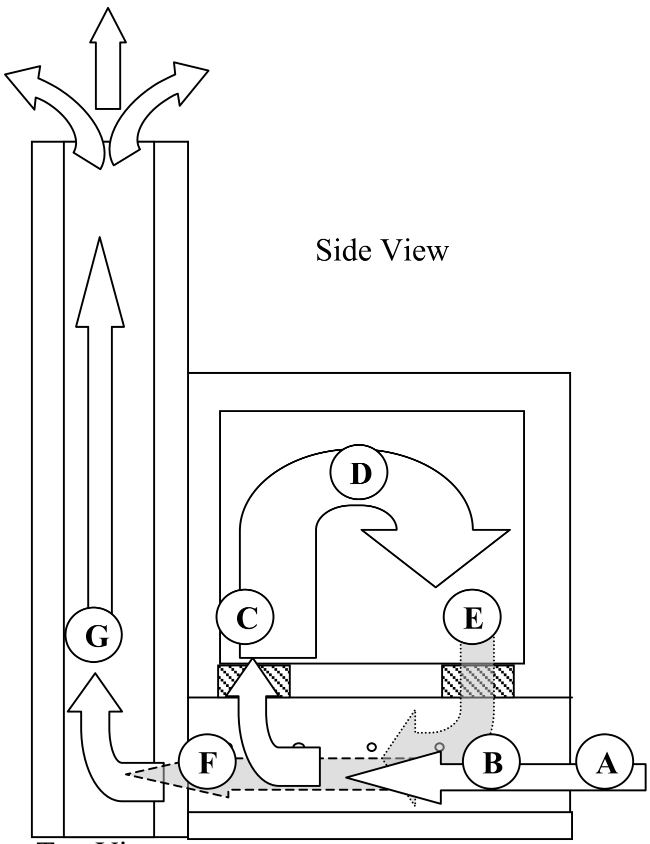
<u>Schematic of Airflow in Mani Kiln</u>

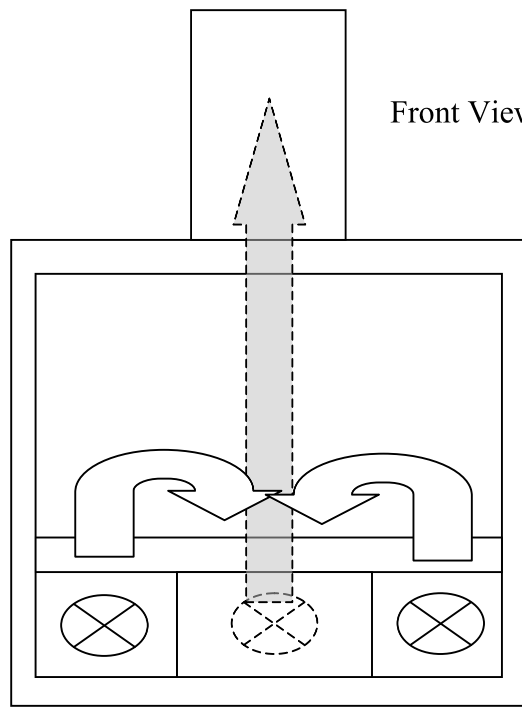
The sketches below show the path of airflow through the Mani downdraft kiln. A circle with an "X" indicates airflow away from the observer, while a circle with a dot indicates airflow towards the observer.

Note how the airflow first flows into the firebox (A) <u>underneath</u> the grate (B), then up through the grate into the fire, then through the firebox exit holes (one for each firebox) (C), then up, around the wares, and back down (D), into the "flue" entrance hole (E), through the flue and into the chimney (F), then up the chimney (G).

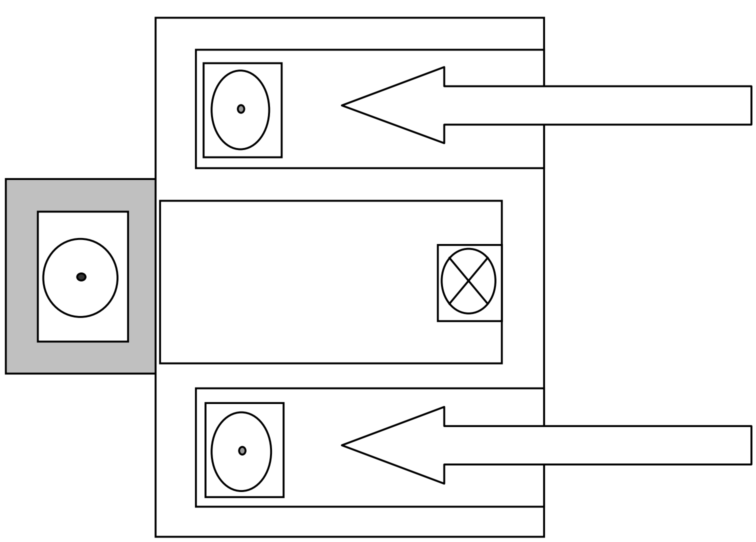
Side View



Front View



Top View

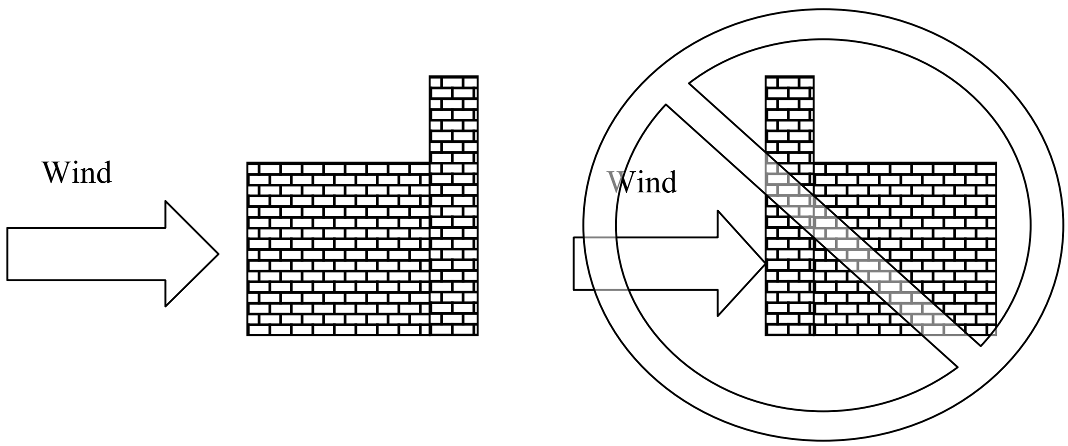


Pictures

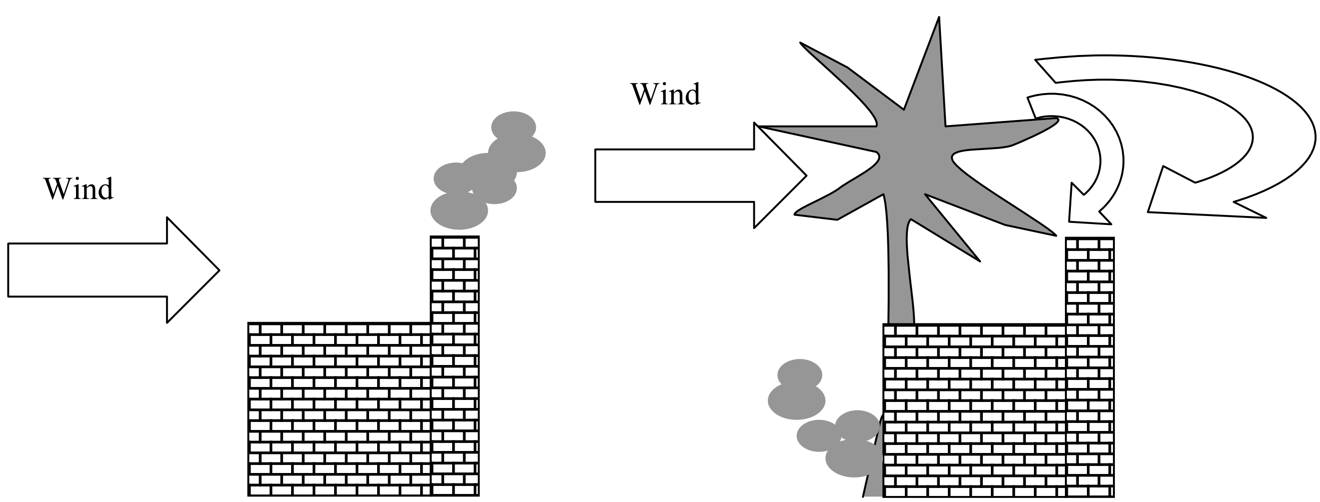
Below are shown the two Mani kilns at the Prey Veng Factory. Note how they are built in a covered area, which protects the kiln from rain. Note also the lack of a rain cover on the top of the chimney (to be added subsequently). Note also the proximity of large trees, which is not ideal, but does not seem to unduly affect the kiln performance.
Filters are drying in the foreground.

Key Points:

- Kiln should be in a covered area protected from rain. Not only is this important to shelter the operators, but rain will erode the clay mortar used.
- A rain cover should be built above the chimney exit, leaving at least a 40 cm gap between the chimney exit and the cover, to allow the smoke to escape. Rain entering into the chimney will cause rapid cooling and cracking of the wares.
- Cement mortar should not be used for any of the kiln walls, as it will not withstand the high temperature. Cement mortar may be used for the last two feet of chimney.
- Orient kiln with the firebox entrance facing the prevailing wind. This way, wind will help airflow through the kiln rather than slow it down.



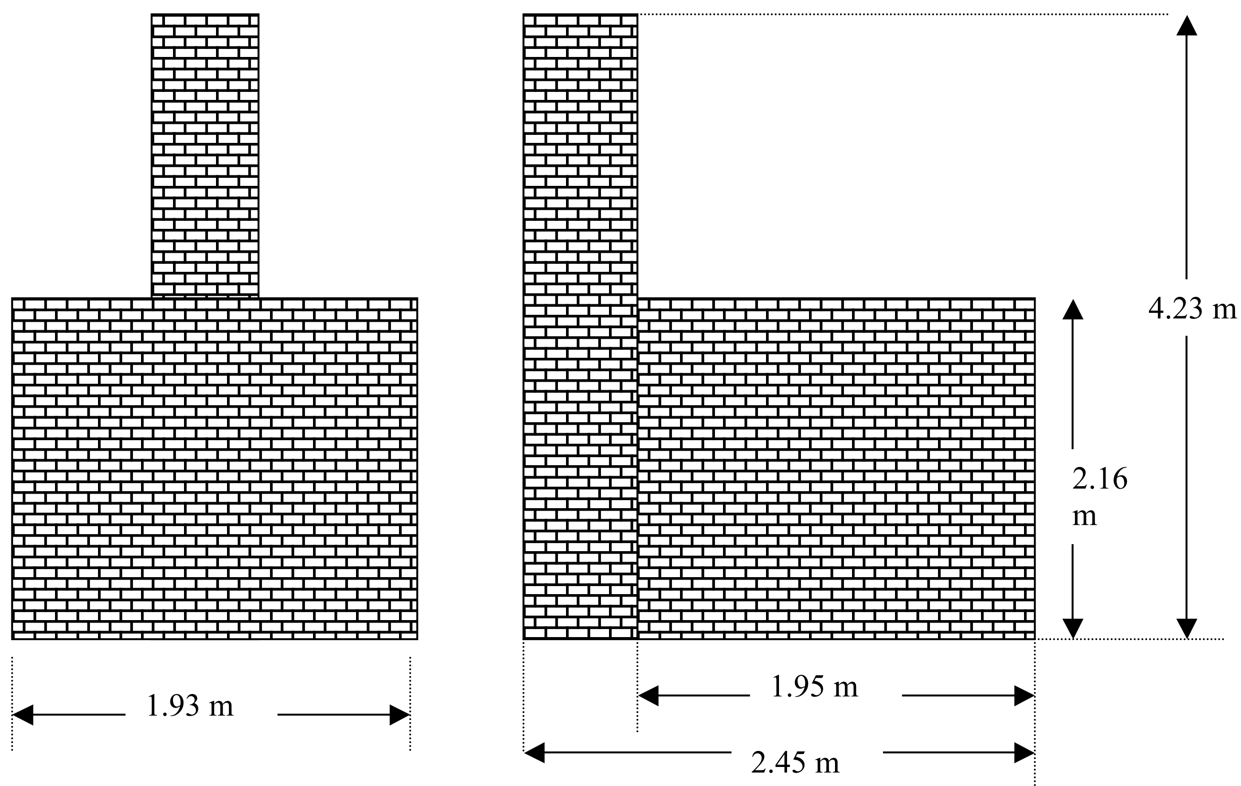
- The kiln chimney should not be close to obstructions like trees or tall buildings. Otherwise wind in the lee of the obstruction may push airflow down the chimney. The trees will also create a fire hazard.

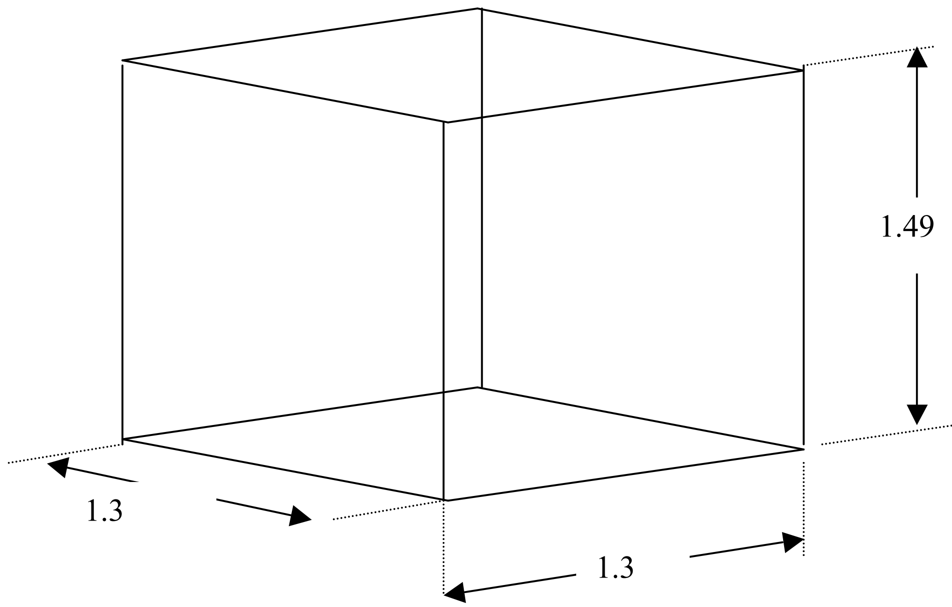


- The ideal wall thickness for the kiln is subject to debate. A thin, single brick wall will obviously require fewer bricks, but will also heat up faster due to a lower thermal mass. A thick, double brick wall will require more bricks, but will use less wood per firing because of reduced heat loss through the walls. Both designs result in working kilns.
- The door for loading and unloading of the kiln is best placed on the side of the kiln, rather than one the front (firebox) side, as shown in the kiln drawings. This allows access to the door for measurement and observation of cones, without the observer being exposed to direct heat from the firebox.

<u>Layout</u> (required area and roof clearance)

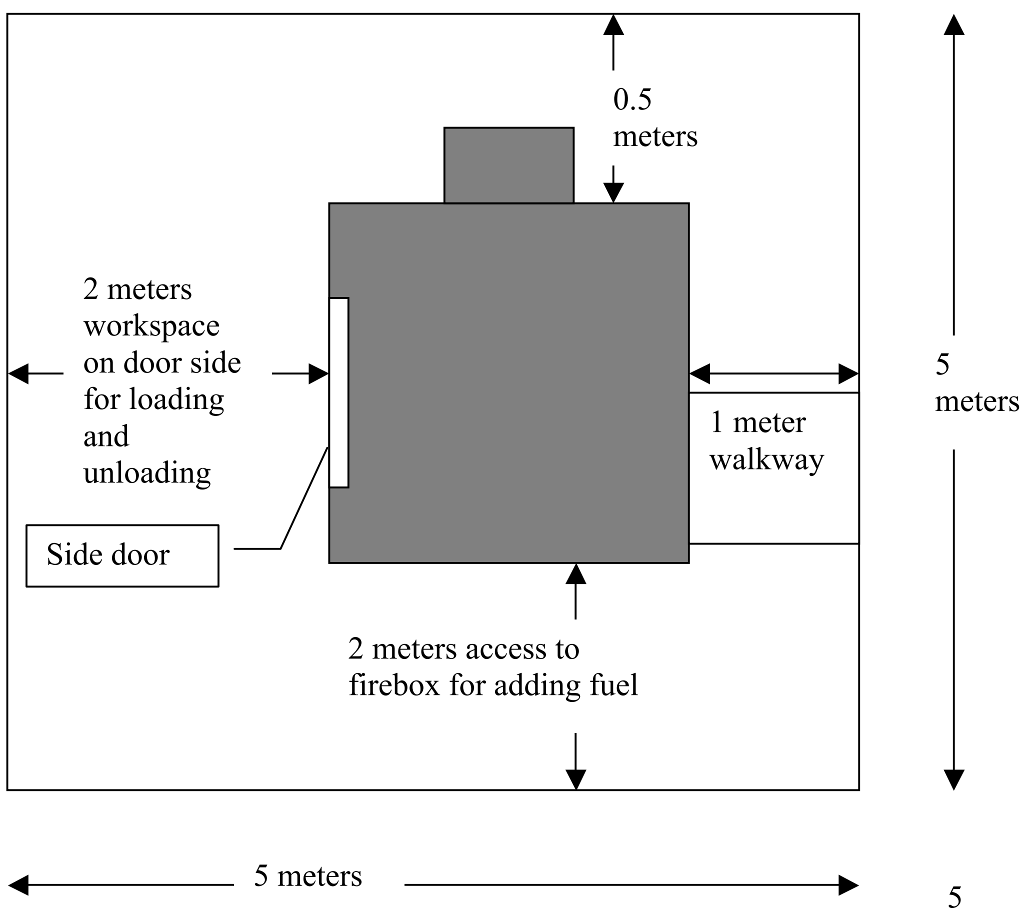
Kiln Outer Dimensions





Wares Chamber Inner Dimensions (meters)

Required Factory Floorspace per Kiln
(Plan View)



Typical process

Process/Operation:
The “green” filters are loaded into the wares chamber, and fire is started in the fireboxes. The temperature is gradually increased .The key to proper firing is to maintain the target temperature rate of increase of 100-150 degrees per hour. More rapid increase will lead to cracking of the wares.
Once the target temperature has been reached, as indicated by the firing cones, the kiln is allowed to slowly cool down over the course of ~16 hours

Problem	Likely Solution
Target Temperature not reached	-check all items for “smoke and flame comes out of firebox entrances” -pre-dry wood by stacking it by the kiln -Check kiln walls for cold air leaks
Smoke and flame comes out of firebox entrances	-Check chimney for blockage -Check that chimney is not in the lee of nearby trees or buildings -Increase chimney height -Increase chimney inner dimensions
Uneven temperature inside wares chamber (most commonly cold at the bottom and hot at the top)	-Start with a slow firing with the flue closed, then change to a normal firing -Open up gaps of ~1/2 cm between the bricks that form the firebox roof, allowing firebox flames directly into the bottom of the kiln -Open up gaps of ~1/2 cm between the bricks that form the exit duct roof.
Wares broken/cracked after firing	-cooled down too fast: did rain enter the chimney?, was the flue open? -are the wares near the firebox exit holes cracked? See below
Wares underfired after firing	
Wares near firebox exit are burned, melted, or otherwise overheated	Add bricks, or other material to direct the flame from the firebox exit away from the wares (a “bag wall”)
Thermocouple reader reading negative, unstable	

Safety Precautions/ Hazards:
Wood fired kiln is probably the safest piece of equipment in the factory. All other equipment has the potential for severe injury.

Safety Hazard	Recommended Precaution

Smoke Inhalation	Avoid breathing smoke
Burns	

Required Maintenance:

Task	Maintenance interval
Clear ash out of fireboxes	After each firing
Check chimney for blockages from debris, animal nests, etc	Once per year
Check kiln for cracking, air leakage, and repair external plaster as necessary	Once per year

Required Spare Parts and Supplies

Cones for temperature sensing – 014 for correct firing temperature, 017 as warning cone
Rake for clearing ash from firebox
Bricks for kiln wall repair
Long pole for checking that chimney is clear of blockages.

Firing the Mani Kiln

Tradition

Most potters in developing countries fire their pottery in the same traditional manner that was handed down to them by their ancestors from generation to generation. The firing technique may differ from country to country but it is steeped in tradition. Probably the only thing that has changed is the type of fuel used to fire their whether it be in a simple pit fire or and enclosed kiln.

Wood is the primary source of fuel for cooking and has been used extensively by potters to fire their kilns in the developing world. For this reason wood is becoming scarcer and scarcer due to deforestation. Because of this problem, some governments are outlawing cutting of trees so potters are resorting to other combustible materials to accomplish the firing process. Some of these fuels such as tires, plastic bottles, practical board, etc., give off dangerous emissions which cause health and pollution problems not only to the potter but to the surrounding community.

Types of Kilns

Above the Ground or Pit Firing

The most common method of firing pottery in developing countries is pit firing. In this method, the pottery is arranged on the ground or in a hole on top of wire grates or metal sheets (lamina) supported by rocks. After arranging the pots over the metal supports, the potters place small pieces of wood, dung, coconut shells or whatever other combustible materials are available under the metal, inside and in between the pottery. The combustible is ignited and the small fires are tended until the potter feels that all the dampness has been completely driven off. At this point the combustible, depending on the country, is carefully placed around and on top of the pottery.

The combustible is then ignited and the potter(s) attend to the fire by filling in holes that have opened up that might let air in, or they create holes with a long stick at the base, perimeter of the firing to allow air in for reasons that have been instilled in them either from what they have learned from generations past or through their own experience. When the firing has extinguished itself the pots are allowed to cool for a time then they are removed.

Open Pit firing

Enclosed Updraft Kiln

The other type of firing is to use an enclosed wall system and because of the way it is designed it is called an updraft kiln. This type of kiln has a firebox at the base of the kiln. The floor, located above the firebox, has perforations to allow the heat from the fire to flow through. Above the floor is the actual kiln chamber where the pottery is stacked prior to firing. Depending on the size of the kiln, it is either top loaded or if it is large kiln, a door is designed into the wall to allow for loading and stacking of the pottery.

There are variations of roofs on this type of kiln, some are simple and some are more sophisticated. One of the simplest versions is to cover the pottery with broken pottery shards that are lying around. Roofs for other updraft type kilns can use a dome. The dome is usually used with a "round plan" walled kiln. Another roof structure is the corbelled arch which can be constructed as a gable or pyramid design. or a typical Roman arch design can be fabricated. The last three mentioned designs are usually built on walls that have a "square plan."

This type of updraft design has an opening at the top of the roof for the heat to exit. A moveable damper can be placed over this hole to control the heat inside the kiln. Depending on the size of the flue opening, the damper could be a brick, a "flat" shard, or one that has been made out of ceramic specifically for that purpose.

The firing process for this type of kiln is to start a candling fire at the entrance of the firebox and continues in this way until all the dampness has been eliminated from the inside of the kiln and the pottery itself. When this has occurred, the firing can be sped up by placing the combustible further inside the firebox. The heat generated from the combustible flows through the perforations in the kiln floor, heats the wares in the kiln then exits the kiln through the opening at the top. When the desired temperature is reached, usually a visual "color" clue seen by the potter through spy holes left in various spots around the kiln, the firing seizes and all openings are closed off to allow the pottery to cool slowly.

The Downdraft "Mani" Kiln

The third type of kiln design is the downdraft model. To fire this type of kiln, as in the updraft version, wood is ignited in the firebox(es) at the base of the kiln. The heat, generated from the wood and/or alternative fuels, enters through opening(s) in the floor of the kiln. The heat continues up inside the kiln and since there is no opening in the roof of the kiln, it is directed down through the wares and exits the flue located in the kiln floor and exits out the chimney. Because it makes this "U" turn, it can be stated that the heat generated is used twice and hence makes this kiln design very fuel efficient.

After hurricane Mitch devastated Honduras and Nicaragua, Potters for Peace (PFP), a US based NGO, introduced the colloidal silver impregnated ceramic water filter (CWF). The purpose was to supply potable water to the poor people in rural areas of Nicaragua where the water was contaminated. This technology was a very lo tech, low cost, point of use (POU) household water supply system.

Because of the large demand for the CWF; the fact that the smaller updraft kilns didn't have the capacity to fire large amounts of CWF's; were very inefficient because they burned too much wood, it was decided that a larger capacity, more fuel-efficient kiln had to be designed. The new design had to be a simple design that would be cheap to build, be fuel efficient, be capable of using alternative fuels and be able to use local labor and materials. After much thought, it was decided that a downdraft design would suit all these requirements. Adopting this design would reduce the potters' dependence on wood as a primary source of fuel.

The other feature of this kiln is that it incorporates a flat-top roof instead of an arch. This design feature was borrowed from a kiln that is used by potters in the United States and is referred to as the "Minnesota Flat-Top" (MFT). It was designed by Professor Nils Lou and named after the State University (Minnesota) where he was teaching at that time. It is appropriate for Third World kiln construction because it does not require an elaborate form to hold up the roof during construction as is needed when building an arch. All that is required for supporting a flat-top roof is a flat panel of wood. Not using an arch eliminates the use of angle iron on all four corners of the kiln, plus tie rods which would be necessary to tie the walls together to keep them from being pushed outward by the weight of the arch.

The Mani kiln has been constructed on site in every country where the CWF's are being produced which includes countries in Africa, Central America, and Southeast Asia.

Mani kiln with arched roof. Note the stacking and clumps of clay used to separate each filter so that there is better circulation of oxygen and to avoid the blackening of the bottoms.

Mani kiln with arched roof. Note the stacking and clumps of clay used to separate each filter so that there is better circulation of oxygen and to avoid the blackening of the bottoms.

Features of the Mani Kiln (MK)

Listed are some of the features that have been designed into the kiln that the potter and/or hornero should be aware of when firing the MK. Following these steps will make this kiln very energy efficient. It should be mentioned that since the inception of this kiln, the design has been evolving in reaction to the feedback from potters of problem situations that have occurred.

1).**The Kiln Wall.**

The wall thickness of the MK is the thickness of the width of the brick available in the country that the kiln is being fabricated. The grade of brick used is common brick used for construction. These bricks are fired above the temperature of the wares fired within the kiln which is more than a 1000 deg. C. The CWF are fired from 850-900 deg. C.

My reasoning for a wall just one brick thick (approx. 6" wide + or -), it seemed that since these kilns were being fired in hot climate temperatures, it would be easier and faster to heat up the kiln with the wares inside, realizing that the brick walls need to absorb a lot of the heat before thhe heat is transfered to the wares inside. In colder climates, a wall two bricks wide with a space in between would be fabricated so that some type of insulation could fill the empty space, such as wood ash or sand which would give good insulating qualities. Also in a colder climate, a small opening would also be incorporated at the base of the chimney which would be a mini firebox. By starting a small fire in this opening it would improve the draft performance by preheating the chimney at the same time the firing is commenced in the fireboxes. Of course, this opening would have to be closed off after the kiln has warmed up sufficiently and the chimney has created a good draw.

2). **The Grate Area.**

The first MK did not incorporate a grate. Since the potters were already firing their updraft bee-hive kilns without a grate, I thought it would be no problem. However, after firing the MK for the first two times, I realized that after getting into the firing, the firebox (FB) would get clogged up with ash and embers. Putting more wood on top of the ash and embers kept the primary air from getting through the fire box, which meant that the FB had to be emptied and cleared before more wood could be put in. This wasted time and also allowed the temperature to drop which then had to be raised again which wasted fuel.

In the next design I made a taller FB so that I could incorporated metal rebar to use as a grate. The rebar grate vertically separated the FB where the wood could be placed on top of the grate and the space below defined the ash pit. It made it easier for ash removal and spreading of the embers without disturbing the wood being fired. The rebars were designed to stick out slightly on both sides of each FB. This allowed the rebar to be pulled out and replaced when they showed signs of wear.

Because the potters ignored that the rebar needed to be replaced, the rebar got so out of shape that they were difficult to remove. The third generation MK (3GMK) now incorporates brick as the grate. If any grate brick eventually breaks, it is easily replaced by removing the floor brick that is located over the FB or it can be replaced by inserting it through the slots that hold them in position on either side of the FB. For this reason, the floor brick and grate brick are the only bricks not mortared in place.

3). **Fire Wall (Bag Wall)**

The original MK's didn't have fire walls. The 3GMK's have a perforated, stepped back sort of pyramid design on both fire ports at the rear corners of the kiln that allows the flame coming into the interior space to be dispersed to the bottom of the kiln for a more even heat distribution. The fire wall is about one third the interior height of the kiln.

4). **Temperature Control**

The MK has three temperature controls. One is the damper which is located on the chimney and is operated manually. It can be pulled out to the full open position during the preheating stage to allow for the moisture to escape and it can be pushed in or out during the firing process to control the draft and pressure within the kiln.

The other control source is the “loose” brick over the FB and flue channels which run under the floor. Since the bricks over these channels are free to move, the bricks can be separated slightly to allow some of the heat in the FB to filter through the floor so that heat can get to the bottom of the kiln to eliminate any cold spots.

If the brick are slightly separated, it should be remembered, the bricks that are over the FB and closer to the flue opening should hardly be separated, other wise the heat will just be sucked into the flue opening. The separation should take place over the FB from about the middle of the kiln to the flame port. Maybe gaps from about a quarter inch to a half inch.

Beside being able to be separated slightly to let in heat from the FB, the brick over the FB and Chimney flue can also be put in an alternating rowlock (on its side) and flat position. This allows the heat from the kiln to get under and into any filter or ware that is stacked upside down or “boca bajo”.

5). **Keep Kiln and Cumbustible Dry**

Make sure that the kiln is housed under a roofed shelter with lots of overhang, especially in the rainy season. If the kiln is allowed to get wet, the firing time will take longer which translates into more fuel being burned.

All wood or alternative fuel (AF) should be stored in a roofed shelter. AF such as sawdust, rice husk, etc., should be kept in plastic bags after it has been left out in the sun to dry.

Do not cover wet wood with a tarp. It will hold in the moisture and keep it from drying. If this is your only method of keeping the wood dry, uncover it when the sun is out and cover it overnight (because it may rain) and uncover the following day if the sun is shining.

All wood should be cut to approximately 20” long (500cm)

Separate thin wood from thick wood

Thicker pieces of wood should be used in the beginning of the firing since being thick they burn slower and longer. Use the thin pieces of wood towards the end of the firing when you want the temperature to climb faster.

If you are burning AF’s make sure that the alternative fuel injector and/or blower system is kept under cover.

Do not put too much wood on the grate at any one time, as this will keep the secondary air from entering over the wood to allow for complete combustion. By the same token, do not allow the embers to pile up to the point where they stop the primary air which is used to burn the charcoal and any volatile gases that are released from the charcoal are burned by the secondary air.

Firing Technique

It is not possible learn how to fire a new kiln for the first time successfully. The potter should know that it takes many times firing of the same kiln before he/she knows how the kiln reacts to all the factors such as outside temperature, wind and characteristics of the fuel used in firing a kiln successfully for the first time.

- **Combustion**

  It is common knowledge that firewood burns as does charcoal, oil, coal and gas. The burning process is called combustion. When watching a small fire burn, we notice that the firewood slowly disappears leaving a little ash and that the fire needs plenty of air.

  This process occurs because fuels are made up of a material called carbon ant the burning process takes place when the carbon combines with oxygen in the air and forms a new material called carbon dioxide. The process produces a lot of heat… The carbon dioxide escapes and only ash is left. Ash is part of the fuel that cannot burn.

  When a piece of wood is heated, initially water and carbon dioxide are given off. Above 280 deg C volatile gases in the wood are given off. These gases will burn if they come in contact with open flames and this temperature is therefore called the flash point of wood. However, these flames only burn at temperatures above 600 deg C., this is called the ignition temperature. The temperature of a wood flame is 1100 deg C while fuel oil has a flame temperature of 2080 deg C.

  Firewood and coal are solid matter while oil is liquid. However, the burning will only take place when carbon is in the form of gas. All materials exist in three different forms depending on the temperature. For example, the three forms of water are well known, ice, water and steam. So first we have to turn our fuel into a gaseous form and then mix it with air. This is the job done in the fireboxes of pottery kilns and is done differently according to the type of fuel used. For the potter in developing countries, mainly three types of fuel are of interest: firewood, coal and oil. For the MK, we must take agricultural waste into account as a fuel source.

- **Combustion in a Wood Fueled Firebox**

Firewood burns in two stages. When a new piece of wood is added to the fire, the wood will first give off volatile gases which will burn. In wood, the volatile gases amount to about 80% of the total mass, the remainder being in the form of fixed charcoal. The flames of the fire are these burning gases and they even will not often touch the firewood. After the volatile gases have escaped only charcoal is left and will burn with gentle blue flames.

In the ceramic kiln the two-stage burning takes place in the firebox which enables the potter/hornero to control the fire. The main problem is to ensure a good strong fire with just the right amount of air needed to combine with the carbon of the fuel. If too little air is let in some of the volatile carbon gas will go out the chimney unburned, this will be seen as black smoke which translates into wasted fuel. If too much air is allowed to enter, it will cool the kiln and this too is a waste of fuel.

Primary air (PA) enters and passes over the embers that have collected at the bottom of the firebox just below the grate. As the PA enters through the bottom of the grate, it helps burn the carbon gases being released from the burning wood on top of the grate due to the high temperature inside the firebox. Most of the PA is used to burn the charcoal in the ash pit so quite often there is little air left to burn the volatile gases being released from the burning wood on the grate. The secondary air (SA) entering through the wood above the grate will allow for complete combustion of these gases. Dividing the air inlets above and below the firebox with a grate, less air is needed and there by less cooling of the kiln takes place. The volatile gases represent up to 30% of the heat value of the firewood. If sufficient PA passes through the fuel the combustion will be complete, but it would mean an excess of air being 50-100% of the air used for combustion. This excess is reduced to 30-50% when SA completes the combustion.

- **The Grate**

  Wood should be spread out evenly on the grate so that air has easy access to it. For firewood distance between the grates should be 15-20 cm apart so that the wood will fall into the ash pit as soon as it is nearly burnt out. Allowing too much space between the grates will allow big pieces of wood to fall through which would block the access of PA. Putting the too little space between the grates will do likewise.

  The grate can be made of steel bars but they will soon wear out. Grates made of fireclay or brick are more durable. The ash pit should be as big or bigger than the area above the grate because a thick layer of embers is needed to preheat the PA. A mouse hole can be provided to let air in from below the ash pit which can regulate the thickness of the embers. The grate for firewood should be about 15-25% of the floor area of the kiln chamber. The 15% would be sufficient enough for firings up to 1100 deg C and the 25% would be sufficient for 1300 deg C and more.

- **Firing Procedure**

Before starting the firing, make sure that the damper is in the full open position, all the spy holes are unplugged and the door is open at the top, about three courses of brick would be sufficient.

Start the firing in the ash pit with large pieces of firewood so that the firing begins slowly which also helps in building up a layer of embers. This is called a candling flame. It is necessary to continue this candling flame until all the moisture has been evaporated from the kiln interior and the wares stacked inside.

You can check for humidity by holding a piece of glass, plexiglass or your spectacles close to one of the openings. If moisture shows up on the piece of glass, there is still dampness present inside the kiln. Use a glove to do this because the air coming out of these openings is very hot.

If no steam appears on the glass, it is safe to commence the firing a little faster by placing the wood and igniting it on top of the grate. Temperature at this point should be above the boiling point of water.

After the moisture has been removed a fire can be started on top of the grate and after about half an hour, it would be safe to close all the openings, except for the damper. The damper can now be used to regulate the air coming into the kiln. A properly designed kiln should be easy to raise the temperature up to 1000 deg C (1830 deg F).

Keep in mind that the initial firing of the MK will take longer than usual. The reason for this being that the kiln is very wet after construction. The last MK which was built in Myanmar (Burma) in July, 2005, took two firings before it dried out completely. It should also be mentioned that the kiln was built during the rainy seas

Mani kiln made with a flat top roof

Cone chart

Temperature Equivalent Chart for Orton Pyrometric Cones (°C)

Cone Numbers 022-14

	Self Supporting Cones						Large Cones				Small
	Regular			Iron Free			Regular		Iron Free		Regular
	Heating Rate °C/hour (last 100°C of firing)										
Cone	15	60	150	15	60	150	60	150	60	150	300
022		586	590				N/A	N/A			630
021		600	617				N/A	N/A			643
020		626	638				N/A	N/A			666
019	656	678	695				676	693			723
018	686	715	734				712	732			752
017	705	738	763				736	761			784
016	742	772	796				769	794			825
015	750	791	818				788	816			843
014	757	807	838				807	836			870
013	807	837	861				837	859			880
012	843	861	882				858	880			900
011	857	875	894				873	892			915
010	891	903	915	871	886	893	898	913	884	891	919
09	907	920	930	899	919	928	917	928	917	926	955
08	922	942	956	924	946	957	942	954	945	955	983
07	962	976	987	953	971	982	973	985	970	980	1008
06	981	998	1013	969	991	998	995	1011	991	996	1023
05½	1004	1015	1025	990	1012	1021	1012	1023	1011	1020	1043
05	1021	1031	1044	1013	1037	1046	1030	1046	1032	1044	1062
04	1046	1063	1077	1043	1061	1069	1060	1070	1060	1067	1098
03	1071	1086	1104	1066	1088	1093	1086	1101	1087	1091	1131
02	1078	1102	1122	1084	1105	1115	1101	1120	1102	1113	1148
01	1093	1119	1138	1101	1123	1134	1117	1137	1122	1132	1178
1	1109	1137	1154	1119	1139	1148	1136	1154	1137	1146	1184
2	1112	1142	1164				1142	1162			1190
3	1115	1152	1170	1130	1154	1162	1152	1168	1151	1160	1196
4	1141	1162	1183				1160	1181			1209
5	1159	1186	1207				1184	1205			1221
5½	1167	1203	1225				N/A	N/A			N/A
6	1185	1222	1243				1220	1241			1255
7	1201	1239	1257				1237	1255			1264
8	1211	1249	1271				1247	1269			1300
9	1224	1260	1280				1257	1278			1317
10	1251	1285	1305				1282	1303			1330
11	1272	1294	1315				1293	1312			1336
12	1285	1306	1326				1304	1324			1355
13	1310	1331	1348				1321*	1346*			N/A
14	1351	1365	1384				1388*	1366*			N/A

Pyrometric cones have been used to monitor ceramic firings for more than 100 years. They are useful in determining when a firing is complete, if the kiln provided enough heat, if there was a temperature difference in the kiln or if a problem occurred during the firing.

Cones are made from carefully controlled compositions. They bend in a repeatable manner (over a relatively small temperature range - usually less than 40° F). The final bending position is an indication of how much heat was absorbed.

Behavior of Pyrometric Cones

Typically, it takes 15 to 25 minutes for a cone to bend once it starts. This depends on the cone number. The cone bends slowly at first but once it reaches the half way point (3 o'clock), it bends quickly. When the cone tip reaches a point level with the base, it is considered properly fired. This is the point for which temperature equivalents are determined. Differences between a cone touching the shelf and a cone at the 4 o'clock position are small, usually 1 or 2 degrees.

Temperatures shown on the charts were determined under controlled firing conditions in electric kilns and an air atmosphere. Temperatures are shown for specific heating rates. These heating rates are for the last 100°C or 180°F of the firing. Different heating rates will change the equivalent temperature. The temperature will be higher for faster heating rates and lower for slower heating rates.

Cone bending may also be affected by reducing atmospheres or those containing sulfur oxides. Orton recommends the use of Iron-Free cones for all reduction firings (cones 010-3). If a cone is heated too fast, the cone surface fuses and binders used to make cones form gases that bloat the cone. If cones are to be fired rapidly, they should be calcined (pre-fired) before use. Cones should be calcined to about 850°F (455°C) in an air atmosphere.

If a cone is soaked at a temperature near its equivalent temperature, it will continue to mature, form glass and bend. The time for the cone to bend depends on several factors and as a general rule, a 1 to 2 hour soak is sufficient to deform the next higher cone number. A soak of 4 to 6 hours will be required to deform two higher (hotter) cones.

for more information on pyrometric cones, contact Orton or visit us at www.ortonceramic.com

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Example of a Firing chart with three terminals (high fire kiln done in Vietnam)

Time	T1	T2	T3
0	50	70	210
0.5	90	350	310
1	125	450	380
1.5	160	534	450
2	220	560	510
2.5	270	620	558
3	320	667	612
3.5	365	712	658
4	412	760	705
4.5	485	803	750
5	528	842	796
5.5	580	890	842
6	608	920	875
6.5	633	948	908
7	690	970	932
7.5	738	990	955
8	782	1025	983
8.5	840	1015	1005
9	873	1040	1027
9.5	905	1058	1045
10	940	1082	1065
10.5	963	1098	1080
11	1002	1118	1105
11.5	1007	1126	1108
	980	1130	1108