MAKING LIGHT WEIGHT REFRACTORY CERAMIC FROM PERLITE AND CLAY

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It is possible to make good, inexpensive, insulative, and fairly durable ceramic materials in a simple workshop with a few basic tools and with access to a potters kiln. This report describes the methods I currently use to make materials for use in stove development experiments for Aprovecho Research Center.

PREPARATION OF PERLITE AGGREGATE

The perlite, which is used in the preparation of refractory bricks, tiles, etc., must be processed before it is mixed with the other components to make the final product. This processing is done by screening the raw perlite into 3 or 4 component sizes and then recombining these components in the correct proportions.

A simple hand screen was built with a two foot wide by three foot long piece of 3/16" square opening screen mounted on top of a sloping 2x2 wood frame. A 3/32"opening screen (1/8"hardware cloth) is mounted on the underside of the same frame.

Hand shaking the raw perlite (I use "Supreme" horticultural grade "blue" which costs $8 for a 4 cubic ft bag) separates the original material into 3 different piles. What remains on top of the upper screen is between the maximum (approximately 3/8") and 3/16" in size. What passes through the top screen , yet remains on top of the lower screen is material that is 3/16" to 3/32" in size. What passes through the lower screen is 3/32" and smaller.

There is always an overabundance of the midsize (3/16" to 3/32") material and a scarcity of the smaller 3/32"size. I reprocess most of this midsize material (by running it between two kitchen rolling pins set 1/16"apart and powered by my belt sander) and re-screen it to produce a fourth component which I call "3/32" crushed". This new material contains a lot more fine powder than the original 3/32" component.

I now recombine these four components by volume according to the following formula: 4 parts of the 3/16"and larger, 2 parts of the 3/16"to 3/32", 5 parts of the original 3/32"minus, and 9 parts of the "3/32" crushed". You can mix up these batches of "perlite aggregate" in quantities as large or as small as you like.

CLAYS

I have at this point made lightweight refractory material using a variety of common commercial potter's clays. All of them are available in bulk dry powder form. All of them seem to work to some extent but some are heavier or tend to shrink or warp more than others. Some of the clays I have tried include: A P Green fireclay, Hawthorn bond, EPK, Sagger XX, Old Hickory #5, and Redart. So far my favorite is Greenstripe Fireclay which is light, strong, highly refractory and most important, cheap ($6 for a 50 pound bag at the local potters supply).

MIXING

Components can be mixed either by volume or by weight. The combination of 85%perlite aggregate and 15%clay by volume seems to produce a good combination of lightness and durability. A sample batch would be: 418gr. (4000 cc) of perlite aggregate, 381 gr. (706cc) of greenstripe, and 950gr. (950cc) of water. Any multiple of these proportions could be used. If you used a heavier clay you would have to adjust the wt. of the clay to maintain a 15%(by volume) percentage.

I first measure the water into the mixing pan and then gradually stir in the clay portion. This will produce something resembling muddy water. I then pour in the perlite aggregate mix and gently but thoroughly mix all ingredients. This will seem dry at first but will eventually come to resemble fine concrete. Resist the urge to add extra water.

FORMING AND PRESSING

The above amounts of components, when compacted in a press, will make one "green" brick with a volume of 1.881 liter. You will need to calculate the volume of the object you want to make and adjust the amounts of the components accordingly.

You will need to build a simple form, which holds about half again the volume of the compacted object. Pour the mixture into the form and then tamp it lightly to try to work out most of the air from the mixture. When the surface looks fairly solid, place the top on the press and press it down to the predetermined volume (in this case 11"X11"X1" or 1881 cc). You will find that just a little bit of water will be pressed out around the edges of the mold and a fairly solid block will be created.

My press is a simple 8-foot long lever, which gives about a 12 to 1 mechanical advantage. Heavy hydraulics are not needed.

With practice you can learn to extract the form from the brick and leave a freestanding, but damp, brick. A little oil or wax or a sheet of plastic wrap on the form will make extraction easier. Multiple bricks can then be created using the same form.

DRYING AND FIRING

The brick will need to air dry for a week or more until it appears completely dry. It is possible to speed up the drying procedure by placing the brick in an oven at a low temperature (175 F or less), but it is better to allow it to air dry slowly and evenly.

I fire the bricks to 1060 or 1100 Centigrade (cone 04 to cone 03 or 1940 to 2012 Fahrenheit). The bricks will shrink about 10% at this temperature.

RESULTS

The resulting bricks will have a density of about 0. 45 gr./ cc and seem to be fairly strong (less crumbly than commercial firebricks). These materials seem to hold up well to being heated to "red hot" in wood burning test stoves. Our test stoves often reach temperatures in the 900 to 1000 degree centigrade range (1650 to 1830 F). This composition may not be suitable for use at temperatures above the firing temperature of 1100 C (2012 F), but these temperatures are not commonly encountered in wood burning cook stoves. The perlite itself tends to shrink excessively at higher temperatures.

These materials seem to take a glaze. In initial trials, two common cone 04 potters' glazes seemed to adhere well. This property might be useful to increase the surface strength of the brick or to increase the reflection of radiant heat back into the combustion chamber.

One of the most attractive properties of this material is the cost. The material cost for the ingredients (retail, in Oregon) to make a simple "6 brick Rocket stove" is about $2.40. If these materials can be mass-produced in developing countries, the finished cost for a stove might be in the five to ten dollar range.

The development of lightweight ceramics for stoves is very much a work in progress. This recipe is only one of several possible approaches to the problem. I am now experimenting with pumice rock, for example. Regardless of the approach adopted, the goal remains the same, better stoves that do not smoke, and use less fuel available to the people using biomass.


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