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ESTABLISHMENT OF CERAMIC JIKO LINER PRODUCTION AT ILESI POTTERY, KAKAMEGA, KENYA

To:

Energy/Development International

By: Laurie Childers

Aprovecho Institute
80574 Hazelton Road
Cottage Grove, Oregon 97424
USA

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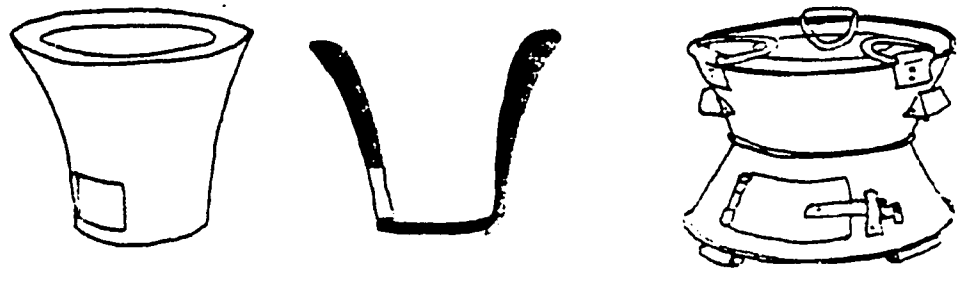
I. STANDARIZATION OF PRODUCTION PROCEDURE AND QUALITY CONTROL OF CERAMIC LINERS

I. STANDARDIZATION OF PRODUCTION PROCEDURE AND QUALITY CONTROL OF CERAMIC LINERS

A. Background: Product Design and Quality Standards

The consultant was requested to focus on the production of the moulded ceramic liner (Figures 1a and 1b) which is inserted into a metal cladding, sealed and insulated with cement and diatomite, in the production of improved "jiko" cookstoves (Figure 1c). Liners of acceptable quality have no vertical cracks in the walls, and are symmetrical in thickness: one-third to one- half inch thick at the bottom and one inch thick at the top. Cracks in the liner floor are insignificant. Walls near the top should be smooth to reduce permeability, should water spill on them during use. The cut door is 4" wide and 2" high.



Figures: 1a Ceramic Liner; 1b Cross-section; 1c Ceramic-lined Jiko

B. Clay Preparation

1. Clay Ingredients

The first step in clay preparation at the Ilesi site is the acquisition of four different soils to be mixed together to form what is called the "clay body." Mixing clays is a traditional custom amongst the Abaluhya potters in the area; they know the pots will crack if they don't mix them. Proper mixing combines the properties of each clay. One clay

may be very plastic but will shrink too much, another is too "short" (non-plastic) to be used alone but has minimal shrinkage; the combination will produce a clay body that is plastic enough to mould and yet does not shrink excessively. Dry binding strength, hardness after firing to 900 C, and thermal shock resistance are additional qualities necessary for a clay body for the ceramic jiko liners.

The first clay ingredient in the Ilesi pottery clay is a dark grey highly plastic clay. It has fine particles in it which enable the clay body to be stretched and formed without cracking while wet, and gives dry clay strength as well. It is dug from a site one mile from the workshop on land owned by Charles Musa, the leader of the Ilesi Pottery Group. The cost for labor to dig and carry this clay to Ilesi is Ksh 5 per headload (Ksh .33 per liner). As the labor is often difficult to arrange on demand, mixing clay is often delayed and potential production is reduced due to an insufficient supply of clay. A recommended alternative is to hire a truck to transport a full load of clay to Ilesi, and store it covered in a pit. A truck can be hired locally for Ksh 40, and the labor to dig a truckload costs Ksh 30. This amount will supply the dark clay for 150 liners. Cost per liner is Ksh .20.

The second clay ingredient is a light-colored kaolinitic clay found on the same plot as the workshop. This clay gives the pots and liners hardness after firing and helps to reduce the shrinkage as it has larger clay particles. It is dug and carried to the mixing site just prior to mixing, and costs for digging labor are included in the mixing costs.

The third clay body ingredient is a decomposing granitic sandy soil, also found on the same plot as the workshop. The addition of this soil opens the clay body, reducing shrinkage, warpage, and allows for the even and rapid drying of the liners. It is also dug and carried to the mixing site just prior to mixing, and these labor costs are likewise combined. Both soils had been carried by headload up the hill, but recently a wheelbarrow has been used and this is more efficient in time and labor.

The fourth soil is purchased nearby. It is the red clay from termite mounds, and is acquired in dry lumps. According to the potters, the addition of termite mound clay allows the newly made wet pots to dry in the sun immediately without cracking. This is possible because the clay has a significant amount of organic matter deposited by the termites, that likely adds both porosity and binding qualities. However, it would be essential that the dry termite clay be finely powdered before adding, and the clay allowed to age properly. (The consultant's observations during the three-week period were that the dry clay was not sufficiently powdered and wet pots did crack when placed in the sun.) A half-wheelbarrow full of termite clay is purchased for Ksh 50, and will last for 3-4 batches. At an average cost of Ksh 14 per batch, the cost is Ksh .46 per liner.

Three people can dig the white clay and the sandy soil and mix two batches in one day. They are paid a total of Ksh 30. Each batch of clay is enough for 30 liners. The mixing costs per liner are then Ksh .50.

Thus, the clay costs per liner are as follows:

Labor, digging grey clay	.20
Transport of grey clay by truck	.27
Labor, digging white clay and sand, and mixing clays	.50
Purchase termite mound clay	.46
Total Ksh =	1.43

Someone with experience is required to control the addition of sand and assure thorough mixing. The mixing labor is unskilled. Tools required are a heavy pounding stick and a shovel.

2. Mixing Formula and Procedure

Precisely weighing dry clay is the most scientifically accurate way to measure for consistent clay mixes. (Even this method fails at times because clay sources are not homogeneous throughout.) Acquiring dry powder is extremely impractical for the Ilesi Pottery Group as clays are dug wet. A considerable amount of time, labor, and expensive equipment would be required to change methods.

For each batch, a level wheelbarrow, filled to the brim, is used for a 2-part measure, and a half-full wheelbarrow used for a 1-part measure. The recipe is a follows:

- 1 part decomposing granitic sand;
- 2 parts dark grey plastic clay;
- 2 parts white kaolinitic clay;
- 1/20 part or more finely powdered termite mound clay; and
- 2 liters of water.

The mixing procedure is to start with half the portion of sand, spread out on the mixing surface. Then, the entire portion of the dark grey clay is laid on top. Most of the other portion of sand is tossed onto the grey clay, withholding about 10 liters of sand. The grey clay and sand are pounded together with the heavy pounding sticks. The white clay is then placed on top of the mixture. The finely powdered termite mound clay is tossed evenly on top of this, and the water added as well. Clay is pounded with sticks, and then shoveled into a heap. This motion is repeated. Then the clay is mixed well with the feet until there are no streaks of clay colors and the sand is evenly distributed. The clay must be checked by an experienced potter who may recommend that some of the sand that was withheld be added during the final mixing.

Clay for moulding liners must have a slightly higher water content than clay for making coil pots. At least a week is recommended between mixing and moulding the clay. It should be kept covered with plastic and moistened if needed while aging. Aging allows the moisture to disperse evenly between clay particles, greatly increasing plasticity.

It is very easy to add too much sand to the clay, and it takes a lot of experience to know the right amount. The clay is tested by the most experienced potter, who knows by feel how much sand the clay requires. Because the wet measuring system is not highly accurate, this is probably the best method for consistency and quality control.

3. Clay Mixing: Observations and Recommendations

a. Usually there is not enough clay on site for continuous production. This is due to the need to arrange for and transport the dark grey plastic clay in small amounts at a time. This wastes time and money and limits the amount of mixed clay available, thus delaying or diminishing production, and likely causing clay to be used before it is aged properly. The consultant's recommendation, and the wishes of the potter, are to fill the large pit (made by digging clay for the workshop walls) with a large supply of grey plastic clay brought by truck.

b. The laborers who dug the grey clay are too tired to mix immediately, so work is delayed. The consultant recommends that enough grey clay be stored in advance, or to have different laborers mix.

c. Mixing is delayed when all the ingredients are not on site at the time mixing begins. The first ingredients receive the best attention while the ingredients added last, the white and the termite mound clays, often do not get mixed in well enough. The consultant recommends that the digging of all ingredients be coordinated so that all four soils are present when mixing begins.

d. Lack of a proper mixing surface causes several problems. The large granite stone near the potter's house that is used for mixing has a good hard surface, but the rounded edges of the stone slow down mixing and make it unnecessarily difficult as care must be taken with the edges of the clay mass. The clay spreads out as it is pounded and mixed with the feet, and chunks of clay and loose sand drop off the edge and must either be retrieved or are lost. What is lost may only insignificantly affect the proportions of the ingredients, but will increase the time and work involved in mixing and waste the raw materials that had to be transported.

An experimental solution, not yet built due to lack of available funds, is to dig a shallow pit, 6 to 10 inches deep, and line it with reinforced concrete. The consultant recommends a size that will accommodate up to two batches, in a square or circular shape. With a

mixing pit, instructions for adding sand can be more specific, but when clay is mixed on the rock, an unmeasurable and inconsistent amount is lost off the sides which needs to be replaced.

e. The consultant found that the clay body was rarely, if ever, mixed well at this stage. It is more work-efficient to mix at this stage than to require the wedger to mix it by hand, and it is the only time that the potters can assure an even distribution of sand and clays. When clay is not thoroughly mixed, it is impossible to mould a liner with even walls without much extra attention and work. In addition, cracks in the dry or fired liner are most likely to occur at the interface of clays that have different shrinkage rates and percentages.

4. Weighing, Wedging, and Rolling: Final Preparation for Moulding

Potters in western Kenya traditionally make coil pots: products made with long rope-like pieces of clay which are joined together. In the traditional method of making coils the potter grabs a handful of clay from the heap and squeezes it with both hands, then folds the clay and repeats the squeezing and folding motion several times. This assures that the clay is mixed well. Then, a coil is rolled between the hands, which compresses the clay and removes air pockets. This is a suitable method for coil pots especially where there is no suitable surface to wedge the clay on.

However, the 5.5 to 6 kg roll of clay required for producing liners is much too large to prepare in this way, and homogeneity and elimination of air pockets is very important.

Final preparation for moulding the liners involves two steps. First, weighing the 5.5/6 kg balls of clay. Secondly, wedging the weighed clay.

5. Wedging Process: Two Methods

The process called wedging eliminates air bubbles and thoroughly mixes a ball of clay. Additionally, it aligns the clay particles around the

center of the ball of clay, enabling it to be opened from the center with maximum binding strength in the walls.

a. Oriental Spiral Method

Begin with a ball of clay of the desired weight on a table or other hard surface that does not bind to the clay.

(1) Place one hand in the lower position. It will do most of the pushing. Try each hand in this position to find which is most comfortable. (Figure 2a. If the left hand is lower, the clay will be turning clockwise, contrary to these illustrations.) The main function of the top hand is to pull and lift the ball of clay towards oneself, and help pivot the ball of clay after each push.

Figure 2a Starting Position

(2) The top hand pulls the clay up onto its bottom point (bringing the back up high) and with the bottom hand for support, twists/pivots the ball (Figure 2b).

Figure 2b

(3) The bottom hand is placed on top in front, between the other hand and the body. It then pushes down and twists the clay counterclockwise. (Figure 2c. If the hands are reversed, twist clockwise.) The top hand pushes somewhat in the same direction; it is mainly for support. This flattens the previous bottom point and creates a new one.

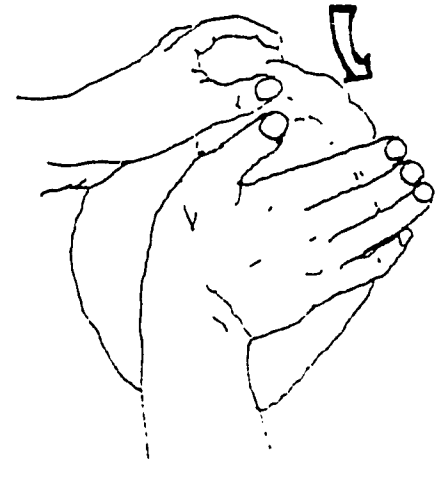


Figure 2c

This cycle is repeated until the outside edge shows no cracks and the clay feels homogeneous.

(4) With this process, the clay is moved in an inward spiral motion. The outside is stretched (removing air bubbles) and compressed by the push, travelling around and up and then inside the ball of clay (Figure 2d).

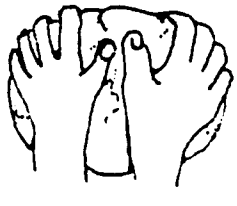
Figure 2d

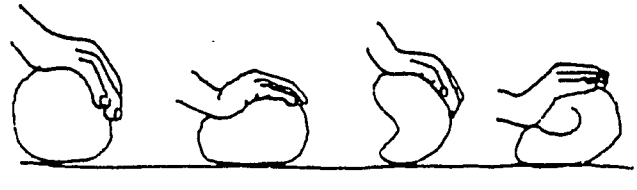
b. Kneading Method

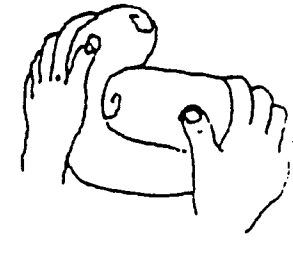
An alternative method of wedging is to roll the clay in on itself symmetrically, very similar to common bread dough kneading methods.

The fingertips pull the clay towards the body and up from the back (Figures 3a and 3b). Then the heel of the hand pushes it down (Figure 3c). This motion is repeated (Figures 3d and 3e), with the hands moving outward as necessary, until the roll of clay is too small.

Figures:







3a - Top View Starting Position

3b 3c 3d 3e Side Views

3f - Top Side View

It is then folded on itself (Figure 3f), patted smooth, and the kneading is repeated.

This method is easier to learn for most people, but slightly slower and slightly less effective than using the spiral motion.

6. Wedging at Ilesi

In order to accommodate proper clay preparation at Ilesi, a wedging table was constructed. The table top is made of poles layered with gravel and then surfaced with a smooth cement top. A balance scale, with 6 kg of sand in one of the buckets, hangs at the back of the table on the side nearest the storage pile (Figure 4). The scale needs only be used for measuring the first roll of the day. After this the wedger should be able to make similar sized rolls by sight, without taking the extra time required to use the scale. The scale can easily be removed and placed under the table for storage to free more room on the table.

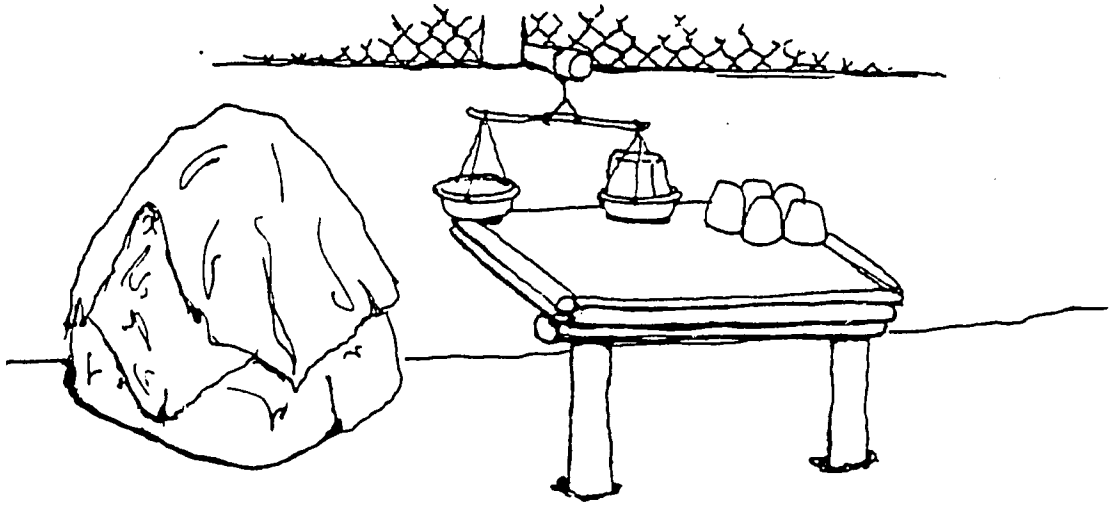


Figure 4. Stored Clay, Wedging Table, and Scale.

It takes about two minutes to size and weigh a roll for each liner. A new apprentice, wedging for the first time, was able to size and roll at about the same speed and careful moulding, 6-7 minutes. This will speed up

as he feels more comfortable with the technique. The major inefficiency observed by the consultant was a tendency to wedge a bit and then weigh, repeating this until a full 6 kg was measured, but then the full amount must be wedged together anyway. Also, if clay is well mixed in the initial mixing with feet, the work in the wedging stage is greatly reduced.

7. Procedures Recommended

a. The big heaps of stored clay must be kept damp and not allowed to dry on the surface. The heap must be covered with plastic, or covered with banana leaves and moistened daily.

b. Big chunks of clay are cut off the heap with metal discs as the pottery has been using. (A wire with wooden handles would also work.) This clay is placed on the wedging table.

c. A 6 kg (or 5.5 kg if the smaller mould is used) ball of clay is weighed on the scale, then wedged and set on the table. It can now be used as a comparative example.

d. The cut clay is then distributed into 5.5/6 kg balls.

e. The balls are wedged.

f. Rolled into ram's head shapes, they can be stacked on each other on the far end of the table, for easy access for the moulders.

Weighing and wedging can be done first thing in the morning. A half hour's head start before the moulder begins working will keep a steady supply of rolls of clay ready to mould throughout the day.

C. Moulding the Liners

The liners for the jiko are formed inside a one-piece mould. The mould for full liners are made of either wood, concrete, or ceramic, with wooden moulds being the most durable and easiest to use.

The highest skill level required in the liner production process is moulding.

1. Procedure

a. The slightly damp mould should first be coated with ashes.

b. A weighed 5.5/6 kg roll of wedged clay is thrown inside the mould.

c. The clay is opened with the fist then drawn up the walls of the mould, using the hand as a scoop.

d. The top is then compressed with the hands.

e. The floor and walls are compressed with swipes of the hand and given final shape.

f. The top is cut level with a knife.

g. The mould is carefully turned upside down, placing the liner where it can stiffen for several days before cutting.

2. Moulding: Observations and Recommendations

a. New clay (especially that less than 3 days old) does not bind to itself as well as clay that has been allowed to age. It is liable to come apart during the moulding process and requires more time and effort to achieve an even wall thickness. Clay must be allowed to age at least one week.

b. When rolls of clay are too small, the walls can tear when being raised and/or extra time is spent adding clay on top. This can also produce an inferior liner. Ash from the mould may coat the surfaces where added clay is joined, preventing good adhesion and leaving a weak spot that

may not show up until the liner is used. Clay rolls must be measured carefully.

c. When the rolls of clay are too big, extra time is spent trying to open the bottom and in removing clay. When a full 6 kg roll is used with the smaller mould, the bottoms are usually too thick. Again, clay rolls must be measured carefully.

d. Not enough ash inside the mould, or too much water in the mould walls, or taking too long to form the liner, causes the clay to bind to the mould. This slows removal and/or damages the liner. At the start of the day, the inside of the mould should be sprinkled with water and a generous coat of ashes given to the inside surface. Once moulding has commenced, the moisture from the clay keeps the mould damp. Ashes should always be applied generously.

e. Liners fall or slump upon dumping when they are too thin. The moulders tend then to overcompensate: made sturdily thick, the liners stand. However, the most significant inefficiency in the liner production system stems from making the liners too thick. The time alone involved is not worth it. A liner moulded quickly (and as a result, thick) takes only three to three and a half minutes to mould but between 10 and 20 minutes (depending on who is cutting) to cut the liner down to size. If the moulder adds another three and a half minutes attention during the moulding, thinning and achieving the desired shape, 10-15 minutes is saved during the cutting. For both the apprentice and the consultant, it took seven minutes to mould a good liner and 3 minutes to cut it properly.

In addition, when the over-thick liner is cut down to size, the firmed inside surface is removed, leaving the liner more vulnerable to the pressures of carving and moving. The consultant strongly recommends that enough attention be given during moulding to achieve the desired shape.

f. Backache is a problem when the moulder has to lean over a short table. As body weight is necessary in initially opening the ball of clay thrown into the mould, a standing position is preferred with a table the height of the moulder's hanging fist. The moulder then does not tire as easily and can produce more liners.

Figure 5

The experimental solution attempted by the consultant was to build cement-topped stool tables for moulding (Figure 5). The apprentice reported that it was good to stand, that he no longer gets tired from squatting and standing up repeatedly.

Both the consultant and the apprentice found it helpful to be able to walk around the mould rather than to have to turn it. This was because turning the mould exhausted the supply of ash quickly and the clay would begin to stick to the table. In addition, the clay-filled mould is heavy and tires the arms.

g. Repeated smearing motions in the moulding process, rather than the recommended firm, compressing strokes, takes longer, leaves the liner too thick, and reduces the strength of the finished piece.

h. If ceramic potrests are to be added, the consultant recommends that this be done when the freshly moulded liner is fairly wet. Extra clay could be added in three places on the top of the inside of the liner before dumping and stiffening. Then the potrests are cut to shape when

leatherhard, at the same time the door is cut. This gives maximum strength. Alternatively, if the potrests are added when cutting, it is especially important that the liner be scored (cutting intersecting lines 1 cm deep with a knife or fork) and wet with liquid clay (called "slip" in the language of potters) where the equally stiff clay knobs are to be added. The added clay must also be scored and slipped. This alternative process is more time-consuming and produces a potrest that is more likely to break off during use than if clay is added during the wet moulding period.

D. Drying Procedure

1. Observations (pre-workshop conditions)

Drying at Ilesi Pottery has been rushed because there is not sufficient room to leave the liners inside for 2 days. The liners have been dumped from the mould directly into the sun in the morning, and brought inside just before the afternoon rains. As a result, the thinner bottoms and the outside surface dried quickly, hard and brittle, while the inside and tops remained heavy and wet. The liners are highly subject to cracks by the uneven drying and handling in the early vulnerable stages: as many as three full vertical cracks have appeared the first day. These take several minutes each to repair at the time of cutting, and almost all of them will reappear after further drying or after firing, so it is essential to prevent them.

Moving the liners also requires time (20 minutes for 27 liners), and with limited space, quite a bit of time has been spent reshuffling and restacking drying pieces, increasing opportunity for damage.

When the liners are overdry they are difficult to cut and the process is extremely slow. Much more pressure is required, putting more stress on the liners. The consultant observed that cutting a relatively dry liner took almost twice as long as a leatherhard liner with no dry spots.

2. Recommendations

The moulded liners should be seasoned through two days drying in the shade, without any pressure on the clay. Late in the second day the liner can be turned over, right side up. It can be cut on the third day. Climatic conditions, especially humidity or extreme dryness may affect this timeline slightly. During humid or very rainy periods the liners will require longer periods to dry; during hot dry periods the liners should be covered with plastic or somehow kept damp for 2 days. Slow drying enables the inside of the walls to stiffen at almost the same rate as the surface, so that the entire liner is in a leatherhard state. Leatherhardness is the strongest state of unfired clay: any wetter and it is subject to warpage and deformation, any drier and it is brittle and difficult to repair.

The consultant recommends that after the liners are cut, they be kept inside the workshop the remainder of the third day. After that the liners can be dried in the sun, but it is best to wait until the day prior to firing, giving the liners at least three hours of strong sunlight. It should be noted that dry clay normally reabsorbs moisture during the night. A liner should be ready for firing when, after removing from direct sun for 15 minutes, the thickest parts do not feel cool when pressed against the cheek. (The skin detects moisture by sensing coolness.)

To facilitate maximum production and safety of liners, a system of leatherhard drying shelves was constructed (Figure 6). The boards can pass through from the moulding to the cutting room. Up to 250 liners can be accommodated in a 14' x 5' space, undisturbed and easy to reach.

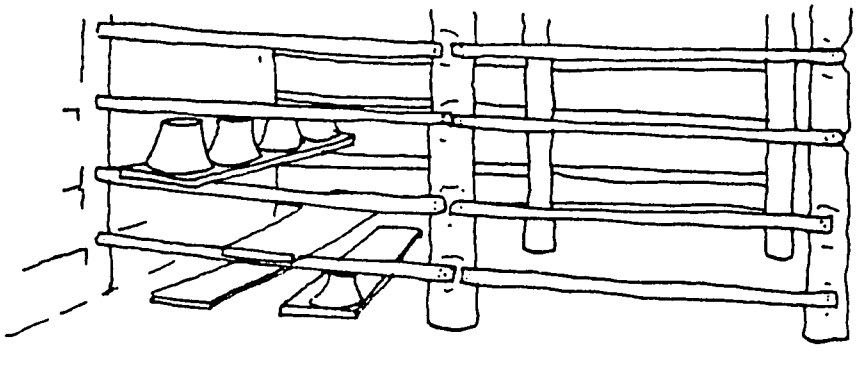


Figure 6. Leatherhard Drying Shelves for Liners

E. Firing Procedure with Improved Kiln

The consultant was requested to construct an improved kiln to increase the fuel efficiency and increase the control and consistency of firing temperature. Because the traditional kiln patterns of stacking pottery and fuel are skillfully done, understood, and well-ingrained, it was the intention of the consultant to alter the firing procedure as little as possible.

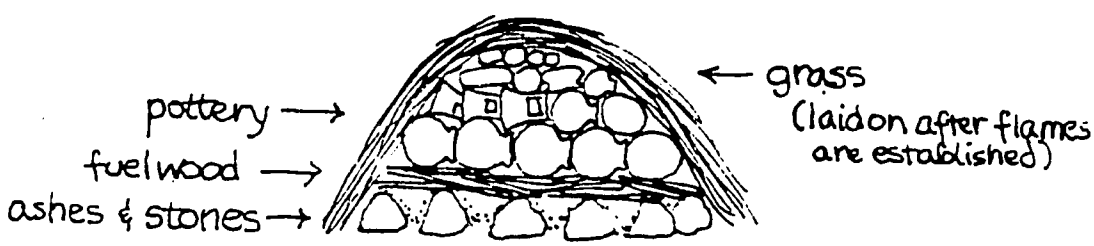


Figure 7. Traditional Abaluhya Open Pottery Kiln

1. Traditional Firing Method

An analysis of the traditional Abaluhya open pottery kiln reveals how it works. The stones placed on the ground serve as a grate, lifting the wood so that air can travel underneath and reach all of the burning wood. A layer of ashes placed on top of the stones serves to help insulate the fire from the heat-absorbing rock. The fuelwood is placed in alternating directions so that air is able to reach as much surface area as possible. Pots are placed on the wood to receive the convective heat of the flames and the radiant heat of the embers. Once flames are established, a layer of green grass is placed over the kiln. When it starts to burn, more green grass covers the flames. The air trapped between the leaves of grass insulates the kiln and forces some convective currents of hot gases around the pots. If the flames were allowed to go straight up and out of the

kiln, they would create a chimney which would overfire pots in the chimney and underfire those outside the hot column of gases. When the wood has burned down to embers, the grass is allowed to burn, releasing a great deal of heat very quickly. This fires the surface of the stack of pottery.

There are several drawbacks to this method of firing ceramics. First, the stones have a high thermal mass that is not fully insulated by the ashes, as they are quite hot at the conclusion of the fire. In addition, they take up space so that a limited volume of air is available for combustion. Layering the pots directly on top of the wood quenches the flames before combustion is complete, reducing the peak flame temperatures. Second, despite the addition of grass, the flames pass too quickly through the stack, preventing heat penetration through the entire thickness of the pot walls. This problem is increased due to the short overall firing time of the kiln. Finally, the radiant heat of the coals only reaches the bottom of the stack of pottery, and the green grass releases moisture that cools the fire. The traditional open kilns attain firing temperatures between 700° C and 900° C. Often all or part of a pot is underfired.

The most significant cause of inefficiency is the frequent need to refire pottery due to using wet wood which resulted in insufficient heat. With the one-charge firing that is done, it is not possible to add more fuel during firing as needed, other than grass on top which can only fire the outside of the pottery stack.

2. Improved Brick Kiln

A brick wall enclosure, with air inlets at the bottom (Figures 8 and 9) was built at Ilesi Pottery Workshop to assure that the pottery liners reach the ideal firing range around 900 C. The wall contains heat and improves draft and combustion. A kiln with a brick ceiling and a conventional chimney can build up pressure and heat, however such kilns require repeated firing experience with the aid of a master to learn to control. They also easily attain temperatures above 900° C, which would

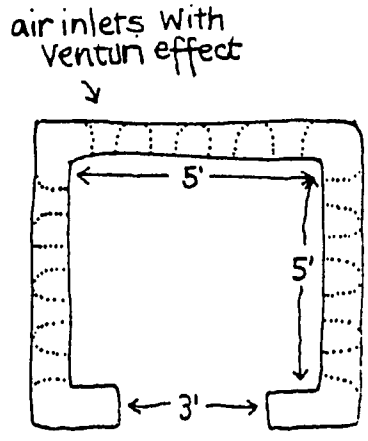


Figure 8. Plan of Brick Kiln

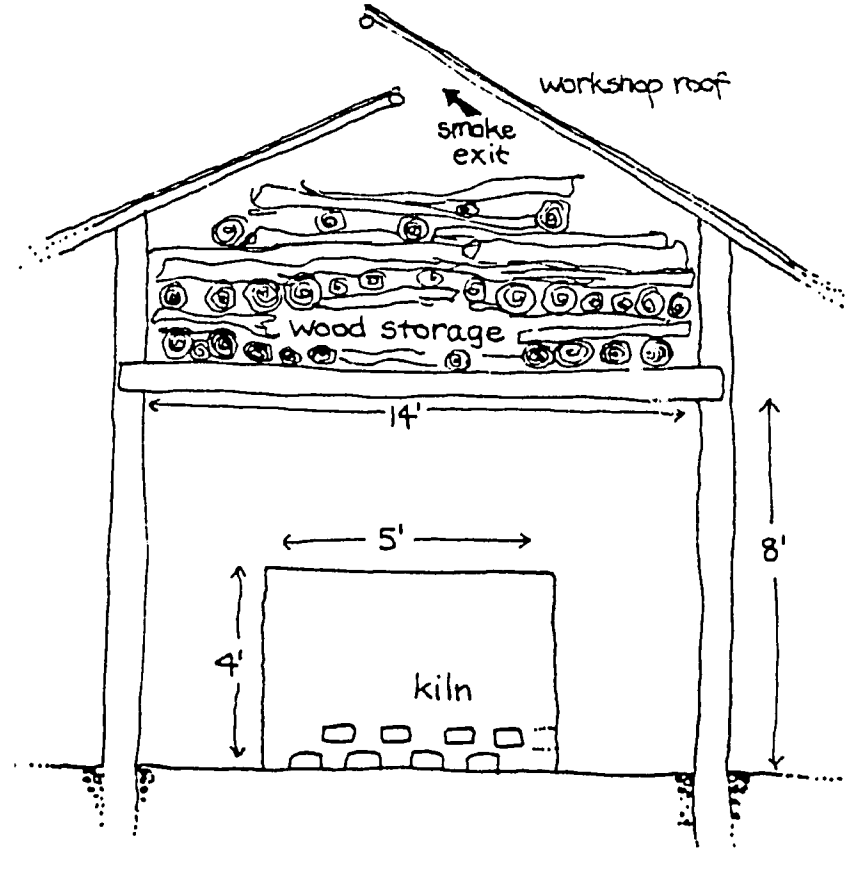


Figure 9. Cross-section of Brick Kiln, Woodstorage Rack, and Chimney Design

be problematic in this application. Over-fired liners are too vitrified and would crack with use.

To alleviate the problem of wet wood, an overhead rack for storing fuelwood was built four feet above the top of the kiln (Figure 9). Wood for succeeding firings is then dried by the kiln's heat and coated with creosote from the voluminous smoke created by the firing process. The wood rack is 14' x 14' wide, and wood can be stacked at least 2' high without structural interference. Surplus wood could also be stacked on top of crossbeams to fill, as needed, most of the triangular space created by the roof.

The green grass cover on the kiln is carbonized, and is not allowed to burn until the very end of the firing. By then most of the pyroligneous gases and tars have been released as smoke, so the final flames are very short in height as well as short-lived. Thus, it presents no danger of igniting the wood stored overhead.

The chimney was designed into the roof structure by means of a gap on one side and an overlap on the side of the prevailing wind and rains. The consultant intended to have this gap span the entire building to assure complete ventilation so that moulding work could continue during firing without the health hazard of smoke in the room. However, the transfer of information to the first building foreman was inadequate and the chimney gap and overlap had to be redesigned. It is only in the centre one-third of the roof now, which will probably be adequate when both the kiln and wood are dry. The cross-draft between the chain-link upper segments of the two long walls provides ventilation when there is wind. On sunny days the draft through the heated roof will be increased.

3. Fuel

With the open kiln method, the potter says he normally uses Ksh 50 worth of wood for a big fire (5-6' diameter). In the first fire in the brick kiln, he put Ksh 70 worth of wood to dry it out, and figured to use half of that for regular firings.

The preferred fuel is a wood called "shikangania" which the potter says burns hot. He has at least two of these trees on his land but normally purchases fuelwood. He has some Leucaena seedlings and was interested in trying bamboo. Both Leucaena and bamboo can be used for firing with the present fuel stacking methods, without the chopping required with "Shikangania". Bamboo would be especially easy to store overhead because it is long and light, but requires a high heat to burn so would be best used in combination with other woods.

4. Size Consideration of Kiln

Having height equal to width gives the ideal proportions for efficient heating in an updraft kiln. Increasing the dimensions by one foot each way nearly doubles the capacity while increasing by only a fraction the fuel needed to fire. Therefore, the larger a kiln is, the more fuel efficient it is. However, if a kiln is too large to facilitate a comfortably rapid flow of wares, it can cause problems as storage space will be needed for both drying and finished wares of the same number fired in the kiln.

The brick kiln built at Ilesi is slightly shorter than a cube: 5' x 5' x 4' are the interior dimensions. The four foot height allows for removal of pots from all sides (except the bottom layers which are removed through the door) to enable the potters to treat their export pottery with the black wattle bark extract while the pots are hot. Pots and liners could still be stacked 5' high inside the kiln, and the extra height insulated with potshards if desired.

5. Brick Kiln: Observations and Recommendations

With only one fire in the kiln, and the kiln and wood still damp at that point, observations by the consultant are necessarily limited.

The potter still needs to acquire an understanding of the new kiln, despite the intention to avoid changing his technique. He has already changed some aspects of his firing technique, such as not putting grass on

the sides. He also lights his open kiln in two places; he lit the brick kiln in one.

The initial fire was started when the kiln was partially loaded. The potter poured ashes into the center at the wood level and then poured paraffin onto the ash which absorbed it. A match was flicked into it, and when the paraffin caught fire, sticks of wood were fed to it vertically to keep the fire going. More pots were placed on top and when the flames were well established, green grass was laid on top.

The center was the only place in the kiln that reached the desired temperature. The moisture in the newly laid brick walls is a major factor in this, and it is possible that the kiln will give a consistent heat throughout once the walls are thoroughly dry, without alterations in the way the kiln was loaded.

The consultant recommends experimenting with the use of large pottery shards in lieu of, or in combination with, the grass. Shards can insulate without releasing cooling moisture as the grass does, and can be reused. The potter did not wish to try the pot shard roof yet, saying he thought it would prevent the pottery from reaching the desired temperature.

The potter stacks pots in the kiln by laying them on their sides. As the bed of wood underneath burns, the pots settle and shift. The liners, with a wide mouth, have a more fragile shape for this activity than the round-bottomed pots, but if he fires liners with other pots, this stacking pattern is probably necessary. Only one liner broke due to weight settling in an unfavorable way so it may not be a problem at all, certainly not the most immediate.

The consultant recommends that the potter be given continued assistance until he has found a method of using the kiln that he feels comfortable with. Subsidizing fuelwood for the initial firings may be necessary as he will be unwilling to risk a financial loss.

F. Development of Workshop to Accommodate Efficient Production

Space use in the workshop shed is designed to allow for continuous production in an efficient manner, such that the labor of the workers goes directly into production. The consultant wished to avoid the movement of step in the process. The flow of materials and movement of people should minimize the crossing of paths and thus the possibility of bumping which causes breakage, lost time, and frustrations, all of which reduce the efficiency of production. Thoroughfares separate from production space, maximal use of space for storage, and a place for everything are ideal.

The scale of production directly affects the need for efficient use of space.

The greatest demand for space in the workshop will be during training sessions. Up to five moulders can be accommodated (including learners and apprentices) and at least 125 liners per day can be moulded and seasoned, without being moved, for two days prior to cutting. At other times, full pottery production including jikos, water jars, and export pottery can take place in the workshop without space constriction.

The liner production process begins with clay storage near the front (NE) door. (See Figure 10 for floor plan of workshop.) Next to the clay pile is the scale and the wedging table. Loose moulding tables (similar in appearance to stools), can be placed wherever the moulders are most comfortable. Shelves, also loose, about 1' wide and 4' or 5' long are placed on wall supports and liners are dumped onto the shelves. Alternatively a table could be built against the post near the kiln, and shelves placed on the table. When a shelf is full, it is transported to the leatherhard storage shelves for slow, uninterrupted drying.

Cutting is done on the other side of the shelves. A shelf is removed from that side and placed on the cutting table. The four or five liners are cut and then stacked on the southwest wall for drying. They can be carried out the southwest door for drying in the afternoon sun, and from

ILESI JIKO WORKSHOP
FLOOR PLAN

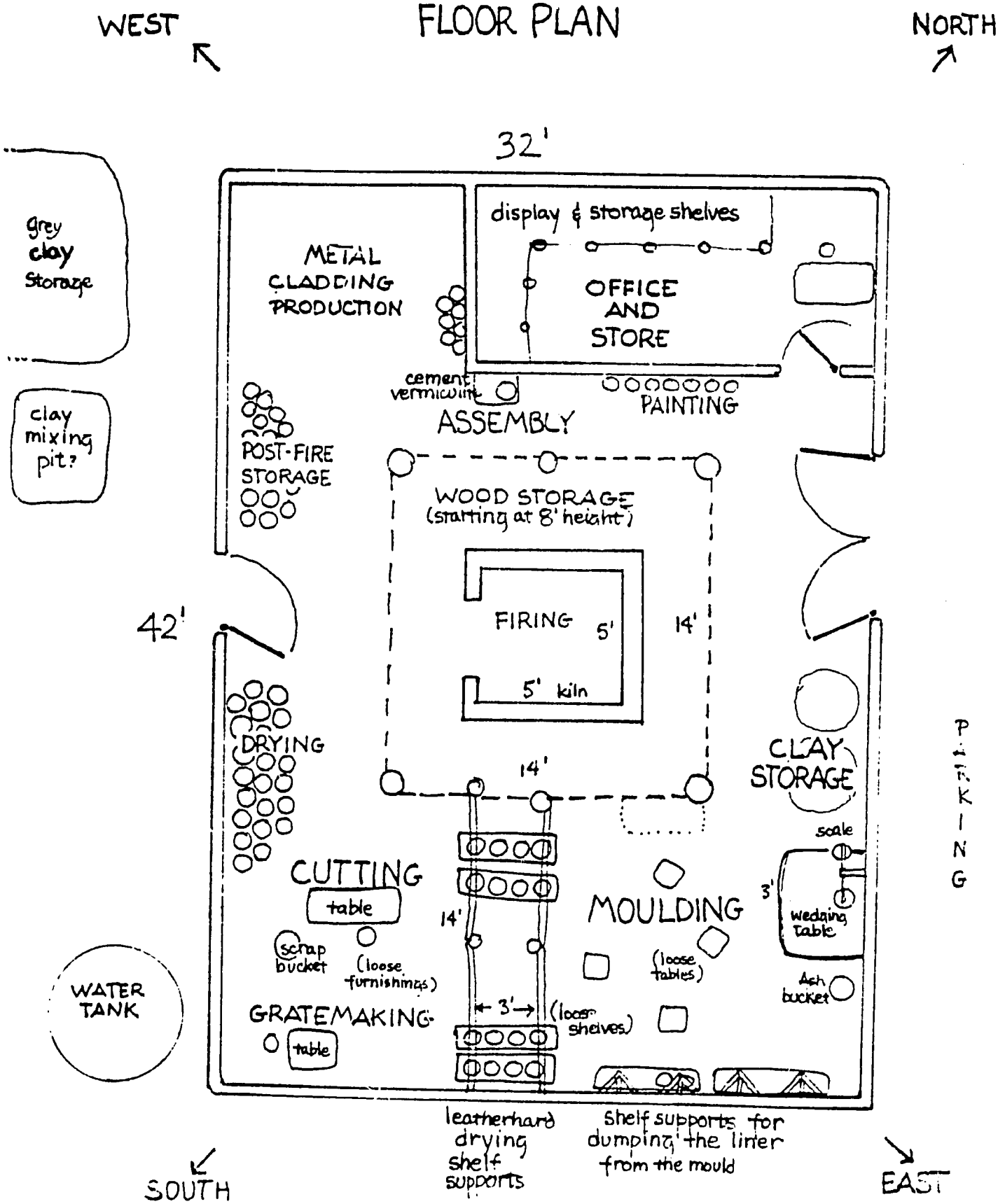


Figure 10

either place have easy access to the kiln door. The gratemaker also has a small table in this room and plenty of storage space. The consultant recommends that a scrap bucket for clay cuttings and grate holes be placed in this room so that the leatherhard clay can be reconstituted.

After firing, liners can be stored just outside the kiln, or on the west side of the SW door, or in the metal cladding production room if it is not being used for that. Assembly of the jikos can take place outside the southern corner of the office. A small table has been constructed against the wall there and bags of cement and vermiculite or diatomite can be stored underneath. Painting can be done NE of the assembly table, and finished jikos can be stored in the office/store, where customers can select from the display and storage shelves. These will be especially useful when there are many models of jikos. Tool storage and record keeping will also be in the office.

II. STRATEGY FOR DEMONSTRATION AND DISSEMINATION

Pre-Workshop Marketing Situation

Ilesi Pottery has been selling all-ceramic charcoal jikos and ceramic-lined jikos for wood this year from the potter's home on the site. Some individuals come to buy them for their own use; some come to buy pottery but see the jikos, are intrigued, and also buy them. The potter has filled large orders for one man who picks them up and takes them to a refugee camp up north.

A. Trial Demonstration in Kakamega Market with Comparison Cooking Tests

The aim of demonstrating in the Kakamega Market is to increase local demand for the jikos. Steady local demand will step up production and assure its continuity. A demonstration in the market with traditional and improved jikos cooking identical foods in identical pots, with equivalent initial amounts of charcoal, provides visual proof that the pottery-lined jiko effectively uses less charcoal to do the same job. Initial sales will serve as a field test; by recording names, addresses, and purchase dates, buyers can later be contacted for follow-up and feedback on fuel use and other comments regarding the performance of the jiko.

It is very important to have jikos available for sale at such a demonstration because, as the consultant and project personnel have seen, people are disappointed to the point of being angry when they cannot walk home with a product they have been convinced to buy. "What good does this do for us?" they ask.

A market demonstration was not conducted during the period of the consultant's work at Ilesi Pottery because the metal claddings that were to be brought from Nairobi were not sent, and there were no completed Ilesi jikos to demonstrate.

B. Recommendations For Market Sales

Jikos can be carried on a matatu, for a price, but the consultant calculates that an entire truckload of jikos would sell at the market when such a demonstration is taking place. A local truck can be rented for Ksh 40 and this would be much more economical. The transportation cost can be added onto the price of the jikos sold in the market, as can the commission of the market salesperson. If people are informed that they can buy jikos cheaper at Ilesi Workshop, then the need to sell in the market may decrease or disappear altogether. Supply and demand will determine this aspect of marketing the jikos.

III. STRATEGY FOR TRAINING ARTISANS

Existing System for Training of Potters

Traditionally, Abaluhya potters are of one clan, and technical skills are passed from parents to children or to children of their sisters and brothers. Clays are gathered from as nearby as possible and are mixed by the newest apprentices. Pots are made in the home with very simple handmade tools, including many for imprinting decorations. Pots are carried to the local market by people who will sell them there for a profit. Potters working on a large scale hire people to dig and mix clay, and to make pots in order to fill large orders for export to Nairobi and Europe. An apprentice, a younger family member, will be taught how to make pots and will be paid when he or she produces pots of marketable quality. Apprentices are taught one step at a time, learning the simplest aspects of production first. After mastering clay digging and pounding, they learn to measure the clays and eventually how to make pots and fire them, gradually acquiring and improving skills under supervision.

A. Suggestions For Apprentice Selection Procedure

It appears at this early stage that there will be two categories of trainees at Ilesi Jiko Workshop.

One will be the local long-term apprentice who will learn jiko production along with other pottery skills which will assure continued production of jiko liners at Ilesi. The Ilesi Pottery Group will continue to train apprentices as they produce a diversity of pottery articles and have thus developed a large market for their products. The most skilled and patient of the trained potters can become trainers.

Another set of trainees will be potters from other parts of Kenya and from other countries, with intentions of producing and disseminating jiko liner production to these other places. At this time logistics involved in

coming from far away make even a 2-week training, much less a 2 to 3 month apprenticeship very difficult for people living any distance from Kakamega. If accommodations can be provided for or sponsored in the future, the Ilesi Jiko Workshop could become an effective dissemination point for these specialized skills. The consultant strongly recommends that only practicing potters come for training in liner production. They would require much less time to train and are more likely to incorporate the new skills into their ongoing production than would be a neophyte to begin a new trade making ceramic liners.

B. Suggestions For Training Procedures

An undoubtably efficient way to produce liners, in use in Thailand, is through specialization of skills. A person only moulds liners, or only cuts them, or only punches grate holes, or only fires the kiln, etc. This is contrary to existing Kenyan traditions of small-scale potteries and apprenticeship systems. It is necessary for at least some people to learn all aspects of the production process to be able to disseminate the production of the liners and to assure continuity at Ilesi. Skilled potters from other areas will be able to pass quickly through the clay preparation and firing and concentrate on learning the moulding process.

A sample two-week training course is given in Figure 11.

Trainings should begin with a cooking test comparing the performance of traditional and improved jikos. The principles of heat transfer can be discussed in relation to the design of the stoves in order to impart an understanding of the important aspects of the jiko design and how it saves fuel.

Training should focus on one step at a time. Trainees should first watch a talking demonstration of the step (e.g., moulding) and then a silent demonstration of the same procedure. Finally, the trainees should try the step on their own.

SAMPLE TWO-WEEK TRAINING COURSE

ON CERAMIC JIKO LINER PRODUCTION, FOR EXPERIENCED POTTERS

	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
a.m.	Cooking Test, using lined and unlined jikos, leading into a Discussion of • Heat Transfer • Stove Design Principles • Kenyan Ceramic Jiko • Clay Body Formulation 3 hrs.	W & W 1 hr. M 2 hrs.	Cutting (C) 2 hrs. W & W 1 hr.	W & W 1 hr. M 2 hrs.	W & W 1 hr. M 2 hrs.	Discussion of firing requirements and methods, simple kiln designs 1 hr. Firing 1½ hrs. Evaluation of Fired Liners ½ hr.
	lunch	lunch	lunch	lunch	lunch	lunch
p.m.	Wedging & Weighing (W & W) 1 hr Moulding (M) 2 hrs	Gratemaking (G) 1 hr. Discussion of the economics of jiko production, and bookkeeping 2 hrs	M 2 hrs. G 1 hr.	C 2 hrs. G 1 hr.	C 2 hrs. G 1 hr.	
a.m.	W & W 1 hr. M 2 hrs.	W & W 1 hr. M 2 hrs.	Firing 1½ hrs. Evaluation of Fired Pieces ½ hr. Assembly of Jikos 1 hr.	W & W 1 hr. M 2 hrs.	W & W 1 hr. M 2 hrs.	Firing 1½ hrs. Evaluation of Fired Pieces ½ hr. Evaluation of Training 1 hr.
	lunch	lunch	lunch	lunch	lunch	lunch/celebrations
p.m.	C 2 hrs. Assembly of Jikos, Discussion of Cement Curing 1 hr.	C 2 hrs. G 1 hr.	Market Demonstration using lined and unlined jikos in local market	C 2 hrs. G 1 hr.	C 2 hrs. Discussion reiterating quality control standards. 1 hr.	

W & W = Wedging and Weighting M = Moulding C = Cutting G = Gratemaking

Figure 11

The consultant recommends that trainees be allowed to make some mistakes in the beginning, for example, they should get some experience cutting a liner that they have moulded hastily and is too thick. Having the trainees time themselves with a clock throughout the process can be a useful tool, but they should not be led to believe that speed is more important than quality. After the trainees have had their first experience with substandard liners, then each liner should be inspected by the trainer before dumping from the mould. This inspection should continue until the trainee is consistently able to produce liners with even walls: one-quarter to one-half inch at the bottom, gradually increasing to one inch thickness at the top. Trainees will require individual attention in order to improve their technique in this discipline. Moulding is the most complex operation in the liner production, and as far as the consultant has seen, the process has no precedent in Kenyan pottery traditions.

For a two-week intensive training for visiting potters, the consultant recommends that each day trainees have approximately the following time assigned to practice these steps:

- wedging and weighing 1 hour;
- moulding 2 hours;
- cutting 2 hours; and
- gratemaking 1 hour.

Daily repetition of each step will be necessary in order for the trainees to memorize the procedures. Manual skills are learned by repeated experience, not by an academic understanding.

During the training, firing should be done as needed. Once or twice a week should be adequate. This will necessarily preempt other aspects of production those half-days.

Those who will manage a jiko factory will need tutorage on the bookkeeping required to be able to determine the costs of the jikos in their own locations. Costs of clay, fuel, claddings, cement, vermiculite

or diatomite, labor, transport, and marketing must all be considered in order to find a reasonable selling price.

C. Skills Assessment and Release of Apprentices

It is probable that some trainees will acquire the necessary skills in less than 2 weeks time, and others will require longer. The trainee potters who are able to consistently produce quality liners (those with even walls of proper thickness, 4" x 2" door, a smooth top, no vertical cracks, with grates of proper thickness and the correct number, size, and placement of holes as described in the construction manual) should then turn to teaching the others, or teaching brand-new trainees, as a final test of their own knowledge. This will instill the procedure even deeper, and gives the trainee some practice training before returning home to do the same. If a person is able to teach another the skills involved, then his/hers are at an adequate level for release. If no new trainees are available, the would-be graduates can "teach" the master potter or the other Ilesí trainers as a test.

The trainee must understand how altering the production procedure (such as fast drying, thick moulding, etc.) can result in an inferior product. A final verbal test covering these aspects should be given by the trainer before the individual trainees are released.