significantly. At the beginning, they relied on technical papers on briquettes and online introductions about the country. Then they developed designs and processes with the incomplete information. Further contact of the people from the region helped them to adjust the assumptions gradually. For example, a professor from another university who had been to the country gave them firsthand description of the local culture and local infrastructure. The communication helped the students to simplify the engineering design to the extreme, which was exactly needed by the local residents in the rural Gambia.

Engineering ethic and the relationship between engineering and humanity is an important but hard to teach topic in the engineering education. It is critical to prepare our students to the global market. Many engineering students were technology oriented but not aware of its social effect. This project prompted the students to be more concerned beyond the immediate world around them and become more socially responsible. They learned that people might have completely different languages, cultures, life styles, value systems, and technical skills, yet still need to collaborate to strive.

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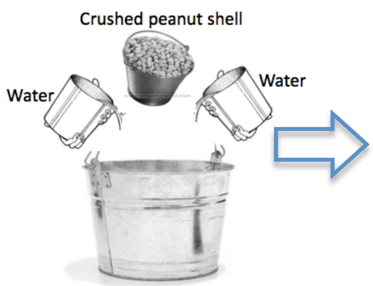
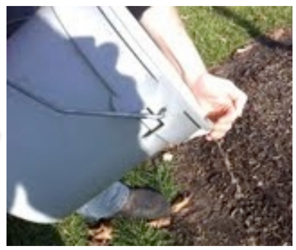
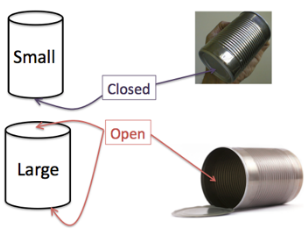
Attachment:

Peanut Shell Briquette Production – Visual Guide

Step	You do this	Then you will get
1	 	
2	 	
3	 	
4	 	
5