

Designing and Building a peanut-shelling machine to help people in third world countries such as Ghana/Haiti

By

Rafiq H Mohd Ramli

Submitted to the Department of Mechanical Engineering in Partial Fulfillment of the Requirements for the Degree of

Bachelor of Science

at the

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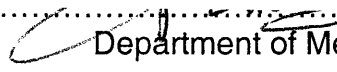
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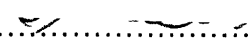
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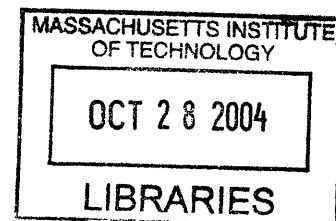
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Rafiq H Mohd Ramli

Submitted to the Department of Mechanical Engineering on May 5, 2003 in Partial Fulfillment of the Requirements for the Degree of Bachelor of Science in Mechanical Engineering

ABSTRACT

A peanut shelling machine was designed and built to help improve the standard of living of people in third world countries such as Ghana and Haiti. Two prototypes were built to test the concept of using a wheel as a peanut sheller. Peanuts would go through a gap between a spinning wheel and a hard friction channel and come out on the other side fully shelled. The peanut sheller was powered using a crank.

Second prototype was built after the concept of the spinning wheel worked after testing the first prototype. Peanuts were shelled without breaking the kernels however a separator mechanism still needs to be built to separate the kernels from the shells.

Thesis Supervisor: Ernesto Blanco
Title: Adjunct Professor of Mechanical Engineering

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Introduction

The idea for this thesis came around during a design process session in the mechanical engineering design class titled Product Engineering Process or more well known as 2.009 to the students in the department. The scope of the class that semester was for the students to develop products that will help to improve the standard of living for any group of people that they choose to. Most of the final ideas in the class were designed to help improve the lives of people in poor third world countries such as countries in Africa and South America.

However, the initial idea for the peanut sheller started from the idea of trying to design an improved grain grinder. After getting through the first round of idea cuts, and meeting with Amy Smith from the Edgerton Center at MIT, the grain grinder was discarded but a similar product which was the peanut sheller came to the surface. The peanut sheller was one of the final ideas that were being considered as a viable 2.009 project by the Green group in 2.009 (The group I was in). In the end, another project called the community water purifying system was chosen instead of the peanut sheller as the final project the Green group was going to pursue. It worked out great for both ideas because the community water purifying system was built by the group, and the peanut sheller was improved with some help from a few people during the IDEAS competition here at MIT.

The next few paragraphs will show the reasons why the peanut sheller is a great idea to continue to be developed.

In places like Haiti and many West African countries, peanuts are a major crop. Most peanut farmers shell their peanuts by hand, an inefficient and labor-intensive process. The goal of this thesis is to build a low-cost, easy to manufacture peanut sheller targeted at individuals and small cooperatives that will increase the productivity of the peanut farmers. Furthermore, this peanut sheller can be manufactured with materials that are readily available in the target communities.

There are also other similar products available such as The Malian Peanut Sheller for small scale use by the peanut farmers. However, the current products cost more than 130 dollars which is out of range for the target group targeted for this thesis. The peanut sheller will target small household industries and small scale productions of peanuts to help them cut the cost of peanut shelling.

Background

The aim of this design thesis is to serve the technologically underdeveloped parts of the world especially where the peanuts are grown, processed and marketed. This in order will help to raise the standard of living of people in the same parts of the world by making them more efficient in the peanut production industry. The peanut sheller will hopefully increase the peanut sector productivity, help improve the standard of living and raise the technological standards by creating a simple and low-cost peanut sheller that for use by households and small cooperatives.

The peanut sheller idea was started from inspirations of previous work done on agricultural technologies in the world's developing nations. However, Eric Schumacher's advocacy of "intermediate technologies" as a pathway to help improve the technological standards in the underdeveloped parts of the worlds deserves some credit. An intermediate technology is a product or an idea that exists in developed countries such as the USA but is usually redesigned to fit in the harsher living environment that people in the underdeveloped parts of the world are exposed to. The peanut sheller fits into the mold of an intermediate technology because it exists in other forms in big factories, however because of the sheer price it had to be redesigned so that it could be used by the targeted group.

In a general sense, the communities that will benefit from the peanut sheller live in the rural areas in West African nations. The people here rely heavily of peanut production as a local condiment or for export. The majority of the world's peanut production comes from regions such as the southern United States and China. However, among the less developed regions, Western African nations and several other countries are great locations to introduce the intermediate technology for peanut processing. West Africa has 14 countries that produce peanuts, making the region the leader in peanut production in the developing parts of the world. There has also been a 53% growth in the West African peanut market for the last 25 years. Besides the West African nations, Haiti was also considered to be a prime location for pilot testing of the peanut sheller. The reasoning behind choosing Haiti was the contact has been established with a peanut processing cooperative there. The final location for the initial testing hasn't yet to be chosen and it will depend on the support the product gets from the targeted group that needs it.

Potential users of the peanut sheller will include individual households, women's cooperatives and subsistence farmers. The potential users represent a large group of communities that will benefit from the product. Similar to other work that is usually done in the agricultural sector in underdeveloped nations; peanut shelling is usually done manually by the women and the children. With the creation of the peanut sheller, the process of shelling peanuts will be more efficient and help reduce the time needed to process the peanuts. The peanut sheller will also help improve the technological standards by the introduction of simple and novel intermediate technologies.

Prior Art

In the US, hand powered or electric powered machines perform peanut shelling for commercial purposes. The Pearman Corporation located in Chula, Georgia is one the manufacturers of such machines. The way their machines works is it shell the peanuts by striking them with rods until the shells split open. The shelled kernels will then fall through a grating where they will be collected and separated from the shells. Their hand powered machines can process up to 68 kg of peanuts per hour and costs \$275. The electric version of the machine can handle up to 250 kg per hour and costs \$1250.

In Thailand, The Thai Rubber Tire Peanut Sheller is generally used by peanut farmers. This machine uses a rubber tire to rub peanuts against a metal housing. The machine was presented at the Post Harvest Technology Conference and is assembled using a full sized automobile tire and many formed sheet metal components. The cost of the machine (hand-cranked) is \$130 which is still cheaper than the Pearman's machines but still considered expensive for the targeted group in underdeveloped countries. The machine can process peanuts up to 60 kg per hour. Other technologies from the same workshop includes a wooden paddle peanut sheller that process peanuts up to 70 kg per hour and a revolving stone sheller with the same capacity as the former.

Another example of prior products in the peanut processing industry is the Malian Peanut Sheller. The Malian Peanut Sheller is a lot cost, small scale sheller. The designs for the machine can be acquired for free from www.peanutsheller.org. The materials needed to build this particular sheller costs \$10. The machine is constructed out of two pieces of molded concrete, and a few basic pieces of metal used to reinforce the concrete and to make the axle and crank mechanisms. Although the costs for the materials needed to build this sheller is low, there is also a one time costs for the fiber glass mold that is used to make the two pieces of molded concrete. The mold makes the technology a bit expensive for the people it is trying to help. The Malian Peanut Sheller can process up to 50 kg per hour of peanuts.

Another way of shelling peanuts will obviously be shelling peanuts by hand. The financial cost of this method is free. However there is a different cost being tied to this particular method that being the time consumed. This is the most inefficient method available for use in the peanut processing industry as the output of each person differs. The output for a person could range from 1-2 kg per hour to as high as 10-15 kg per hour depending on the persons health and motivation. However, the peanut shelling time is considered a time for the women in a community to meet and talk with each other which creates a dilemma to introduce new technology for peanut shelling which can disturb the harmony of a certain community.

Method of Shelling	Cost	Output	Miscellaneous
Pearman's Hand Powered Machines	\$275	68 kg/hr	None
Pearman's Electrical Powered Machines	\$1,250	250 kg/hr	None
Thai Rubber Tire Peanut Sheller	\$130	60 kg/hr	None
Malian Peanut Sheller	\$10	50 kg/hr	Extra cost of Fiber Glass Mold
Hand Shelling	Free	1-15 kg/hr	Time cost

Figure 1: Summary of Prior Art in the Peanut Shelling Industry

Conceptual Designs

The peanut sheller consists of three main parts which could be divided into a few smaller subsections each. The three main parts are the sheller, the power source and the separator. Conceptual designs of each part were done and a few combinations were tried to find the optimal way to produce the final product.

1) The Sheller

This is the most important part of the machine as it does the shelling of the peanuts. The sheller uses a moving wheel to grind the sun dried peanuts against a high friction hard surface. The wheel is powered by an external power source connected to the center of the wheel. The power source for the sheller will be explained in the next section. The peanuts will go through a small gap wide enough between the wheel and the channel so the peanut kernel can go through with being broken while it is being shelled. The unprocessed peanuts will come in one end of the spinning wheel and come out the other end fully shelled. Figure 2 shows the sheller.

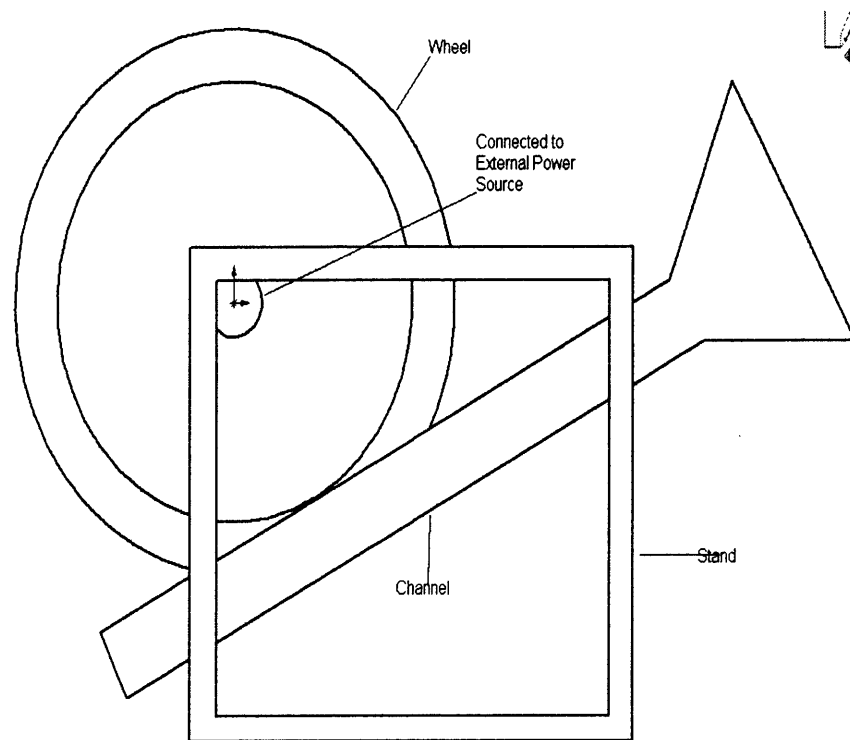


Figure 2: Schematics of The Sheller

2) The Separator

The peanut kernels from that come out from the sheller however has not been fully separated from the shells or waste. A few different ideas were thought of on how to do implement the separating process and the ideas will be explained thoroughly when accompanied with their respective sketches.

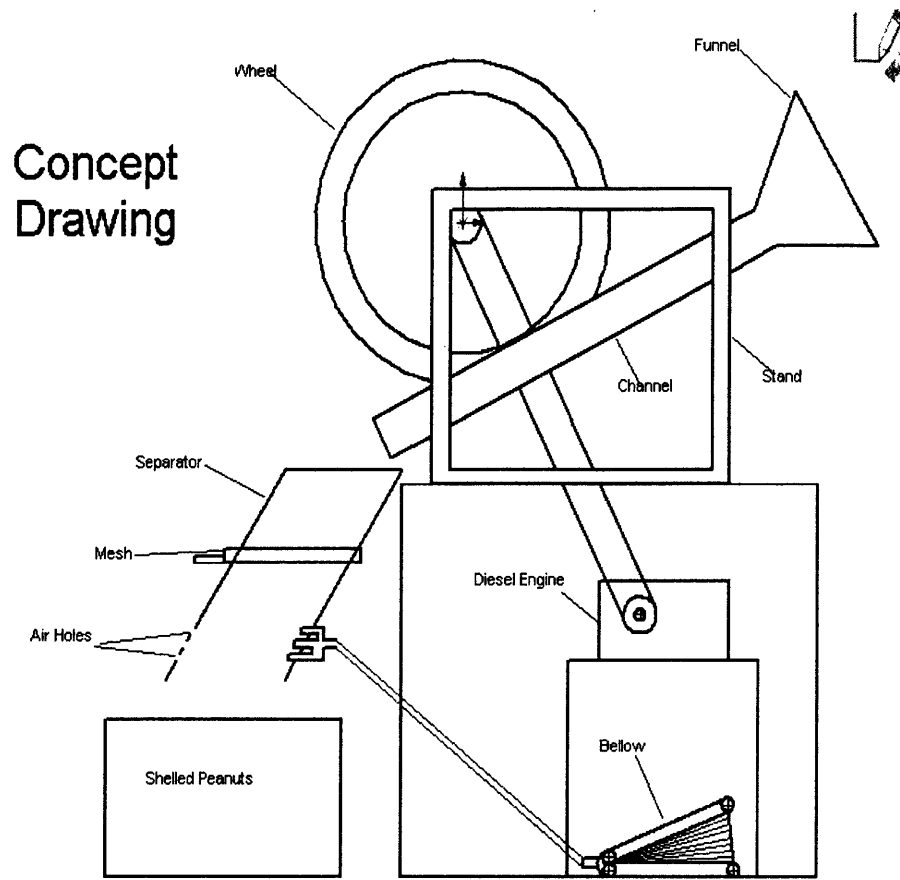


Figure 3: Separator with Grates and Air Holes

Separator with Grates and Air holes

Figure 3 shows the concept of separating peanut kernels from their shells using a series of grates or meshes combined with air. After being shelled, the peanuts and the shells will go into the sloped separator where the larger shells will be stopped by the grate while the peanuts and smaller debris fall through it. In the next section, air will be generated by stepping on a bellow, generating a cross flow that will blow the smaller debris to away from the peanut kernels. The heavier peanut kernels will then fall into a container at the end of the separator, ready to be sent for processing or cooking.

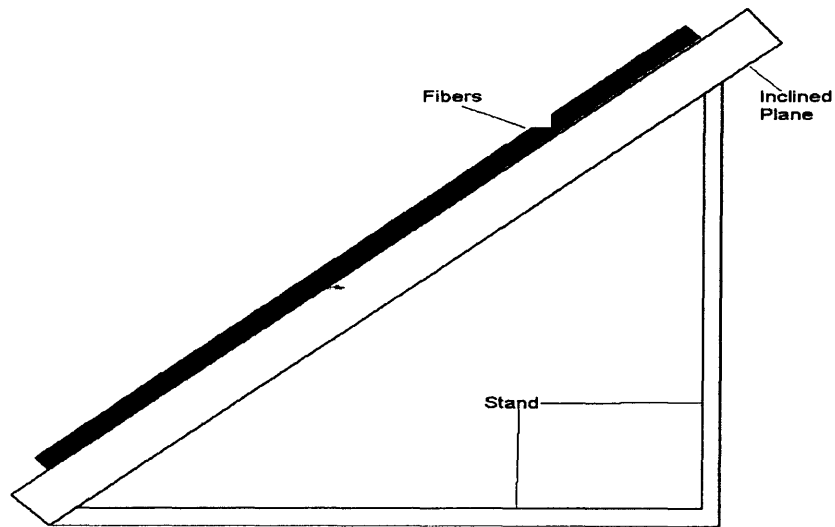


Figure 4: Separator with fibers and inclined plane

Separator with Fibers and Inclined Plane

Figure 4 shows the concept of separating the kernels from the shells using extruded fibers on an inclined plane. This particular separator uses the physical properties of the kernels and the shells. The kernels are generally round and will roll down an inclined plane easily. On the hand, the shells come in different shapes and sizes so the extruded fibers will ensure that the shell will stick to them while the kernels get separated.

3) The Power Source

The power source for the peanut sheller is the part that makes the machine function as it is supposed to. The power source is connected to the center of the shelling wheel, and is needed to spin the wheel so that the peanuts can be shelled. A few different ways of powering the machines were thought of, and they will be explained next.

Human Power

There are two ways the human power could be used to power up the peanut sheller. The methods that will be used are:

- i) Hand powered – A crank shaft will be connected to the center of the wheel or known as the axis of rotation. The crank shaft will then be cranked by the person who is operating the machine so that the wheel could spin and in turn shell the peanuts.
- ii) Leg powered – Generally the human leg is stronger and has more endurance than the human hand. A human could produce a constant amount of force longer with his legs than he could with his hands. So, generally a leg powered machine will be preferred over a hand powered one. There are two different ways the leg power could be harnessed to power up the peanut sheller. The first of the two will be using bicycle pedals. A bicycle chain will connect the pedals to the center of the wheel. By pedaling, the wheel will move and in turn shell the peanuts. However, it was learnt that there are certain places where the peanut sheller was going to be tested that pedaling is not a good way to produce power culturally. The reasoning behind this is that most of the people working in the household shelling industry are women and they usually wear sarongs or skirts while working.

The other way that the power of the leg could be harnessed is by using a treadle. A treadle is a stepping machine that involves several sets of interconnected gears that move the main gear (the one that will be used to move the main the wheel) in just one direction independent of the direction of the feet plates. In other words, the wheel will move in the same direction whether you step or release the foot plate. This device will help in harnessing the strength and endurance of the legs without sacrificing any cultural inhibitions. However, a treadle is not a device that is easily made and it goes against the notion of creating a simple machine.

Engine Power

Compared to human power, an engine is comparatively expensive due to the need to buy an engine and then buy the fuel to run it. However, an engine provides a stronger and constant power to the sheller which would in turn increase the productivity of the peanut farmers. The cheapest engine is the diesel engine and the diesel engine is readily available in a lot of places and even in the rural areas. As stated earlier, the costs of fuel however will reduce the net output or sales for the people who end up using it. However, for this version of the peanut sheller, no extensive study has been done to compare the pros and cons of using a diesel engine compared to human power.

Innovations of Prior Art

Innovations of the prior art or in layman terms, why should someone choose the peanut sheller instead of the current existing peanut shelling products will be the next topic of discussion.

The reason why the peanut sheller should be chosen over existing products:

- i) It is inexpensive
- ii) Small Scale capability
- iii) Does not need outside help to build – materials and tools are readily available and do not require external communication with other parties to build.

The commercial machines such as the Pearman's products are simply too expensive for the people the peanut sheller is trying to help. Even the hand cranked machines cost more than \$130. Although diesel engines are readily available, electric powered machines are impractical because electricity will be better used for lights instead of powering the peanut sheller. In the end, the peanut sheller is better because it is small and inexpensive and fits very well into the household peanut industry.

The only other peanut sheller that will be affordable for the targeted group is the Malian Peanut Sheller. The Malian peanut sheller is a good low cost alternative, but on the other hand it requires access to fiberglass materials to make the molds for the concrete pieces that makes the sheller. If the person building the molds has access to fiberglass materials, then the Malian Peanut Sheller will be the best option for him. However, most of the places in the underdeveloped country don't have access to such technologies and will probably have to contact the designers and buy the mold from the United States. This will increase the costs of the peanut sheller significantly.

The peanut sheller aims to eliminate the need for molds and help from outside parties. The peanut sheller requires no foreign assistance at all. It can be built using local materials by local craftsmen, which in order eliminates the need for communication and interaction with outside parties.

As stated in the previous section, the peanut sheller uses the concept of a spinning wheel inside a U-shaped channel. The builders have options of either using discarded bicycle tires, or cut a circular wheel out of high density wood. The channel can be made from either PVC, wood or metal, and the stand for the sheller could also be made from the same materials. The machine itself is very easy to be built and requires just a few skills besides basic carpentry. The peanut sheller concept does away with the high costs and focuses on simplicity and making life easier for the people using it. The concept is also simple and the greatest thing about the peanut sheller is that the design is modular. The peanut sheller can be expanded to have a higher throughput by either using a wheel with a larger surface, or using a few set of wheels in parallel. Locally accessible materials

can differ from region to region, so the peanut sheller can be adapted to using different materials.

The separator as stated earlier helps to separate the shelled kernels from the shells. Prior designs for separation use manual labor or forced air. The separator can be built from wood and the size of the separator can be changed depending on the needed throughput. The easiest form of the separator that can be built is to have a wooden inclined plane with a high friction surface such as rubber on top of the wooden plane. In this concept, the kernels will easily roll down into a container while the shells and other particles will stick to the high friction surface. This concept will also make it easy for cleaning when the wooden plane is full with shells. Another thing that makes the design great is because of the low cost needed for the separator; a few sets could be built and can be used while one is being cleaned.

Design Process

The implementation plan was focused on iterative prototype designs, each one enhanced by new knowledge gained from lab testing, field testing, and research on cost and material availability. The nature of the task creates a complex optimization problem. Factors that must all be considered are cost, safety, throughput, ease of use, probability of adoption, cost of repair, component lifetime, modularity, frequency of repair needed, among others.

For this reason the implementation strategy can be broken down into three phases. The first was functional development, which focuses on developing knowledge about what factors influence the functionality of our device, and how to optimize those factors. The second focuses on simplification and optimization of cost and manufacturability. In this phase the working prototype will be redesigned to find ways to retain the basic functionality but use simpler, cheaper components and find creative ways to further reduce complexity. The final phase will focus on looking at the sheller from a manufacturing standpoint. The final phase includes optimizing the final design for construction in the target community with materials that are locally available. This will include making plans for the devices we design, but also for jigs, etc. that will aid in construction.

The first prototype of the peanut sheller was built in the 2.009 class for an in class demo. The prototype was built using a bicycle tire, and was supported by an aluminum stand. The channel that was used was made from a PVC pipe cut in half, and layered with a piece of rubber to increase the friction. The wheel was spun without a crank which made the output of the peanut sheller inconsistent.

A separate separator was also built for the demo session. The separator was made from cardboard and wire meshes. After the peanut was shelled, the end product was put on the separator and then the separator was shaken by hand. After that, forced air was

used from a fan to separate smaller debris from the peanuts. The peanut sheller worked as it was supposed to, but the process was really inefficient.

After seeing the results from the first prototype another brainstorming session was done. Different modules for the sheller, separator and power source for the peanut sheller was thought of and written down as can be seen in the Concept Design section. After that, the modules were sketched so they could be visualized easier. This also helped to find better ways to do a specific module for the peanut sheller.

After finalizing which modules should be used, technical drawings of the parts were made. This step was important to make it easier before going into the workshop to build the second prototype. After finishing the second prototype, some testing was done to see whether the prototype worked better than the previous one and finding out which areas could be improved for later versions of the peanut sheller.

However, due to lack of funding, a separator couldn't be built and the second prototype of the peanut sheller wasn't built to the actual specifications needed for comparison with other current products.

Current Work

As stated earlier, the first and second prototypes of the machine has been built. The first one used a lot of pre-fabricated parts such as a bike wheel with a tire and bearings and axles from a bicycle. It was thought that this design was impractical for the final product due to the complexity of the bicycle tire. However, the first prototype served the purpose of showing that the concept worked and it was a good one.

For the second incarnation of the peanut sheller, a hand crank was added to the wheel, and instead of using a bicycle wheel, a solid piece of high density particle board was used for the wheel. The new design also worked on making the prototype more modular by allowing the user to change the wheel height and the angle of the peanut channel.

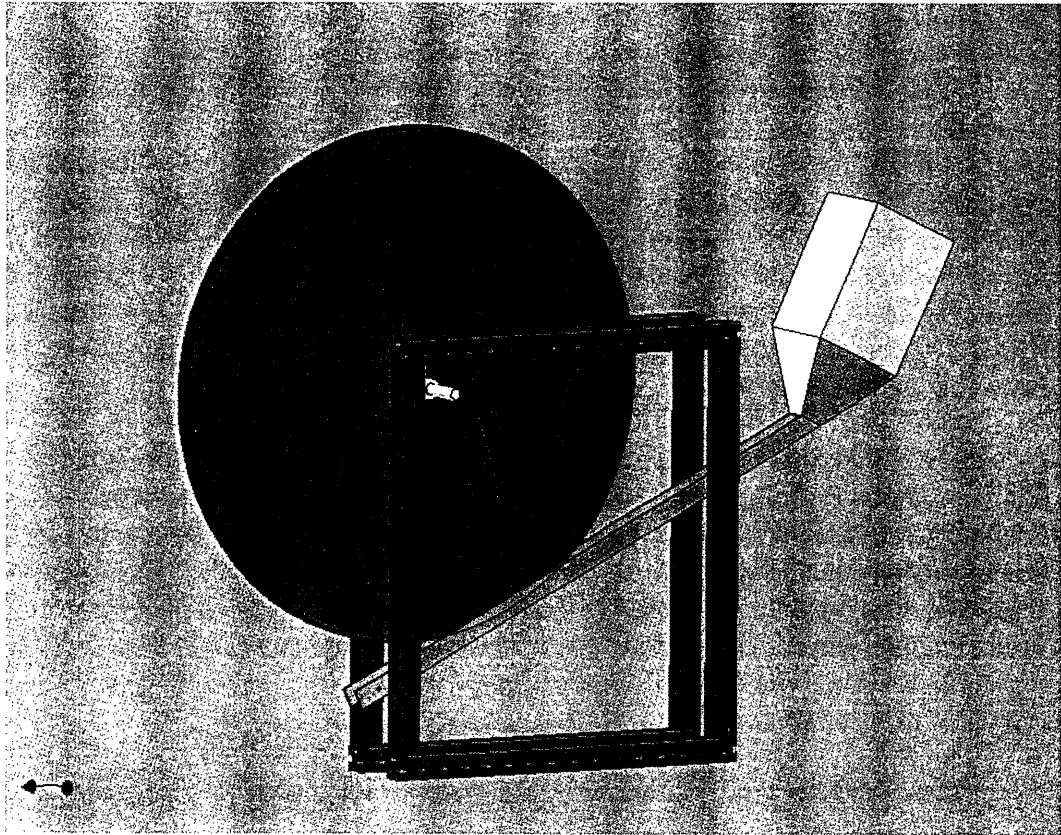


Figure 5 — 3D model of peanut sheller prototype

As evident from Figure 5, which is a complete 3D model of each part of the new prototype, designed in AutoDesk Inventor, the second prototype of the peanut sheller is much simpler and modular than the first one. Tests have been done, and the concept still works. More funding will be needed however to have the final prototype ready and in the scope of the thesis, the concept of the peanut sheller works. The peanut-shell separator however is still in the design phase again due to lack of funding.

Implementation Plan

The general implementation plan was explained in the previous section. Between successive prototypes, extensive studies will be done for the current prototype session. The first prototype was tested during the demo session in 2.009 with dried, salted Planter peanuts to test out whether the concept of the peanut sheller was sound. It was found that the concept work to expectation. The second version of the prototype was tested for the IDEAS competition using sun-dried peanuts brought back from Haiti by the members of the Haiti Class (Edgerton Center Special Seminar) who traveled there during last January (IAP). The second prototype also worked as planned and future designs are considered for a better final product.

The final product once finished, will hopefully be taken to Haiti for field testing and validations from the peanut farmers. During this time, an investigation will be done for both the functionality of the peanut sheller and the cultural acceptance of the people there to the product. Thanks to Amy Smith from Edgerton Center, there are a lot of contacts with people in Haiti mostly Peace Corps volunteers and local members of peanut growing cooperatives. So, in other words, the peanut sheller already has a suitable group of people willing to work with it so that the goal of helping people in underdeveloped regions can be achieved.

The field tests will hopefully be followed by an analysis of the findings and a thorough design review of the things that were acquired.

Challenges

A few challenges were met during the whole design process. The biggest challenge was monetary and as stated a couple of times before, the lack of funding the peanut sheller resulted in a less than specified prototype. More funding will be needed to develop a final product that hopefully will achieve its goals in helping others. The peanut sheller also has to work within strict cost requirements in order to make it worthwhile for the peanut farmers who will be using it.

The next challenge was cultural limitations. Due to cultural limitations, the more efficient way to harness the human energy was loss in the design process. Because of difference in culture, the design of the peanut sheller has to be in context with whom and what it is working for to develop a final product that they will want to have.

The final challenge is the technological barrier which is what the peanut sheller is trying to breach. The peanut sheller will have to be built using materials and manufacturing practices that are readily available in even the poorest and most rural communities. As an example, right now in the second prototype, the peanut sheller uses bearings or some kind of bearing surface at the point where the wheel axle touches the stand. Bearings might not be easily accessible wherever the peanut sheller might end up at, and it will probably require some creativity to develop a cost-effective and simple solution to the problem.

Support Network

As stated in the implementation section, one of the primary on-site contact points will be Peace Corps volunteers in the field. With the help of the Peace Corps workers, the peanut sheller will be introduced to the villages where peanuts are the main crop. Below is a list of the contacts that will enable the peanut sheller to reach the people it's trying to help.

Name	Email	Position	Experience
Donna Perry	donna.perry@yale.edu	Fellow in Agrarian Studies at Yale University	Experience working with peanut farmers in Senegal (5 years of field experience as a Peace Corps volunteer and anthropologist in West Africa).
Dan Broockmann	broockmann@yahoo.com	Peace Corps volunteer in Mayisad, Haiti	Extensive Peace Corps contacts in Haiti
Jessica Hsu	kjesshsu@yahoo.com	Peace Corps volunteer in Haiti	Affiliated with an organic peanut butter cooperative in Haiti
John M. Staatz	staat@msu.edu	Professor of Agricultural Economics	Expertise on agricultural policy in West Africa

Table 1. Our primary community and advisory contacts.

Future Work

The ultimate goal is to enable mass manufacturing of the peanut sheller in Haiti. Thanks to the Haiti Class, relations have been established with several engineers at an atelier (workshop-mass assembly plant) in Haiti. Similar relations could also be pursued near field locations in West Africa.

The peanut sheller will hopefully be finished with proper funding some time in the future, and hopefully will be manufactured using the schematics provided. The costs of the peanut sheller might be significantly reduced if it can be mass produced in factories according to the plans that will be provided to them. This is necessary part of development because if the manufacturing process is not facilitated, the peanut sheller might not travel beyond the short range of highly skilled manufacturing environments with complex tools and training.

There were also plans of trying to fit the whole peanut sheller into the frame of a bicycle which will make it more stable for use. Whether or not the plans will proceed depends on time and whether proper funding will be received for the project.

Community Impact/Conclusion

The peanut sheller would initially be tested in several pilot projects with various households. The immediate impact of the peanut sheller would be as a technological novelty. The peanut sheller would spur the minds of young engineers and would stimulate basic technological innovation in the rural community. This is one of the benefits of the development of intermediate technologies.

One salient case of the success of basic peanut processing technologies can be found in the case of women's cooperative in the village of Dan Issa, Niger. An African Development Foundation grant and technical assistance enabled the cooperative to purchase peanut shelling, oil pressing, and grilling equipment. During a 10 week period in 1999, the women's cooperative was able to process three tons of peanuts into \$2000 worth of peanut oil.

The peanut sheller, with sufficient market penetration, would offer a substantial increase in shelling efficiency. Most shelling is done by hand in peanut-producing regions of the developing world. This type of task is usually done by women. Savings in time could be translated to increased time for other agricultural tasks, but also for schooling or small business development. One potential drawback is that there may be initial cultural barriers to usage of the machine

The low-cost peanut sheller is a classic case of an intermediate technology. Ultimately, it could significantly reduce peanut processing time for rural women and children, opening up time for other tasks. It presents an opportunity for entrepreneurs to develop and improve the peanut sheller for business purposes. And it is another step in technological progress and agricultural innovation for many parts of developing world.

Hopefully, in the future, with sufficient funding, the final product of the peanut sheller will be produced. Currently, the concept of the peanut sheller works perfectly, however the concept of the separator was never tested to see whether it works. The peanut sheller is an excellent idea that will help improve the standard of living of a lot of people in the underdeveloped regions of the world. It will also help to increase the technology standards so that more advanced technologies could be brought in to help these people. Finally, it will also help increase the educational standards of the children in these parts of the world because they will have more time and money to go to school instead of trying to help their family make ends meet.

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ThinkCycle site: http://www.thinkcycle.org/tc-space/tSPACE?tSPACE_id=41963

“World Peanut Market: An Overview of the Past 30 Years” by C.L. Revoredo and S. M. Fletcher, University of Georgia Research Bulletin, Number 437, May 2002.

Video of working prototype:

http://web.mit.edu/2.009/www/project_results/sketch_models/GreenA/GreenA1.html

Prior Art photographs

<http://web.mit.edu/yipal/Public/peanut>

Dan Issa women’s’ cooperative

<http://www.adf.gov/danissa.html>

Thailand’s Rubber Tire Peanut Sheller

www.idrc.ca/library/document/060359/chap5_e.html#chap5.1 and
www.idrc.ca/library/document/060359/.

“Low Cost Peanut Sheller” by Rafiq H Mohd Ramli, Will Delhagen, Shaheer Hussam, Alexander Yip, MIT, April 2003

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Appendices

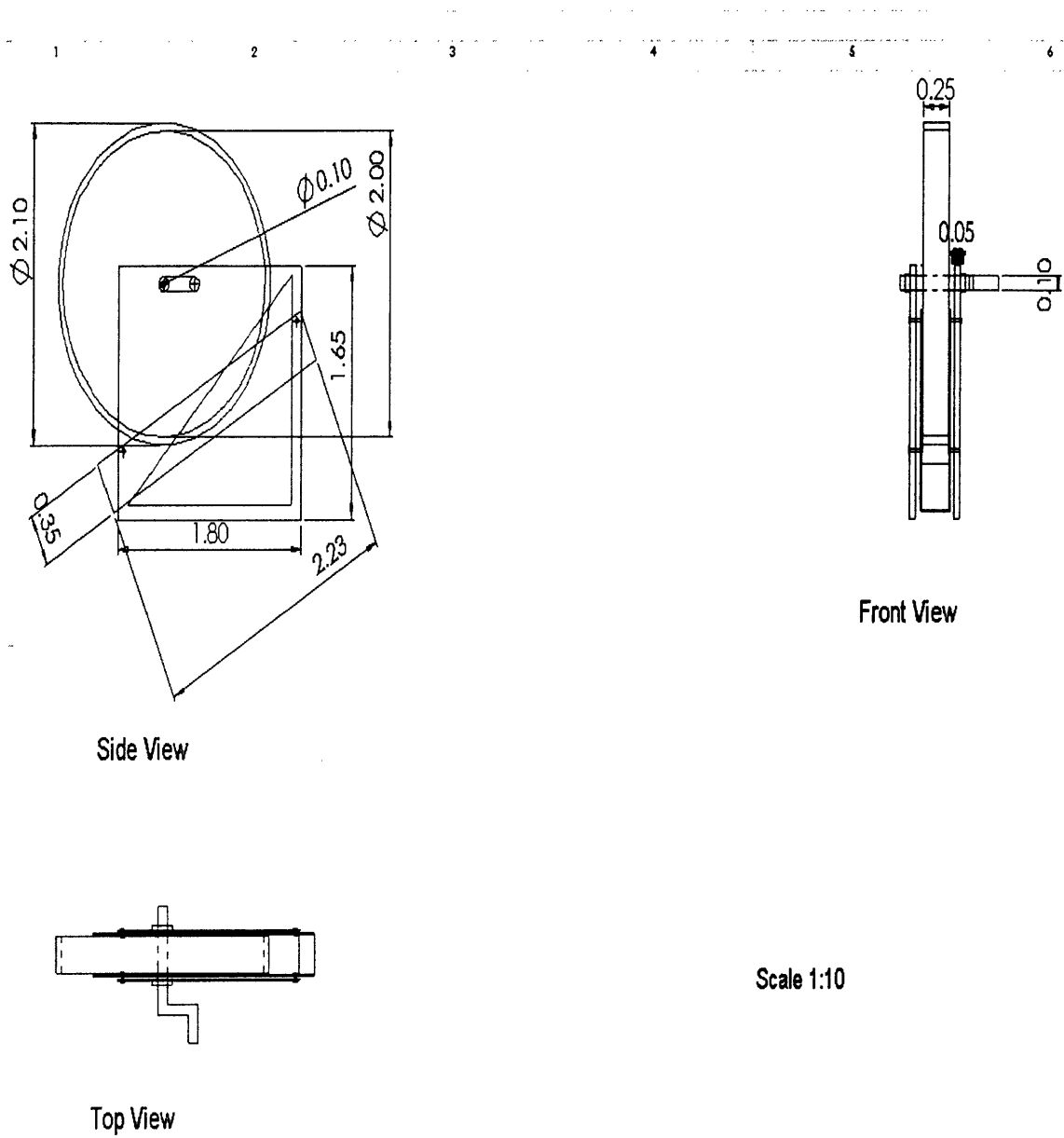


Figure 6: Schematic of Sheller

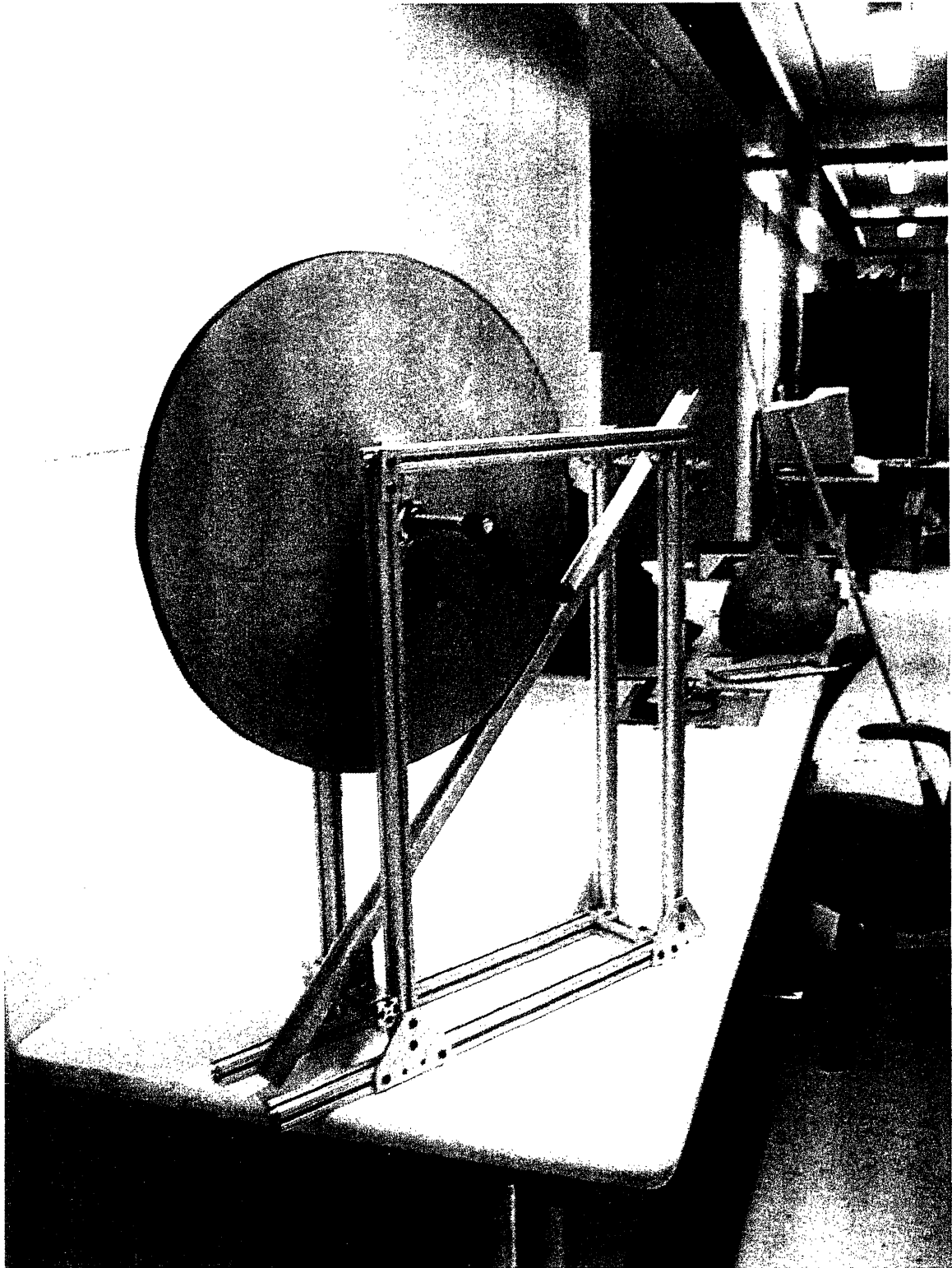


Figure 8: Actual Picture of Second Prototype