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Trial by Fire: A Study of Soda-Fire Kiln Construction and Glaze Formation

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Kristina is a Senior at Bridgewater State College whose work was produced as a result of an ATP summer grant, under the mentorship of Profs. Preston Saunders and Rob Lorenson. Her future plans include Graduate School, and ultimately teaching at the collegiate level.

**Abstract**

This research was centered around the construction and firing of a soda/salt-fire kiln, the study of glazes conducive to the soda/salt kiln, and production of a strong foundation for a cohesive body of wheel-thrown work in which to glaze and fire. Utilizing my existing ceramics background, I investigated the appropriate techniques and skills to build this kiln and the chemistry involved in the formulation of glazes. The use of porcelain in wheel-thrown forms has broadened my ceramic knowledge and allowed for the implementation of new textural techniques and glaze choices. My body of work in porcelain bisque-ware will be enhanced by the treatment of glazes and use of this specialized firing technique. This tactile approach to research has allowed me the invaluable experience of creation and design preparing me for future graduate research, and the opportunity to share my findings, work, and experiences with others in the ceramic community.

**Introduction**

This research consisted of three main parts. The first part was designing, building, and firing the kiln. The second part was researching glaze chemistry and testing, and third was the production of quality wheel-thrown ceramic works. The primary focus was to design, construct and fire a soda fired kiln. After researching different styles and fuel options we chose the barrel-arch cross-draft gas-fired soda kiln. My research also included the study of glaze chemistry specifically formulated for this specialized soda fired kiln. I also worked towards creating a cohesive body of ceramic wheel-thrown work consisting of graceful forms focused on the simplicity in form as well as functionality. I created these works to be fired in the soda kiln and to be used for the testing of multiple glazes and glaze techniques.
This research project allowed for personal growth in both artistic and educational arenas. The successful completion and firing of the soda kiln allowed me the opportunity to experiment with new firing techniques as well as explore different forms in clay set in an independently motivated creative working environment. The kiln design and construction along with the study of glaze chemistry has given my research a technical dimension as well as a hands-on one. The personal growth I have made through independent studio time has added to my research, greatly rounding out my experience as well as making it emotionally, physically, and intellectually rewarding.

Methodology/Significance

The design and construction of the kiln includes my partner and fellow potter Derek Hambly. Our research projects overlapped significantly and we chose to work as a team in all aspects of the kiln construction. Derek, having built a kiln in the previous summer, proved a great resource as did the considerable experience of our professors and mentors Preston Saunders and Rob Lorenson. Both Professor Saunders and Professor Lorenson had been involved in several kiln constructions prior to the development of this kiln.

Before the kiln building could start a design had to be finalized so that the proper materials could be ordered. After great debate amongst ourselves along with some very valuable advice from a kiln building supply company in Rome, Georgia we decided on the cross-draft barrel-arch gas-fired soda kiln. Next we quickly decided on the size of the kiln's interior to be about eighteen cubic feet. We chose a smaller kiln to allow for a shorter firing time and because less ceramic work is required to fill the kiln. This allows us more frequent firings. Due to a small ceramic community a smaller kiln is more efficient and practical. The kiln was built behind Woodward Hall on the Bridgewater State College campus.

Our next step included a great deal of math to figure the correct amount of materials and what sizes. When ordering material we had to choose the proper dimensions of the bricks to coincide with the planned interior size of the kiln. We ordered over three thousand pounds of soft and hard brick in several sizes and shapes, as well as self-hardening mortar, and castable refractory mortar to be shipped in from Georgia. At that time we also purchased wood for the frame, cement for the foundation of the kiln and angle iron for the permanent outside support framework. Other materials included; specialized blades to cut the bricks, trowels for the mortar, screws, nails, and so on. After receiving and purchasing all materials we were ready to begin building.

The necessary items, we started construction by mixing and pouring a concrete slab to work as a foundation in the shape of the kiln and to help protect the asphalt ground from the twenty-three hundred degree heat that the kiln would reach during firing. The concrete slab was poured about six inches larger than the actual size of the kiln on all sides to leave room for a permanent support structure to be installed later. Before pouring the concrete we placed re-bar in a cross-cross pattern for additional support. Next we put down a layer of soft brick followed by a layer of hard brick. Soft brick is a lighter, more porous material used as an insulation layer. Over the soft brick we installed a layer of thick hard brick. Hard brick is very dense and heavy and made to withstand extremely high temperatures. The entire kiln is constructed with hard bricks and then insulated with soft brick on the
entire outer perimeter. The soft brick is used as the exterior and the hard brick as the interior because hard brick is much more durable and resilient in regards to longevity.

Next we moved to the construction of the walls including the entrance and exit flues. In building up the walls careful consideration was taken in the size openings left for the flues. The entrance flue is used for burner ports and the exit flue leads out into the chimney. The exit and entrance flues are directly across from one another and must be equal in their respective total square inches, because what comes in must go out. The math for this was relatively simple however we struggled with material sizes. The sizes must be equal to assure an even temperature throughout the kiln. The entrance flue also referred to as burner ports consists of four smaller openings and the exit flue has two larger ones. We also had to leave small openings along the back wall to be used during firing for the introduction of the soda mixture.

Following the main body we constructed the chimney. The chimney must be at least one and a half times the height of the interior dimension of the kiln. The interior height of the kiln is four feet so we decided on an eight-foot chimney. The larger ratio was intentional to create more draw of flame horizontally across the interior of the kiln. The chimney also must taper down in internal dimension from the bottom to the top. The interior dimension at the bottom of the chimney started at about twelve inches by fourteen inches and it tapered down to eight inches square at the very top. Considerations for dampers at the exit flue site were taken and kiln shelves were used to slide in and out in between the chimney and kiln wall. We also added a set of passive dampers on the outside of the chimney about half way up for additional control when creating a heavy reduction atmosphere. Passive dampers are a way of creating a more subtle atmospheric adjustment.

Our next step was the construction of a removable wooden arch mold to be placed on top of the walls to work as a temporary support while we installed the arched hard bricks. The mold stops the bricks from falling inside the kiln before the key brick is placed in each row of arch brick. After the arch bricks are all placed and the mortar is allowed to harden for a few hours the mold is then removed.

We now had to build a permanent steel support structure outside of the kiln to support the arch as well as provide
stability during firing. A kiln expands and contracts due to temperature changes during the firing process and the support structure must take that into consideration. We chose to use a steel support system that we cut to size and welded together, then attached to the concrete slab. Before continuing we started a small fire inside the kiln in order to promote the setting of the mortar in the arch bricks. After the steel angle iron support structure was installed we then moved onto the back and front walls that enclose the arch. When constructing the front walls there were several considerations to account for: both the back and front walls need to have small openings to allow the soda mixture to be introduced into the atmosphere during firing. The front wall needs to have a large opening to work as a door for loading and unloading work. The front wall door was bricked up before firing and after loading ceramic works.

Our next project was the bag-wall design and insulation. The bag-wall is located in the interior of the kiln and is designed to control the flow of the flame and prevent works from direct flame exposure. The bag-wall is located about one foot from the burner flames. When the flame hits the wall it is directed upwards and along the arch, the flame swirls inside the main chamber and then out the chimney flue. This simple wall is an interical part in controlling all aspects of the kiln’s internal atmosphere.

The final step in the kiln construction was the installation of kaowool and finally the castable mortar to cover the arch. First we measured and cut the kaowool to fit the arch. Kaowool is a fire retardant fiber used to insulate the arch instead of using a layer of soft brick. Next we cut and laid chicken wire over the kaowool to allow the castable mortar a surface to adhere to. Lastly we mixed the mortar and spread it over the wire to form an adobe like roof and for even further insulation. We specifically chose this technique to contain as much heat inside the kiln during firing as possible. This design also allows for almost no heat to leak out from the arch. The mortar used is designed to set at high temperatures and would not fully cure until the firing. So once again a small fire was started inside the kiln and the venterian burners were used directly on the mortar to set.

The design and construction of the kiln lasted about five weeks. During the construction I was also working in the ceramics studio to produce work to fire, and researching glaze recipes designed for soda firing. At the same time we ordered materials for the kiln and also ordered clay to be used for my personal works. After much debate over which clay body to work with I decided on a porcelain clay body and subsequently ordered one thousand pounds of porcelain. The adjustment to this new material proved difficult, to say the least. Porcelain, unlike a regular clay body, does not contain grog. Grog is basically sand and it gives clay its stability. Porcelain is also very soft, having the consistency of cream cheese. A porcelain body is also very sensitive, allowing very little room for error when in the wet stage as well as when adding pieces onto wheel thrown works. As a
result of this unforeseen set back I was forced to start over in my wheel throwing, to relearn in a new material. Instead of starting with the sketchbook full of new ideas I began with simple forms and worked my way up in both form difficulty and size. Despite my struggle I still produced a considerable amount of work for the first firing. My forms include cups, bowls, pitchers, vases, and other larger forms. The next step towards the firing was a bisque fire of my completed green ware to prepare it for glazing.

During the construction of the kiln I also was researching glazes in books, magazines, and on the internet for glazes conducive to a soda fire kiln. I chose four glazes for the first firing to test: two slip glazes, one matt glaze, and one gloss glaze. I chose several glaze finishes in order to test the effect the soda mixture has on the finished texture. A slip glaze consists of primarily a powdered clay body and produces a matt finish that is very susceptible to flashing in a soda kiln. Flashing is when extreme temperatures cause a burst of color on one or more sections of the piece. A matt finish glaze usually has a consistent matt finish only interrupted with a textual effect caused by a build up of the soda mixture when firing. A glossy glaze will produce a glass like finish when fired. I then applied the newly mixed glazes to the work along with several studio glazes. The studio glazes have been proven successful in oxidation as well as reduction atmospheres, however not in a soda kiln. After preparing the work for the kiln we were ready to load and fired the kiln.

Before we loaded the kiln we prepared cone packs to place in several places inside the kiln to be used as a temperature gage as well as check to see how evenly heat was being distributed at different levels as well as the front and back of the kiln. The cones are designed to melt at certain temperatures as a fail-safe or a back up for a malfunctioning pyrometer. Loading the kiln went smoothly and we managed to fit all of our pieces in and then we bricked up the door, and left the kiln and its contents to sit overnight before starting the firing in the morning.

The morning of the firing we received news of rain and we quickly built a temporary shelter for the kiln to keep it, its contents, and the forced air burners dry during the firing. We lit the burners at seven am. At around four am we realized we would soon drain our two one hundred gallon propane tanks and had to refill them. We refilled the tanks with no problems and continued firing until two-thirty the next morning, until we ran out of fuel. We were then forced to introduce the liquid soda compound into the kiln before the desired temperature was reached.

Not reaching temperature in our first firing was not a shock. However it was disappointing for two reasons. Be-
cause the kiln did not reach temperature, the glazes did not reach maturity and I was unable to determine their success. They were subsequently ruined. Because we did not expect to fire off properly the first time and we knew adjustments would have to be made we were prepared for this result.

We determined from the firing that several things went wrong, however they are easily adjusted. We know that the bag wall design was an issue. When we place the bag wall originally we had planned to use four venturian burners and later changed to using a more effective forced air burner system, which only required two of the four burner ports. As a result the forced air burners lined up with openings in the bag wall and subsequently the wall's desired effect of pushing the flame up and over the wall failed. This would not have happened if we had used our original burner system. We believe due to the volume of air being forced out the chimney by the forced air burners that the interior of the kiln was too much heat. This problem is also easily solved with the installation of dimming switches in both forced air burners to give us a greater control of the air output in the kiln.

This research opportunity has allowed for personal growth in my chosen craft of ceramics as well as a tremendous learning experience. It was my goal in this research project to learn as much about kiln building as possible as well as work on my portfolio, which I will be using to apply to several graduate degree programs. Knowing that my own personal goal is to become a college professor of ceramics this project has giving me many of the tools I will need in the future to achieve this goal. This research project also taught me how to struggle; I learned how to have the discipline to reach my academic, professional and artistic goals. The results of this research will be shared with both my peers as well as professionals in the field of ceramics. My findings will allow others to learn and grow from my experiences as well as gain inspiration and encourage similar research projects.

**Future Plans**

I will be continuing my research into the fall and spring semesters. During this next academic year I will continue the production of quality ceramic works as well as glaze experimentation and testing through the firing of the soda kiln. We plan to fire the kiln several times depending on how quickly we have enough work to fill the kiln.

I will also be applying to several graduate programs utilizing work created during this research project as well as work produced during the next academic year. My portfolio also will be greatly improved from the use of this specialized firing technique through the soda kiln. After graduate school I will apply for teaching positions on the collegiate level.

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References


Ceramics Monthly
http://www.ceramicsmonthly.org/mustreads/soda.asp

Ceramic Industry
http://www.ceramicindustry.com/

Ceramics Today
http://ceramicstoday.com/articles/salt_soda.htm

Clay Times
http://claytimes.com/

Critical Ceramics
http://www.criticalceramics.org

Cuzick Pottery
http://www.cuzickpottery.com/kiln.htm

St. Earth Pottery