How I Built my Rustic Masonry Heater / Pizza Oven

by Henson George

21st Century Self-Reliance:

A Survival Preparation Anthology

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From the Anthology

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Finished and fully Functional Masonry Heater

It is my design in writing this short eBook to illustrate how I designed and built my own contraflow masonry heater / pizza oven along with the errors I made in both design and construction as well as the solutions I developed, often times with assistance from one of my close friends. The hope is to give some insight into this process for not only the novice, but also the more experienced mason. Several of the problems I encountered have been documented in other contraflow heater construction descriptions. Finally I hope to encourage anyone who has a desire to build a masonry heater to forge ahead, develop a plan, and not become discouraged. My masonry heater functions perfectly and is far superior in keeping my home warm in the winter than its predecessor, a rather large iron wood stove. Incidentally I live at 8000 feet above sea level beneath the 4th highest peak in Colorado.

Photo #1


Photo #2


Photo #3

My Experience

You may find this hard to believe but my experience as a mason consisted of watching a few you-tube videos, reading about 15 accounts of masonry heater installations, reading some of the history of masonry heater development in northern Europe and Russia and talking on the phone with a real live stone mason for about 40 minutes. Laugh out loud right? Oh I just remembered, I also have played with Lego blocks since I was a kid. Honestly no matter how absurd this sounds it is the truth. My first masonry experience was putting stones on the outside of my house the season before beginning the masonry heater, see photo #25. Like I said I talked for at least 40 minutes on the phone with a real live mason. Jokes aside he told me about stone selection, brick ties, different methods for stacking stones as well as the importance of keeping everything plumb, level and square. This truly was the extent of my knowledge and experience yet today in season 5 of burning wood in my heater I have not yet had any serious issues that I have been unable to answer and accommodate. It has proven to be a reliable, warmth giving, fully functional and technologically successful contraflow heater and pizza oven.

Charles' Law / Boyle's Law / SWAG

My primary concern when building this masonry heater was to make sure it drafted properly so that all the smoke and gases exited the house via the chimney. As we all know hot air rises. As temperature decreases the rate at which this occurs also decreases. Proper drafting in a fireplace or masonry heater is accomplished by proper design. A couple of guys studied the physics of gases, pressure temperature and volume extensively a few hundred years ago. Charles and Boyle were their names and their conclusions help us to keep the smoke out of our homes.

If we consider Boyle's Law which states that when temperature remains constant as volume decreases, pressure increases. On the other hand Charles' Law concluded that when pressure remains constant and temperature increases, then volume also increases. We can infer from this then that if pressure remains constant, as temperature decreases so will volume. This is in fact what happens in a fireplace. As the hot smoke and gases exit the firebox, the temperature will slowly decrease. Therefore we must reduce the volume of the smoke channels to accommodate the decrease in temperature if you want to keep the smoke moving towards the chimney.

My chimney is an 8 inch diameter pipe. The area of a circle is Pi radius squared. The area of an 8 inch pipe then is 50.24 square inches. Using our 3rd principle above SWAG (scientific wild ass guess), a gradual reduction in volume to 50.24 inches will be necessary from the firebox. I therefore started with a channel leading out of the firebox of 92 square inches, (a rectangle 23 inches by 4 inches). From this point I gradually reduced the area of the smoke channel over the length of the system from 92 square inches to 50.24 square inches. It works like a charm.

Design Thoughts

Design your oven simply so that form follows function and is in principle with Boyle and Charles. Even with a contraflow design smoke and gases should continue up and down, over or out, the smaller the volume becomes. Obviously the longer the smoke moves through the heater the more heat will be imparted to the masonry. My oven was designed to have the hot smoke and gases, after reaching a maximum allowable height inside the heater, to travel back down to the floor one time before making its exit at the top of the chimney.

Some of the European designs, I have read about, travel up and down 3 or 4 times before exiting the system to extract the greatest amount of heat possible from the burned wood or coal. Because of my limited experience I decided to be conservative in my first project. One descent before exiting the system was a worthy goal in my estimation. As indicated before my heater is still standing and fully functional in its 5th year of service and keeps the house far warmer than its predecessor. This is most noticeable when getting out of bed in the morning. After a long night without a fire burning, the retained heat within the stone is slowly imparted back into the house as the house cools off. Conversely the metal stove lost its heat quickly and the early morning home temperature was on average 10 to 15 degrees colder than it is with the masonry mass. It is frequently 20 to 30 degrees below zero in this neck of the woods.

My primary concern when designing the heater, as indicated before, was in fact the proper function of adequate suction and draft to keep the smoke out of my house and the fire roaring inside the firebox. I was careful to apply Boyle's/Charles' Laws while designing and building my heater by taking frequent measurements, in cross section, during the construction phase. The key, once again from the firebox to the chimney exit, is to keep the smoke channel progressively growing smaller and smaller.

I believe that any plan will work if the reduction in smoke channel area is applied gradually from firebox to chimney and the principles of PLS or plumb, level and square are also applied throughout the construction phase. From there the possibilities are limitless. Horizontal or vertical channels are personal preference, size and design features can also be your own. I constructed one layer at a time and then let cure. I think if I had constructed two or more layers my PLS would have suffered. My skills as a mason, previously noted, are limited but my attitude is non-stop. Some of us climb faster than others so don't be in a hurry. Take your time and think about what you want to achieve then using paper, pencil and Legos give some ideas a try. I had an old mason of 50 plus years tell me I was crazy for thinking that I could get hot smoke and gases to travel downwards. No matter what I said about it already being a proven fact mattered not. The tried and true history of the contraflow masonry heater he would not believe.

All fireplaces collect creosote and must be cleaned out. You must design for this process unless you want trouble in the future. With vertical contraflow smoke

channels directly under the chimney all of the creosote can be brushed down into a nice neat little pile ready to be accessed via a little door with a shop vacuum. I have seen some designs that are impossible to clean and keep clean.

Consider also how to repair any brick failures or other malfunctions if your calculations are somewhat off. If you start your first fire and your house fills up with smoke you certainly want to be able to remedy the situation. Have you ever noticed firebricks inside a fireplace that were broken? Even though they call them refractory bricks this does not mean they have unlimited tolerance for high heat and abuse. They will eventually break down. So how are you going to handle this situation when it arises? I designed my heater so that I could access the entire top of the pizza oven through the top three cast refractory slabs. The contraflow damper, the only moving device other than the doors in the heater, is also accessible through the top and can be repaired in the future if the need ever arises. Through the pizza oven, firebox and clean out doors I can access all the other components fairly well. The smoke channels can be accessed from the top by removing the heater / chimney adapter transition.

Finally, the air intake coming into the bottom of the firebox ash cleanout area and eventually into and through the firebox, is one of the reasons I have such a remarkable draft. This can be regulated by the position of a half brick which fits over the opening in the firebox cleanout cavity where the air comes in from outside. You can regulate this from wide open to completely shut. Even though the air intake is 6 inches in diameter, much smaller than the 8 inch diameter chimney area, there are a number of other air intakes through the doors of both the firebox and clean out. Each of these doors has small air vents that can be regulated. Finally I think the 92 square inch area leaving the firebox, per Boyle's/Charles' Laws, is accommodative in relation to the 50.24 square inch area at the top of the chimney (SWAG).

Draw up a Plan

Before I got too far into the plans on paper I started looking around the internet for hardware. I ordered the firebox and pizza oven doors as well as two cleanout doors from a guy on the east coast for around 1000 bucks. I needed the hardware dimensions so that I could design and build my masonry heater around the hardware. Once I had selected the hardware and purchased a pile of refractory brick and mortar, I began seriously thinking about what this would look like on the 4 by 8 foot foundation I built for it. I knew that I wanted the stone fascia to sit on the edge of the foundation all the way around so I needed to leave at least 6 inches around the perimeter before laying down any brick. I figured that with 6 inches I could use stones anywhere from 6 to 12 inches for the actual fascia and these are plentiful on the mountain nearby. I wanted the fascia to be as knobby as I could get it, to match the outside of my house. This was the aesthetic I was trying to achieve.

I began by laying brick out on the foundation without mortar just to see how things were going to potentially work out. Refractory bricks are 9 inches in length 4.5 inches wide and 2.5 inches thick. I noticed that after allowing for the 6 inches of stone fascia around the perimeter I had exactly 4 bricks to span the width of my foundation. I also noticed that a length of 5 bricks was sufficient to contain my firebox and pizza oven as well as the two smoke channels necessary to pull the smoke down one time and return it to the chimney connection where it could exit my house.

Finally an air intake was needed to bring exterior air into the firebox and this could easily be accommodated in this 4 brick wide by 5 brick long configuration. After laying out several complete layers of brick with several alternate possibilities, it became clear what and how I was going to achieve my aim. At this point I began drawing on graph paper each layer of brick (each brick individually). In addition I began building the heater 3 dimensionally one layer at a time with Lego blocks. Lego blocks are surprisingly similar to firebrick in that 2 wide is 1 long. I could then see 3 dimensionally what I was drawing 2 dimensionally and building in real life.

By laying out just a few rows I could begin to see how the firebox door was going to take shape, as well as the cleanouts and contraflow channel. So before getting way ahead of yourself lay out several layers of brick and get a feel for how they work together to achieve my suggested design goal of form following function. Using the Lego blocks at this point can give insight into the same thing. As I said before if you can get the draft and the containment of the smoke down while burning a roaring fire you have, in my book, a fully functional fire apparatus inside your home. Following Boyle's/Charles' laws will insure proper drafting, and building each layer plumb, level and square will insure it does not fall over.

Layer by layer

Here in photo #4 is my first layer after it had been mortared. This oven core first layer is 4 bricks wide and 5 bricks long, with the addition of the foreground clean out that only extends up three or four layers. Incidentally, this cleanout is the primary cleanout I refer to several times in this writing because of its strategic location directly under the two vertical smoke channels, which are directly underneath the entire 8 inch metal chimney pipe that extends up through my roof. The hole on the right is the air intake coming in from under the floor and through the foundation into the firebox. If you can look at this photo close enough you will see that each brick is staggered or off set from each row of bricks adjacent to them. Just like laying brick vertically, proper technique suggests laying brick horizontally benefits from the same procedure. You can also see the firebox cleanout door sitting in the lower left hand corner on the floor next to the heater foundation. At this point my corners are square and my surface is level and smooth. Get this right and the rest is downhill.


Photo #4

Photo #5 shows the second layer of refractory brick with the air intake still visible, the firebox clean out has started its shape as well as the contraflow smoke channels. The smoke channel clean out is just in front of the smoke channels. The smoke channel closest to us in this picture is the up and out channel and the one farthest from us is the down channel. You can also see the rubber mallet used to help position each brick and the sponge used to clean the brick and smooth the mortar joint. I imagine at least one of those buckets has hot water in it. The others are refractory mortar. Notice also that the bricks on the second layer stagger those on the first layer. Continue this strategy throughout all layers.


Photo #5


Photo #6

Photo #6 shows the third layer of brick (all refractory). The air intake isn't visible here but is in fact at the back of the firebox cleanout. The clean out for the smoke channels has also started to take shape with 2 rows of bricks.

In the next photo #7 you will see some of the hardware (firebox cleanout door) and one of two ways I attached it to the brick. In this photo you can see, if you look closely, a couple of motorcycle spokes running from the top corners of the hardware to

lay at an angle in a trench or channel cut out of the brick on a diagonal from the door opening. I also drilled a couple of holes through the hardware on the vertical side walls of the door frame itself. I then screwed the door frame directly into the two bricks (after predrilling the masonry holes) on each side of the clean out door with masonry screws. Even to this day they are strong and secure. The motorcycle spokes seem to help.


Photo #7


Photo #8

In photo #8 you can clearly see the 4th layer of bricks which make up the bottom of the firebox. The ash clean out and air intake for the firebox are no longer visible but are underneath the firebox grate opening on the far side. The continuation of the gas channels and the completed clean out for the smoke channels is in the foreground. You can also see the firebox clean out door on the left side screwed and mortared in. There is also a drywall knife in the foreground used to apply mortar to the brick and I

think I see the masonry trowel in the background to the right of the mortar on the stack of brick used for the same purpose. At this point I was unsure which device worked best.


Photo #9

Photo #9 shows the first 5 layers of refractory brick along with the outline for the first time of the firebox. Also on this layer you will notice the connection between the two smoke channels has been covered. I included under this row of two bricks two pieces of angle iron to help support the lintel connecting the two smoke channels. There will be quite a bit of weight on top of this small lintel. The angle iron was 1/8th inch thick and probably 2 inches wide. They were a perfect fit and exactly the same thickness as the mortar itself. From this photo it looks like a perfectly level row of bricks and lintel.


Photo #10

We are now on layer 6 in photo #10 and you can see a brilliant design feature I lucked into without a great deal of thought. In the firebox you will see that I now have a step along the outside edge of the firebox. There is an identical step on the side closest to the viewer that you cannot see. This allows me to rest split wood from one side step to the other without resting wood on the floor of the oven. This in essence does 2 things. One, it keeps the wood off the firebox floor (which will improve its longevity) and two, it acts as a fireplace grate which allows me to wad up several pieces of newsprint and ignite them easily just below the wood. I never need kindling. I can set 6 large pieces of split wood crosswise to each other in 3 layers and with 2 pieces of newspaper, use one match, and start a fire every time. The air intake is coming straight up and through the wood pile so it makes starting fires a cinch.


Photo #11

In photo #11 seven layers are complete. You can see the beginning of the firebox door. The two smoke channels are still there. The closest channel is the up channel and therefore slowly getting smaller as it rises while the other is the down channel and is slowly getting smaller as it descends.

Plumb, Level and Square

I have failed to mention anything substantive so far that relates to keeping your work plumb, level and square. You can accomplish and institute these principles with a number of different tools. Plumb can be achieved with a 4 foot level held vertically, a plumb bob or string, a laser level that shoots vertically and horizontally or even a square. Level can be achieved with a 4 foot bubble level, laser level or string and tape measure. Square comes from our friend Pythagoras who discovered that two sides of a right triangle when squared and added, equal the square of the third side or hypotenuse. Each layer is set upon a preceding layer and therefore presupposes that it conforms to PLS. Start with the first and make sure you have PLS. When you begin the second, make any adjustments to maintain PLS. With the third do the same thing and make any corrections necessary to modify the previous layer and bring it back into PLS conformity. That is the key and the ongoing battle.


Photo #12

Layer 8 and those corners still look pretty good. The firebox is two layers up from the bottom of the firebox hardware door and the two contra-flow gas channels still look good. I only used a 4 foot level on the corners vertically and horizontally along each row of brick and across all surfaces. By this technique alone I was able to keep this oven in conformity to PLS. It is still standing and functioning like new, 5 years after completion. ;)


Photo #13

In photos #13 & 14 you can see layer number 11. I skipped the description of three layers because they were all the same. We are currently 5 rows above the bottom of the firebox doorframe and on the layer where 5 cast refractory arches sit to complete the firebox ceiling.


Photo #14

This refractory cement was purchased at the same store where my bricks were purchased, and was poured just like cement into a form I built to specifications. See photo #15. I built similar forms for the lintels and oven-top slabs. The forms were built using a screw gun and 3 inch screws to hold 2 by material together with plywood. This refractory cement is pretty smelly stuff if you catch my drift. I mixed it in a large 50 gallon plastic bucket with an electric drill and one of those drywall mixer arms that fit into your drill chuck. When you have a good consistency, slightly runnier than peanut butter, pour it into the forms and let cure. Strip the forms in 24 hours and

they are pretty much ready to go. You may want to knock off some rough edges with a piece of sand paper or file.


Photo #15

Finally, in photo #16 you will see all four refractory cement-formed arches mortared together on top, along with a cast refractory lentil across the front brick face which forms the top of the firebox door opening. You can't see it here, but to add additional strength to the lintel I put a piece of three inch steel angle iron behind the masonry on the inside bottom edge of the lintel. The cast arch pieces are all unsupported except for their arch shape. It is difficult to see from this photo, but between the firebox lintel and the first of the four molded arches there is an approximate 4 inch by 23 inch channel which allows the hot smoke and gases to exit the firebox and enter the back of the pizza oven.


Photo #16


Photo #17

Notice the first layer on top of the cast refractory arches and lintel in photo #17. The smoke channels are easily visible and I think I can detect that the right smoke channel is smaller than the one on the left. From this point two additional layers are added across the entire surface of the heater top. This ultimately becomes the pizza oven floor shown here in photo #18.


Photo #18

You can see the 4 foot red level across the top. On each layer it is necessary to check and double check that you are plumb, level and square. I ran that 4 foot level up both sides of each corner vertically from bottom to top and horizontally across every layer in all directions.

In photo #19 you can see 5 layers above what was seen in photo #18 on the firebox side. In the front of this photo you can see the start of the pizza oven door as well as the smoke channels going down (one row of brick to the left of the pizza oven floor), and the up channel just under that 4 foot level. This is also the layer where the arch of the pizza oven top begins. Thinking back, I wish I had built a brick arch over the firebox as well. This was a fun project. I had to build a form to fit inside the oven on which I could begin the arch process. I started on the firebox side with forms in the back 1/3 of the oven space and began mortaring arch bricks together. I continued

until the final brick in the top of the arch was in place. I didn't stand on it when it was finished although I feel certain it would have held my weight. I did the pizza oven arch in 3 segments coming forward.

Photo #19

In the photo #20 you can see the completed arch. It's not perfect, but close and certainly eminently serviceable. This is my first arch and hopefully not my last. On the left you can see the contraflow down-flowing smoke channel as it descends along the side of the arch on the left. I still need to construct the front smoke channel to allow smoke to exit the pizza oven right behind the pizza oven door. You can more plainly see this future channel in photo #21.

You may also notice that the bricks used in the pizza oven ceiling arch are bricks specially made for this purpose. These bricks are smaller on one edge than they are on the other. They have a slight angle to them as opposed to a standard brick which is a near perfect rectangular solid (hexahedron). There are several different angles and sizes available all designed to create different radial arches.


Photo #20


Photo #21

Photo #21 is an excellent picture to illustrate one of my blunders. If you notice the arch of the pizza oven on the right comes down flush with the exterior of the oven core. I have nothing upon which to build the wall that extends above the pizza oven arch on this side. Screwed? Fortunately there is a solution to every problem. I started by inserting some 3 inch aluminum bolts (corrosive resistant) into some predrilled holes (1 inch deep) along the right side of the pizza oven arch about half the way to the apex of the arch. These eventually acted as anchors for a small pour of refractory cement that allowed me to create a flat surface to lay a few more layers of brick upon up this side of the pizza oven arch. A retaining wall needed to be built to hold this cement in place along the right side. In photo #22 you can actually see the form toward the top on the left side. I supported it with some diagonal 2 by 4's tied off and secured at the bottom.


Photo #22

After I poured the refractory cement to the correct level I finished it off to a smooth finish so that several layers of brick could rest upon it and remain plumb and level. In photo #23 the bricks have been built to layer 26 ~ the last layer. If you look closely you can also see the 3 cast refractory oven-top slabs with a little white mineral wool between the rabbet on both sides of the middle piece. I also used mineral wool along the entire wall underneath the three slabs as well as around the connection of the chimney assembly. This material stops any leakage of smoke or gas.

In photo #23 you can see also the silver metal straps around the entire masonry heater in 5 locations. These were installed after the first firing to insure everything stayed in place after several cracks appeared. This solution has proven to be sufficient. I continued using the heater throughout the first winter season without applying the stone fascia exterior. Smoke and hot gases have always remained inside the heater without a hint of leakage. The following summer I built the stone masonry fascia on the outside of the masonry core and have successfully used the masonry heater each winter season after that. I live at 8000 feet in the mountains of Colorado and have temperatures routinely in the 30 to 40 below zero mark. My house is nearly 2100 square feet and the masonry heater has proven to be up to the task for keeping my home comfortable throughout each winter season. You will also notice two pieces of split wood to the left of the heater core resting on top of the heater foundation. For each fire I use 6 pieces of similar sized wood with two pieces of newspaper to start all my fires. No kindling is required.


Photo #23

Looking on the left side just under the 2nd metal strap from the top you can see the last refractory pour to solve the pizza oven design error. Each problem I encountered, a satisfactory solution was found and applied. That is a fire poker hanging from the contraflow damper handle near the top on the right. Also the silver chimney transition adaptor can be seen well here transitioning the smoke from the upper smoke channel to the 8 inch diameter black chimney pipe. This is simply sheet metal bent and shaped to accommodate the two different sizes and shapes of the smoke channels and chimney pipe.

Build a 3 Dimensional Plan

I know I mentioned this before, but my suggestion is to make a 3 dimensional plan as well as a 2 dimensional plan for each layer of the heater / oven. This way you will know exactly how many bricks you will use and you will have a 3 dimensional model to reinforce your ideas of air flow, cleaning and maintenance issues and even adherence to Boyle's / Charles' Laws. If you don't like Legos then use cardboard, wood or any other material that will give you a better understanding of your heaters limitations and its strengths. You will be able to see how the air will flow and in which direction the heat will radiate, as well as where the potential breaking points or points of failure might be. I like Legos because Lego blocks are almost an exact scale model of a refractory brick. Whatever method you choose to use for a 3 dimensional model and a 2 dimensional plan, this step is paramount to a successful design and construction process. Success comes through planning, persistence, revision patience and setting achievable goals. After that, additional planning and refining may be necessary.

Build a strong foundation

I can't tell you how much a bunch of refractory brick and mortar weigh but I can tell you it is a lot. I will look for my written plan for my heater and count the number of bricks I used. I know that I could only carry a few hundred safely on my 3500 pound trailer at once. I can't remember exactly, but I know I made a number of trips to Pueblo, CO to one of only a few refractory brick plants in the U.S. My point here is to convey to you the huge weight of one these masonry heaters and the necessity of designing and building a foundation that will support the weight. Certainly the last thing anyone would want to experience is to have their heater begin to crumble sometime in the future because of inadequate support. Consult an engineer if necessary. A dollar of prevention can save 10 later on.

My first floor is 5 feet above the dirt so my foundation is about 6 feet tall. It starts with a footer 10 inches thick by 8 feet long and 4 feet wide. See photo #24.


Photo #24

That is the masonry heater foundation inside the perimeter of the house. It is 3 ICF blocks tall and sitting on a 10 inch tall footer. I filled the ICF's with horizontal steel rebar in each layer of block and vertical steel rebar every 3 feet. These ICF blocks were filled with concrete and allowed to cure. The interior of the 4 by 8 foot ICF block rectangular hexahedron was filled with dirt and then compacted. I allowed the vertical steel coming out of the blocks to bend over the top at 90 degrees and then combined with additional steel I formed and poured another 10 inch slab spanning the length and width of the ICF blocks. After the 1st floor was installed the heater foundation with top slab stood above the floor level by 8 inches. The ICF manufacturer's rep told me that I could build a skyscraper on top of it. I am not so sure of that but this design has proven to be sufficient for the weight of the heater / oven.

Build one layer at a time

I know I have mentioned this somewhere in this writing but I will reiterate it here. I built one layer of the heater / oven core at a time and allowed it to dry before adding another layer. I did this because the refractory mortar was a little greasy and my ability to keep each layer of brick PLS without a solid base was difficult for me. On the other hand, by allowing each layer to dry completely before adding another layer on top allowed me to apply a little more pressure, if necessary, to make sure PLS was maintained. I used a rubber mallet to tap and urge each brick into its correct plumb, level, and square position. Each new morning I came out, I was amazed by the strength and solidity of the masonry. As it became taller I could climb on it like it was a boulder. Again, starting each new layer on a plumb, level, square and solid structure made it much easier to keep it that way.

Go slow and sure

I put this point here because we all become frustrated with our work and our lives at times. By slowing down a bit, considering our position and our goals, the means to achieve those goals are frequently given to us. Take the time necessary to get it right the first time. If you don't you can gear down to a lower gear and try again. I once heard somewhere that we all have the time necessary to complete all the tasks we want to complete on this earth. There is no necessity for anxiety or hurrying. My advice then is to make your plan, mortar one layer of brick at a time, allow it to dry and proceed with the next layer the following day. Take the time to keep everything plumb, level and square. Run a level across the horizontal surface as well as the vertical faces of the heater, with special attention to the vertical corners running all the way up. Use the Pythagorean Theorem to check your corners on each layer. String lines can be used as well as laser levels to check PLS. A simple 4 foot carpenter level can be used with good results.

Cast Refractory

I used cast refractory pieces in a few places in my oven. The first place was as a lintel in the oven core over the firebox door, from one vertical side of the door opening to the other. See photos #16, 17, and 18. The second time was the four cast arches I used for the ceiling of the firebox. Casts will still benefit from the supporting nature of an arch see photo #14 & #16. In photo #15 see the form that I used to cast the 4 segments of refractory arches to cover the firebox ceiling. I used similar hand-made forms for all the refractory pieces I needed. The third time I used cast pieces was for the 3 slabs used to cover the top of the oven. These were 3 inches thick, 36 inches long and 17 or so inches wide. They weighed close to 100 pounds. I needed help from a friend to lift them and place them on the top of the oven. Lastly, I used this cast refractory cement to build a ledge on the outside edge of the pizza oven to support the wall above it. Basically I built a form to hold the cement in place, aided by concrete ties imbedded in the top of the pizza oven arch. This ended up being a perfectly satisfactory solution to a design error I made in a fully conscious state. It happens to the best of us.

Arches and Lintels

Arches and lintels are not architectural features designed for the human aesthetic. They are in fact necessary structural elements designed to support loads and span distances. Doors and windows are primary examples of where an arch or lintel would be needed. The lentil or arch spans the distance and supports the weight above the opening. Structural in nature, lintels and arches have a unique and almost primitive appeal that exudes Stone-Age strength and support. In the refractory heater core I used a lintel over the firebox door opening and 4 cast refractory arches for the ceiling of the firebox. I then used a brick arch over the pizza oven and finally used two large sandstone lintels over the firebox and pizza oven doors in the stone fascia.

Gas channel configuration

The gas channels for my heater / oven don't actually start until the smoke gets to the top and above the pizza oven. At this point smoke and gas will exit the system directly up the chimney if the contraflow damper / cutoff is open. If, on the other hand, it is closed and the updraft in the chimney is sufficient, the hot smoke and gases will be pulled down from above the pizza oven to the first layer of brick on the bottom of the heater, and through an ever decreasing area channel size, to the outside and up-channel, leading into the chimney. This updraft channel is also decreasing in area size all along its length until finally dumping its contents into the 8 inch diameter chimney pipe. As stated previously, the two vertical channels I created in my heater are directly below the chimney. When I clean my chimney I climb up on top of my roof, and with an 8 inch chimney brush and many sections of rod to attach to the brush, I plunge the brush through the entire length of the chimney and rid myself of creosote for a year or two. My heater burns fairly hot so I probably have less clean up than others. Anyway the channels then can be brushed with another brush, adapted for the purpose, and finally sucked out easily with a shop vacuum through one of the two cleanout doors. My point is to illustrate the need for good design. Your channels can be any way you want them to be whether horizontal, vertical or diagonal. Think of your objective, do a little reading, then make, draw and build a model keeping clean out, creosote buildup, and other potential maintenance in mind.

Refractory Mortar

The mortar used for the refractory bricks is called refractory mortar. Duh? It is designed and created to withstand greater heat than a normal mortar joint. It comes in 5 gallon buckets and is ready to use after just a little stirring. Unlike regular mortar, refractory mortar is used to create joints only 1/8 inch or less. Get a couple of different kinds of trowels to use. I did use a trowel for this step of the process. Also a rubber hammer comes in handy tapping the bricks into place plumb, level and square. Finish off the joints with a moist sponge and check for PLS. I mortared one layer of brick a day. The results were always good the next morning when everything was dry. I attempted two layers once and realized the chances of maintaining PLS were reduced substantially. I went back to only one layer of brick a day, which proved to be adequate. I used this same technique when applying the stone fascia. Admittedly, doing it this way does not make sense on a commercial level but it is completely satisfactory if you are working for yourself.

Top Oven Cover

The cover for the top of my oven spans 36 inches and is made from cast refractory cement. Just like the firebox ceiling arches I cast using a home built form made to my specifications (see photo #15), I followed the same method to build 3 separate rectangle slab forms and then poured them. The middle of the 3 slabs only had support on the two oven ends so I created a channel or notch to support this piece along the lengths also known as a rabbet. Here is a description and picture: http://en.wikipedia.org/wiki/Rabbet By using this rabbet the center slab rests upon the two end slabs which have support along 3 sides instead of just two. Mineral wool was spread between the 3 pieces of cast refractory and the oven, as well as between themselves along the 2 rabbets. The slabs are each 3 inches thick 36 inches long and approximately 17 inches wide. They weigh about 100 pounds each and when putting them in place I needed the assistance of one of my friends. The last thing I wanted was to break one of those on its final approach into place.

Mineral Wool

Mineral wool is fire resistant and comes in a number of different sizes. I used a small roll about 2 feet wide and an inch or so thick. I stuffed it around all hardware, dampers, oven top and the heater / chimney transition adapter. The mineral wool's purpose is to act as a gasket and stop all smoke and gas from entering the house. It also works well as a buffer underneath and between the 3 cast refractory slabs acting as the top of my masonry heater. Some masons, I have heard, use it to wrap the entire inner core of the masonry heater to form a transition zone and to reduce any fractures in the outside (visible) masonry. Personally, my objective was to have all of the masonry (refractory brick and stone fascia) absorb as much heat as possible and then disperse that heat back into the home when it begins to cool off. I want the outside stone to get hot. I don't want any of my heater (core or fascia) to breakdown and crumble, but I do want it to get as hot as possible.

Slip Forming

Slip forming is a method for laying masonry, typically with uneven field stone where you build a form with plywood braced and reinforced. All that is left after building your form is to place your stones flat side out along the plywood form and then fill in with concrete or mortar. Let the wall dry then disengage the forms raising them vertically to accept the next stone layer. This method provides satisfactory results and any novice can do it. Pointing is still necessary but with the flat side of the stones facing out, the aesthetic is appealing. I will probably use this method sometime in the future. My aesthetic objective on this home was, the knobbier the better. There is a fairly good account of a guy on YouTube (address below) and the slip forming he used here: https://www.youtube.com/watch?v=IIuVcvXzlZA

Stone fascia

The stone, not only the masonry heater fascia, but also the stone on the exterior of my home was gathered from the Blanca massif a few miles to the north. I have an assortment of sizes from one handers to four handers. That is the amount of hands required to pick up or simply move a stone. Most are two handers and were picked primarily for their aesthetic value. Almost all stone shapes can and will eventually be used. Since my seat for the first row of stone was 6 inches wide, anything up to 10 or so inches across was suitable. I did not use any brick ties because I felt that my method for stacking stones would suffice nicely to prevent any stones from falling away from the wall. After 5 years of heating and reheating the oven my technique has proven to be successful. I have no leaks of gas or smoke into the house and the fire roars at a very high temperature. My exact technique was as follows. I laid one entire layer of stone sitting comfortably on the concrete base, each wanting to fall into the oven core. Moreover I tried to make the flattest side of each stone sit upwards. I then mortared this row and waited until the next day before repeating the process. The following day the stone masonry was like one piece of stone, i.e. rock solid. Each new stone layer I added each day sat comfortably on the previous layer of stones with a bias to falling in toward the oven core. One layer at a time I moved to the top of the oven. I did need two stone lintels over the firebox and pizza oven doors. I cut a large piece of sandstone in two and used half for each lintel. I use a hammer and chisel to cut the sandstone.

Mortar Mixing

I mixed my mortar for the stone work in a wheel barrel next to the well pump and pile of sharp sand I purchased for this purpose. I was told by my local mason that sharp and washed sand mixed with Portland cement and water were the essential ingredients. He also told me where to get them. Mixed to the consistency of peanut butter the sand, water and Portland cement seem to do the job well. The objective here is to have mortar that will surround each stone and fill all the voids. Most professional masons use a trowel or trowels to apply the mortar to the stone. I, on the other hand, wore big strong rubber gloves and used my hands. I basically threw the mortar in and around the stone and smoothed it down with the edges of my hands. Later when it had set up a little I found a pointing stick to smooth the mortar and point the mortar around the stone.

Pointing

Pointing is finishing, refining and making smooth the mortar joint between the stones. I try to make the line of mortar straight and well defined and typically will use a stick for the process. They work well and when they get too ground down you can always get another. Let the mortar set a little and get semi-rigid for good results. I applied most of the grout for the stone fascia with my hands and then used the edges of my hands to smooth and semi-point the stone.

Finally I would use a stick, typically with a flat side and a pointy side. That way I could make the wider joints smooth with the flat side and the mortar line along the stone crisp, straight and sharp with the pointy side.

Contra Flow damper

This device is the control switch to maximize the efficiency of the heater. As already pointed out when the device is open smoke rises through the damper and immediately into the chimney and out of the house. When closed the chimney draft then pulls air down the interior smoke channel on the inside next to the pizza oven arch as seen in photo #20, 21 & 19. This simply causes the smoke to remain in the heater a bit longer and as a result impart more of its heat to the masonry. The damper was specialty-built to specification out of ¼ inch thick steel by my engineering buddy up on the mountain. I installed it with masonry screws and the masonry itself. I surrounded it and tucked it in with white mineral wool.

Heater / Chimney Adaptor Sheet Metal Configuration

This is also a custom piece of work. It, like the contraflow damper, was fabricated by guess who? You are right, my engineering friend up on the mountain in his shop. This piece of sheet metal transforms the air space coming out of the heater in a slot 1 ½ inches by 27 inches into an 8 inch diameter round chimney pipe. It is in essence, held in place by gravity and by the weight of my chimney pushing down on it. It connects nicely to the oven with white mineral wool in between itself and the masonry mass. I have never had a problem with it. In photo #23 you can see 3 bricks sitting on each side to hold it in place. After finishing the stone fascia the following year I removed these 6 bricks. The weight of the chimney itself is sufficient to hold it in place.

Problems

When I finished the inner core of the oven, winter was upon us and I needed heat for my home. I had been using the old iron wood stove but I was anxious to heat up the masonry mass and have a little greater, longer lasting warmth in our home. Needless to say as soon as everything was ready I filled it with split wood and a couple of pieces of news print underneath the pile and lit it with one match. Within half an hour I began hearing deep low pops. Soon after that I began seeing a few cracks around both sides of the oven core around the firebox. It didn't take long before the very hot decided to break away from the not so hot. I immediately contacted my engineer friend and decided on several steel straps to wrap around the inner core. You can see them plainly in photo #23. This solution worked perfectly. I have never had a problem with smoke leaking into my home or with the bricks falling out away from the heater or the heater breaking apart. The following summer I surrounded the core with field stone gathered from the mountain close by. To date 5 years have passed and the cracks have not allowed smoke or gases to enter my home. They expand in the winter slightly and contract in the summer when the heater cools down.

My friend told me not to fill the cracks or try to repair them. He advised that the cracks were necessary for expansion and contraction. Good advice. I have followed his advice and for the last 5 years now I'm proud to announce that the heater works wonderfully just as prescribed with no problems from smoke or fire in the wrong place. I don't know whether or not going slower with the initial fire would really have made a huge difference. How many fireplaces or masonry heaters have you ever seen that did not have a crack in them somewhere? I get my heater very warm. Nay, I get my heater hot! The masonry needs to expand somewhere. Obviously all 8 X 4 X 6 feet of this masonry hexahedron are not going to heat up to the same temperature at the same rate. As a result cracks are inevitable with any masonry heater or fireplace unless you can make critical expansion joints which are movable against each other and placed precisely where the heat is transitioning.

I did keep a small gap between the oven core and the fascia stone by surrounding the core with cardboard before applying the stone fascia. This gap might be $1/16^{th}$ to maybe $1/8^{th}$ of an inch wide. Unfortunately this did not help either. My stone fascia cracked also with the first fire the following winter. I think perhaps if I could have made the gap closer to an inch wide the heat would have had a better chance to circulate and heat the fascia more evenly. The cracks are noticeable but only if you are looking for them. Fortunately I get no ill effects from smoke or gas entering my home and the roaring fires that I light are capable of heating the entire masonry mass into a radiating almost pulsing heat source.

Changes I would make to my own design

If I could predetermine where they might occur I would use expansion cracks in the core and the fascia. Maybe the answer is placing them in every conceivable place the heater might crack. I think there might also be merit in leaving a larger airspace between the inner core and outer fascia as well as between the firebox and the rest of the heater core. If hot air can circulate more evenly across all surfaces, allowing them to heat up at the same rate it might make a difference with cracking. I think I will try a combination of expansion cracks built in as well as a wider air channel between the core and the fascia and the firebox and the remainder of the heater core. Perhaps an inch or more would allow all parts of the heater core to heat up at the same rate and prevent cracking. As I said before I have never had a problem with smoke escaping from the heater. The only issue is one of aesthetics.

The pizza oven blunder could not be fixed by moving the oven over a bricks width to the left. The smoke channel was there. I also could not have made the pizza oven smaller by a half brick because the door dimension was set. I could have stacked another row of bricks up the outside of the core but that was more costly than using the refractory cement solution. If I would have seen the potential problem when starting the project I would have just made the length of the oven ½ brick longer.

One last design change I would make would be to channel the hot smoke and gases over the top of the pizza oven instead of through it. This would keep the ash out of the oven instead of allowing the ash to accumulate in the oven. When I make pizza I have to clean out the ash and allow the fire to burn down before cooking or baking. If the hot smoke and gases surrounded the pizza oven instead of traveling through it I would not have this problem. Live and learn.

That is about it. I appreciate you reading this short writing and I hope that you have gained some insight into building your own masonry heater someday. The next heater / oven I design and build will probably have at least two more vertical channels to allow the hot smoke and gases to make one additional trip down and up before exiting the chimney to allow the masonry to absorb more of the heat.

Finally this is the home that I built to surround the masonry heater / pizza oven with the stone masonry on the exterior walls. This stone was gathered off the Blanca massif a few miles to the north and one row at a time was fashioned with the knobbiest appearance I could give it. I guess it fits my personality. This represents the first ever masonry experience in my life. The second was the masonry heater the following summer.


Photo #25

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