CHARCOAL MAKING PROCESS

INTRODUCTION

Sustainable charcoal as an alternative to wood fuel can have a significant contribution to the reduction of deforestation. As opposed to felling trees, the use of dry agricultural waste as a source of fuel can have a positive environmental impact.

The waste is carbonized using a simple kiln and then crushed and held together with a binder and formed into briquettes. These briquettes are a more efficient and eco-friendly alternative

With the task at hand; to improve the charcoal making process, we formed our problem statement – Design a low-cost kiln using locally available materials to improve the burning process of dry agricultural waste to produce charcoal.

CONTEXT AND SITUATION

In order to contribute to the reduction in deforestation, the improved charcoal process needs to be a low-cost, time-saving technique that produces the high yield of good quality charcoal using locally available material to ensure this technology is appropriate.

The challenges commonly experienced and that we faced were:

- Choice of materials to use
- Kiln design
- Methodology of the burn
- Scalability of briquetting

The kiln design being a crucial component in ensuring the best charcoal production possible was our main focus and the briquette press was also an addition challenge we took on.

Use of a 210 liter steel oil drum as a kiln is mainly used in this form of sustainable charcoal production. However, in Kamphelo, these drums are not available even at the nearby Petauke market. The team in collaboration with the community members decided to make a brick-mud kiln instead. Bricks are made within the community. This also enabled us to make our kiln design.

The prototyping and experimentation phase was done using 60 liter steel drums.

The square, tapered shape we finally chose was due to a number of reasons. The tapering to direct the smoke up and a chimney could also be put in place to direct the smoke even higher. The square shape was settled upon after noticing the difficulty in plastering the round kiln the community's headsman had made after our first visit. The one-sided opening to allow wind and air flow into the kiln was put on the most windy side. The slits at the base of the kiln allowed air flow into the kiln and through the cobs for carbonation.

Figure 1) Final kiln (left) designed and constructed by team and community members

Figure 2) Internal base of the kiln to allow air flow in for carbonation.

The only advantage the original oil drum kiln has over this brick-mud kiln is portability. But the brick kiln produced twice as much charcoal as the oil drum.

SOLUTIONS

After introducing this technique to the community and conducting several burns in the mild steel oil drum, one major concern resonated with all the members. The mild steel oil drum was not available in the community. They also mentioned that it would be too expensive if made available. It was then necessary to identify the raw materials available in the village that could be used as an alternative. This formed our problem statement – design a low cost kiln using locally available materials to improve the burning process of dry agricultural waste to produce charcoal.

Figure 3) Tapered shape brick kiln

Bricks were the obvious choice as they were readily available and affordable. The next step was to brainstorm on several designs for the brick kiln. The three major design features we focused on were the shape of the kiln, the base and the air inlet. We collaboratively tried out different designs during sketch modeling sessions.

The shape of the kiln had to effect efficient burning. In between visits to the village, the community constructed a cylindrical kiln with air spaces around the base, where a door had also been designed. The team considered a cylindrical kiln but its construction would be complicated and since we intended to use clay as a plaster to hold the bricks together, it would lead to several air spaces on the surface. A square and a tapered shape were then considered as either would be easier to construct. We settled on the tapered shape as it would direct the smoke emitted during the burn much higher than the square shaped design.

Figure 4) Side view of brick kiln showing air inlets at the base

For the base and the air inlets, it was necessary to have a design that allowed enough air to enter the kiln and also enable air supply to be cut off with ease during carbonization. The cylindrical kiln the members of Kamphelo had constructed did not allow much air to enter the kiln and hence resulted in several unburnt cobs.

Figure 5) Aerial view of the slits on the bas during construction

We then settled on a design that directed airflow through the base support structure of the kiln, where air would get to the maize cobs from the bottom through several slits at the base and reach the top layers of the cobs. The base of the kiln was therefore raised with four brick-sized openings supporting the kiln which would take a short time to seal when necessary.

THE TECHNOLOGY

The brick-mud kiln was designed to carbonize biomass (agricultural waste) such as maize cobs and husks, grass and banana peels.

The construction of the kiln should be in an open space where there is free air flow and the smoke produced form the carbonization process can escape. The bricks are laid out forming a square, tapered structure.

The dimensions of the final design built were 112cm by 96cm, length and width respectively. Its capacity was 32kg of un-carbonized cobs and husks. About 270 bricks were used in this design which took approximately three and a half hours to build.

Mud is used to plaster the bricks together and as a final coating to seal any cracks. It takes 6-8 hours to dry completely before any burn can conducted.

Figure 6) Mud-plastered kiln to prevent air flow through the cracks between the layered bricks during carbonation

The cobs and husks are filled into the kiln in alternating layers without too much compression so as to ensure good flow of air within the material during the burn. This material is lit through the door and the bricks are placed vertically in this space to close it and plastered with mud once the biomass has ignited.

The slits at the base of the kiln allow air supply into the kiln for carbonization. As the biomass is carbonizing, smoke is produced and escapes through the top outlet. This smoke consists of carbon gases and water vapour. It progressively changes colour from dark-grey smoke to white-yellow to a more translucent hue. A flame is then seen through this outlet and this is a sign that the carbonization process for the production of coal is almost complete and the air supply inlet at the bottom-side of the kiln is then shut with bricks and sealed with mud and the outlet is shut too with a metal sheet and sealed to cut off air supply so that the coal does not turn into ash.

The timings for the above process was determined through observation, experimentally and using some of our experience from the prototyping stage too.

Table 1 Weights of agricultural waste and subsequent charcoal yield

	Cobs		Husks		Coal	
	Kg	**%**	**Kg**	**%**	**Kg**	**%**
Burn 1	29.5	92.2	2.5	7.8	5.5	17.1
Burn 2	26.5	89.9	3.0	10.1	16.5	55.9
Burn 3	34.5	88.5	4.5	11.5	N/A	N/A

VENTURE DESIGN

To enable the continuation of the project as a sustainable venture, the team identified and discussed various aspects of a start-up that could lead to the commercialization of the charcoal making process using agricultural waste. For this purpose, we used the business model canvas.

The Business Model Canvas

This model is designed to put into account the different areas that should be explored when starting a business. This then makes iteration much more purposeful with a holistic view of the venture.

Key Partners	Key Activities	Value Proposition	Customer Relationships	Customer Segments
Maize farmers CBO : Community co-operative – Salani Mutonzhye NGO : T.R.C.D.A	Develop a collection system and storage of maize cobs Design and construction of kilns and charcoal presses	Entire process takes a few hours as opposed to months Use of maize cobs which would otherwise be of no value Charcoal	**Co-creation** Develop a feedback mechanism on quality of briquettes **Communities** Provide a sustainable venture	Mass market – Individuals using charcoal Niche market – those who prefer to use environment friendly and ‘green’ products

Forestry Department Charcoal Farmers	Establish appropriate price point for briquettes Packaging and distribution of product Information dissemination on the technique	briquettes provide a more efficient burn Smoke emission is nearly eliminated		
	Key Resources Human resources providing labour and training and capacity building Initial capital Agricultural waste: maize cobs and husks Storage space for maize cobs Transport of cobs to burn site and briquette to market Location for kiln set-up and burns		**Channels** Deploy a sales force in Petauke markets Stock product in local supermarkets through the CBO and NGO Home delivery system in nearby communities	

Cost Structure	Revenue Streams
Initial start-up costs Fixed costs : rent for storage space	Asset sale : Briquettes Volume dependent: weight per bag Training and capacity building

CONTINUING WORKS AND NEXT STEPS

Moving forward, we would like to hand the project over to a local non-government organization located within Petauke – Titukuke Rural Community Development Association (T.R.C.D.A). The NGO focuses on alleviation of poverty and would serve as the community's resource centre for further information and guidance for the continued success in the project.

The following outline further research needed to address the problem statement adequately:

Improvements to the kiln design

Cobs further away from the airway tend to burn at a faster rate than those much closer. We looked into widening the slits on the base closer to the airway and narrowing those further away so as to reduce the amount of air getting to the back. This design however, caused the cobs closer to the airway to burn much faster than those at the back. Further prototyping is therefore necessary.

Improvement on the process

Pre-drying the agricultural waste, in this case maize cobs, should be conducted to determine whether a more efficient burn can be obtained with less smoke emission. Other waste should be tested in the brick kiln as well and a comparative analysis carried out to identify which yields more charcoal.

With the great amount of smoke produced and expelled to the atmosphere during the initial stages of burning the cobs, it is necessary to investigate the properties of the smoke.

Binder

As an alternative to cassava porridge, the community identified a root that has similar viscosity to the cassava porridge. The ***mtumbetumbe*** root, commonly known as ***mwaniya***, is crushed to expose the root fibres then placed in a container of water whose amount depends on the size of the root used. It is then stirred around the water until the water becomes viscous.

Clear ratios of root size to amount of water could be investigated. The scientific name of the root is still yet to be identified and it's availability in other parts of the world is unknown. More research could be done on this

Deforestation

The traditional method of making charcoal that includes felling trees leads to deforestation. The rate at which deforestation takes place over a certain period of time is unknown to the team. This could be followed up by the forest department which could also support the community.

Agricultural waste availability

Information on the amount of agricultural waste produced during the season would enable charcoal makers to plan accordingly depending on the availability. This helps to determine the sustainability of a possible business venture of making charcoal as it helps to attain projected amounts of charcoal that could be produced over the season.

Dissemination of information

This technique was well accepted and adopted by members of Kamphelo village. The information, however, was limited to Kamphelo and only a few surrounding communities. The team struggled with coming up with appropriate and efficient methods of disseminating information on the process, kiln design, limitations and other relevant information to other areas across Zambia.