The unique features of rocket-fired devices such as a kiln, heater, stove, dryer, or cooker:

1. **Smokeless**: Smokeless is the goal of all rocket engine design, so complete combustion of wood gasses, including tars and creosote, is paramount and also no potential energy is wasted out the chimney. The goal is to have less than 9 micrograms per cubic meter of particulate emissions to meet WHO and EPA clean air standards. This is clean enough to keep asthma sufferers non-aggravated.

2. **Controlled Oxygenated Airflow**: The burn box area is enclosed on five sides for the purpose of controlling the airflow direction in a laminator fashion, i.e. all in one direction as opposed to a campfire that sucks air uncontrolled from all directions. Rocket flames are controlled within a burn tunnel to keep them going in one desired direction. The flames/gasses are then allowed to rise using heat buoyancy to increase suction that is transferred to the burn tunnel and then into the burn chamber. This increased draft pulls additional oxygen through the system ensuring enough oxygen for a thorough, complete combustion. This is referred to as a "self-induced draft" as opposed to other forced air drafts such as a “bellows-induced draft” that an old time blacksmith would use. A self-induced draft draws additional air across the wood and coals to increase the heat and ensures enough oxygen for total wood-gas combustion.

3. **Emissions Incinerated within the Heat Riser**: Within the heat riser, a highly insulative material is required such as refractory soft bricks or layers of kaowool. This helps bring the gasses to a high temperature with minimal thermal load. At approximately 600°F, most visible particulates are incinerated, indicated by no visible smoke. When temperatures in the heat riser reach 1600°F most of the wood tars have been completely combusted. At above 2000° in the heat riser, a very high percent of particulates have been incinerated. A wood-fired rocket engine is one of the very few designs that burns hot enough to reduce/eliminate particulates without the need of additional chemical reaction-based items such as a catalytic converter used in very new woodstoves and commonly used on automobiles.

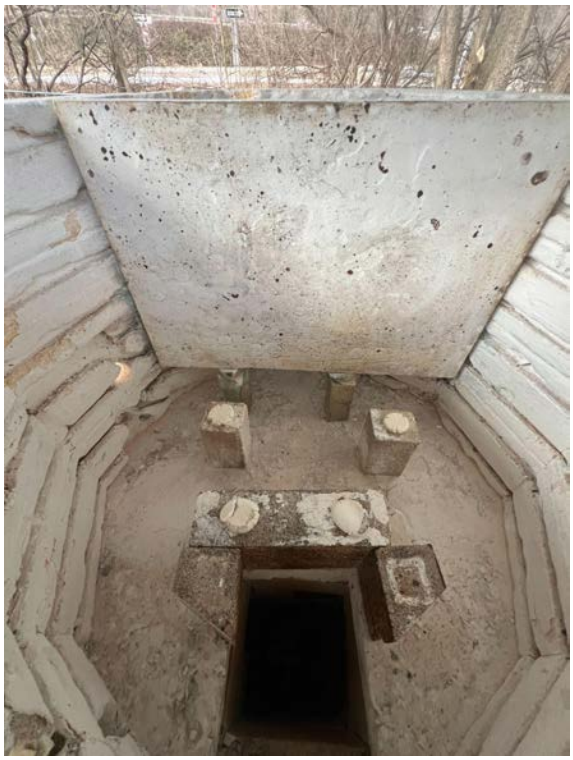
Do 

How to Design a Rocket Engine:
There are several variations of rocket engine designs based on the particular intended purpose. For the purposes of using a rocket engine in the heating of a kiln, the J-tube design works best in our experience, the design segments for a rocket kiln should be in the proportions of 1/2/3+.

For example: On a small discarded electric 4 ft.³ kiln shell (two rings of a 23” inside diameter used electric kiln) the burn box size is suggested to be approximately 7”x 7" (17cm x17cm). Therefore 7” (17cm) is one unit, so using this formula the inside length of the ceiling of the burn tunnel should be two units in length or approximately 14” (35mm). The heat riser should remain 7”x7" (17cm) in area while being at least 21” (50cm) tall: 3x the first unit of 7” (17cm), rounding up in height if necessary. The kiln adds a bit

more to the heat riser which helps to the heat riser length. The increased air buoyancy in the taller heat riser creates a stronger draft resulting in increased draw being pulled across the burning wood adding to an increase in oxygen. (This increase in draft is variable. One will need to adjust to their particular kiln's needs depending how tightly packed the kiln is and with temperature change during firing.) The kiln is necessarily placed in a high position for this design to work optimally, requiring the use of a step stool for loading.

Stagger kiln shelves increasingly over the heat riser. The bottom shelf should be placed on 4" hard firebricks and a firebrick bag wall made to block the heat from finding the chimney directly. The lowest bottom shelf sits atop the 4 inch brick bag wall not covering the heat riser at all. Wares can also be wadded and placed on the kiln floor as it also reaches the same temperature or a little hotter than the middle and top of the kiln. The second shelf overhangs the heat riser a third of the way. The top shelf overhangs the heat riser 2/3 of the way. This makes for an even-firing kiln.



For an updraft design no interior kiln shelf chimney wall is needed, just a 7x7” (17cm x17cm) hole cut in the lid on the opposite edge from the heat riser. The extra shelf space can be utilized for placing more saggers or unglazed pieces. A cut chimney hole can shed small brick particles into glazed ware so a downdraft is preferable for a glaze firing. Create a brick or kiln shelf damper over the chimney hole to close the kiln after firing.

For the downdraft version it is necessary to cut a 4 x 10” (10cm x 25mm) hole in the lid that will align it’s edge with the chimney interior wall created by installing a vertically placed kiln shelf lifted 4”(10cm) off the floor with small bricks or stilts, and slotted into the kiln wall. In this design, any flaking particles shed only into the chimney area behind the downdraft kiln shelf wall. Leave the damper wide open during firing and close completely when done. Seal visible heat cracks with clay or cob.

How to fire:

To light a wood-fired rocket engine, place a piece of lit wadded paper in the burn tunnel pushed toward the kiln to induce the draft up into the heat riser, then quickly drop wood kindling in and light the bottoms of these sticks. Alternatively, light the bottom of the kindling with a propane torch, pointing the flame into the burn tunnel.

Arrange kindling in the firebox oriented for maximum airflow into the burn tunnel (angle tops of sticks toward kiln, bottoms of sticks away from kiln) where they are sitting on the perforated kiln shelf. The 7”x9” (17cm x 23cm) perforated shelf acts at the primary air intake and thoroughly combusts all the coals created by the wood stacked above it. Add wood approximately every 3 minutes, or when the pyrometer stops rising in temperature. While firing and adding wood, take care not to pack coals into air holes blocking airflow. Occasionally it may be necessary to clear ash from under and on top of the perforated shelf during firing if kiln stalls, though for most firings this is not needed.

Keep one brick covering the top of the burn chamber and adjust a 2nd as needed to ensure flames are always burning in a downward direction. The flames should not climb out of the firebox. If unable to control the flames

downward, the most likely reason is poor draft caused by a bottleneck somewhere in the system (fallen brick, fallen ceramic object in heat riser, wood blocking burn tunnel, chimney hole in lid needs to be larger, wares too tightly packed, etc.)

Correct wood stacking for maximum airflow pictured above, tops of kindling angled toward kiln.

Avoid arranging wood so that it blocks airflow into the burn tunnel.

Place and adjust brick covers atop the burn chamber to control airflow to help direct flames down and sideways into the burn tunnel.

Chimney needs to be approximately 3 ½’ to 4’ tall made of double-wall or insulated metal 8” (inside diameter) pipe, soft firebricks, or ceramic wool held in place with a sturdy wire mesh.

An overstuffed firebox can result in flames coming out of the chimney, a sign of wasted fuel. Gently stir the ashes to keep the perforated kiln shelf open and supplying air to the coals. A brick a few inches in front of this can be adjusted during firing and to close the kiln at the end. Ideally use a pyrometer to gauge the heat rises and falls and to help knowing when to stoke. Use cones for a highly accurate reading. Be cautious about what combustibles may be above the kiln and do not fire indoors (Chimney gases may exceed 2,000F (1,100C).

Wood needs to be extremely dry, 2” diameter or less, and 12-16” length. The smaller diameter the wood is, the better. The commercially available “Kindling Cracker” is a wonderfully designed tool that offers a safe way for anyone to split wood quickly. Flooring cut-offs or woodworker’s small scraps are ideal for burning. Hardwoods are preferred. Softwoods are fine depending on the desired temperature and speed of the firing. Temperatures above cone 11 have been reached in 3-5 hours of firing with 3-4 wheelbarrows of dry kindling.

Kindling Cracker and mallet

There is not enough time for much ash accumulation though light flashing occurs at high temperatures. Soda firing can give beautiful atmospheric results, remembering that the kiln, furniture, etc need to be coated with a thin layer of alumina hydrate + EPK shelf wash. It is easy to fire this in oxidation, and reduction can be achieved by closing the burn box, damper, and/or partially covering the primary air below the perforated kiln shelf.

Here is the remaining ash after firing to cone 11 in approximately 5 hours. No ash cleanouts were required.

Rocket fired kilns can be a useful and economical tool for small scale clay projects. Discarded outdated electric kilns can be taken apart for their refractory bricks or re-utilized as a cheap or free firing chamber. This design is quick and easy to build and can be disassembled and stored easily after firing. With some experience the rocket kiln can be reassembled in 45 minutes. <<<<This design can and should be adjusted to fit particular needs and available resources.>>>

Ceramics is fun.
Sitting around a fire is relaxing.
Enjoy the day!

Team Rocket Kiln
Lisa Orr
Rodney Morgan
Chris McClellan, aka Uncle Mud
and assorted Permaculture pals