Starting a Rocket Stove Project
With the Seyhan Adana Rotary Club

Making Energy Efficient Stoves

By Ken Goyer

Millions of people in the world cook on open fires or on unimproved stoves. An improved stove would be a tremendous benefit to them because they would save half or more of their fire wood, save time, breathe less smoke, improve their health, receive fewer burns, and save the environment.

The best improved stoves are based on the Rocket Stove principles. The Rocket stove in its purest form is a theoretical construct based on The Ten Rules of Combustion by Dr Larry Winiarski. These rules were originally stated over twenty years ago and they can be used to make many different types of stoves. Please see the appendix for Larry's Ten Rules of Combustion. Also see the booklet "Design Principles for Wood Burning Cook Stoves", by the Aprovecho Research Center.

The goal is to apply these Ten Rules of Combustion to make a stove that will serve your needs. The stove must be within your resources to make. Generally speaking, the more money you spend to make a stove, the better and more useful and more attractive it will be. But most of us are limited by our finances or the availability of materials in the choices that we can make. I hope to present some of these choices here so that good and useful, but affordable stoves can be built.

Demonstrating the Rocket Stove Principles

Many people have never seen an improved Rocket stove, and so they do not understand the benefits that come from their use. Therefore, it is beneficial to make some stoves quickly, that can demonstrate the principles and how these stoves work. Later, the details and finer points can be refined into stoves that that will be durable and marketable. When Rocket combustion chambers were first developed they were made from sheet metal. But because of the intense heat inside, which is necessary for all of the wood to be burned up, the combustion chamber itself burned up. This made for a very short life for the stove and made it impractical. The search began for materials which would withstand the extremely high temperatures of combustion. Eventually, lightweight insulating ceramics were developed that fill the dual role of withstanding high temperatures and providing the insulation necessary to keep the heat inside. We are constantly searching for new materials to fill this role, but the best materials so far are ceramics made from clay.

Ytong, an inexpensive, locally available brand of aerated concrete held some promise as a construction material. Unfortunately, testing has shown that it too, probably will not withstand the high temperatures necessary for the hot face of a combustion chamber. We have made a number of demonstration stoves using Ytong and some of these stoves are now in use by various people. After six months or so we can question the users for their opinions about these stoves and how they might be improved.

These Ytong rocket stoves are based on Larry's Ten Rules of Combustion.

The First Step, Choosing the Stove

The first step in making energy efficient stoves is to decide who will use them and for what purpose. The same principles can be used to make many types of stoves, very small stoves suitable for making tea, to very large industrial stoves used in commercial kitchens. Stoves can be made with chimneys for use indoors and they can be designed for heating as well as cooking. It is probably best to start with one simple design first.

These are some of the stoves made to demonstrate the Rocket stove technology

All good Rocket stoves begin with an insulated combustion chamber

This is necessary to keep the heat from being lost from the stove. The goal of the stove is to have high temperature combustion, so that everything is burned up, and then to transfer this heat to the pot so the food can cook.

There are at least two ways to make an insulated combustion chamber

The first way is to make lightweight insulating ceramic bricks.
The second way is to use a high density, but thin, ceramic hot face and then back it up with insulation.

Making lightweight insulating ceramic bricks.

Making a combustion chamber from lightweight insulating bricks is a good idea because these bricks can be quickly and cheaply mass produced. Once a formula for the brick has been discovered by experimentation, and a shape and size for the brick has been chosen, then these bricks can be made by a brick maker quickly and in large quantities. The bricks serve as the hot face and the insulation of the stove. They can be used free standing or put into a container to make a portable stove. One drawback is that they can tend to be a little soft. So some care must be taken with them both in the manufacture and transportation and when the stove is being used. The tendency is for the stove user to rub the back of the combustion chamber with sticks thus causing it to crumble. Even so, very good and inexpensive Rocket stoves can be made from this material.

When I first arrived in Adana, I attempted to make some insulating bricks. Since time was short and since it takes some time to make and fire bricks, and we needed them right away in order to demonstrate the Rocket stove, I decided to use a formula that has been successful in the past instead of starting by testing. Testing would have told us what the best mixture of ingredients would have been. Unfortunately, these bricks were a failure. They were too soft and they crumbled. Later, I ran the proper test but in the meantime we made stoves from Ytong for demonstration purposes.

Six of these trapezoidal bricks will make the combustion chamber of a Rocket stove.

The proper thing to do is to run some tests **first!**

These are not ordinary bricks! If properly made, they will float on water. The fact that they are lightweight means that heat will not pass through them (as fast) and so they are insulative. How do you make a brick that will float on water? By putting organic material such as sawdust into the clay. When the brick is fired the sawdust burns out leaving little holes that fill with air which acts as insulation. By putting in the right amount of sawdust you can make a brick that is lightweight enough but strong enough. Too much sawdust makes a brick that is lightweight but too weak. Too little sawdust makes a brick that is not insulative and will rob the heat from the fire. The way to determine how much sawdust to put into the clay is to make an experiment. Other ingredients might also be helpful. The way to find out is to experiment.
Varying amounts of clay and sawdust are mixed together and made into small test discs. These discs are fired in a kiln and then studied to determine if they are strong, but light enough to float.

For a test, I made discs using the following amounts of clay, sawdust, and alumina cement.

Disc no.	1	2	3	4	5	6	7
clay	10 parts	10 parts	10 parts	10 parts	10 parts	10 parts	10 parts
sawdust	8 parts	9 parts	10 parts	11 parts	12 parts	13 parts	14 parts
cement	0 parts	0 parts	0 parts	0 parts	0 parts	0 parts	0 parts
Disc no.	8	9	10	11	12	13	14
Clay	10 parts	10 parts	10 parts	10 parts	10 parts	10 parts	10 parts
sawdust	8 parts	9 parts	10 parts	11 parts	12 parts	13 parts	14 parts
cement	1 part	1 part	1 part	1 part	1 part	1 part	1 part

Disc no.	15	16	17	18	19	20	21
Clay	10 parts	10 parts	10 parts	10 parts	10 parts	10 parts	10 parts
Sawdust	8 parts	9 parts	10 parts	11 parts	12 parts	13 parts	14 parts
Cement	2 parts	2 parts	2 parts	2 parts	2 parts	2 parts	2 parts

Ingredients were measured by volume using a small container. Measuring spoons would have been helpful. The ingredients were mixed and formed into small discs and allowed to dry. Then they were fired in a small chamber made from Ytong scraps. A propane torch was used as a heat source. After cooling, the discs could be examined.

The discs were fired using a propane torch. Because they are small and thin they fire quickly.

Will It Float

After firing the discs they were examined. All of them seemed to be pretty strong and all of them floated on water. (To see if a disc (or other object) floats it should be placed into a plastic bag to keep it from absorbing water). This is a good sign that the clay is of good quality But this means that the test was inconclusive. Maybe the discs could have even more clay thus being stronger yet and still float on water. A good test would have samples from both extremes. It would have some discs that would not float and it would have some discs that were too fragile. Then a sample from the middle could be chosen. So this test should be repeated using less sawdust to clay. Actually a brick that will float has a specific gravity of less than one, since the specific gravity of water is one. The lower the specific gravity the better the insulation. We have made successful bricks with a specific gravity as low as six tenths. But we know from testing, that insulation at least two inches (5 cm.) thick with specific gravity of less than one, will make a good combustion chamber for a Rocket stove.

Thin ceramic hot faces

The other option is to make or find a thin ceramic to be used as the hot face, the piece nearest to the flames and the hottest part of the stove. Since this is high mass and will rob the stove of its heat, it should be thin. Thick, heavy bricks or other ceramics should not be used since the high mass will rob the stove of its heat causing poor combustion and poor performance. The wall of a clay flower pot, certain ceramic roofing tiles, and certain floor tiles can be cut into the right shape to make a combustion chamber in this manner. This combustion chamber is then backed up with insulation. When the stove is in use the high mass hot face gets hot but the insulation stops the heat from being lost any further. This can make a very good stove if the right ceramic is made or located. It needs to withstand the constant hot/cold cycling of the stove without cracking excessively. Another disadvantage is that the insulation must be contained in some vessel, like a metal can. But if a portable stove is to be built then the can is already necessary.

This potter is making clay cylinders to be used as the hot face in Rocket stoves.

Even a primitive heap burn successfully fires the cylinders. (As it will test discs)

The cylinders are then cut into segments to allow for expansion and contraction. An opening is cut for the wood to enter and the pieces are wired back together.

Here is a combustion chamber made from a flower pot.


To make it into a stove the combustion chamber is then placed into a can or other container. Large flower pots have also been used instead of the can. Surrounding the combustion chamber is insulation. Few materials make good insulation for high temperatures-- Dry, uncompacted wood ash, perlite, pumice, vermiculite, Ytong…That leads us to the next idea.

The Next Idea

Take the Ytong stove and bore it out to a bigger inside diameter and put a ceramic cylinder inside for a hot face. Don't forget to cut the cylinder into segments to allow for thermal expansion. Once combustion is complete and the gasses cool a little the Ytong **probably** will hold up to the lowered temperature and make wonderful insulation for the stove.


Ken’s Wordless Workshop

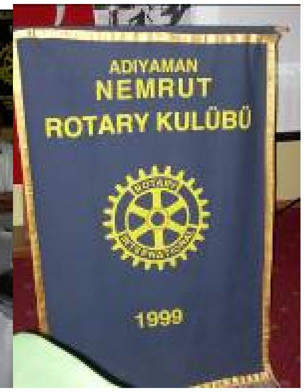
Mind the Gap!

While all of the Rocket stove rules are important to follow, there are two categories that need some special attention. The first is to pay attention to the combustion and the second is to pay attention to the heat transfer to the pot. Even if you have lousy combustion but you have good heat transfer from the flames to the pot you will have gained with your stove. Of course, it's better to have good combustion too, but don't overlook getting the heat from your fire into your food. This is done by keeping the proper space in which the flames travel under and around the pot. This space needs to be big enough so that the fire will not be choked off, but small enough so that the heat will hit the pot and not just go off willy nilly. (I hope you know what willy nilly means). Please feel free to continually study the subject of heat transfer.

Thank You!

I want to thank all of the wonderful people who took me into your families, fed me, translated for me, helped me, listened to me, and let me get dirt in your cars. I wish you the best with this project and I hope I can be of service to you in the future. Best regards, Ken Goyer


ADANA
SEYHAN
ROTARY KULÜBÜ
1976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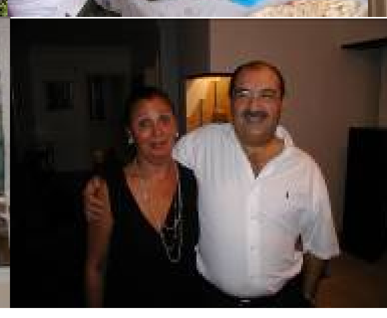
NEMRUT
ROTARY KULÜBÜ
1999































All these guys’ mothers or wives are testing the Ytong Rocket Stove.


Let’s not forget who can really benefit most from the improved biomass stove.

10 RULES OF ROCKET STOVE COMBUSTION

By Dr. Larry Winiarski

1. Don't heat more wood than you are burning. Don't heat too much wood (surface area).

2. Get the right amount of air. Not too much, not too little.

3. Air should enter with velocity. Like blowing on the coals.

4. Air/fuel/air/fuel…..mixing.

5. Air interleaved or underneath the wood.

6. Wood arranged, 2-3 pieces of wood with spaces for air. People in bed keeping each other warm.

7. All combustion to take place in insulated low mass surroundings. Don't lose heat. Don't absorb heat at startup.

8. Complete combustion at high temperature, then extract heat.

9. Vertical chimney, insulated and hot provides strong draft, more time for combustion. This is the big secret of the Rocket Stove.

10. Air flow passages the same cross section.

11. Feed opening sized for power output of stove. Too large= too much cold air, too little velocity. You need the velocity to keep the flames going up and mixing air.

12. Dry wood. 2-3 sticks for radiation. After starting, not too much surface area.

BELEŞ OCAK

1. Yakacağınız kadar çalı çırpı kullanın. Fazlası gereksizdir.
2. Yeteri kadar hava sağlayın; ne çok ne de az olsun.
3. Hava, mangala üflüyormuş gibi hızlı girmeli.
4. Hava ve yakacak karışımı şart.
5. Hava girişi dalların arasından ve alttan olmalı.
6. Dal parçaları yan yana dizili olmalı, aralarından hava geçmeli. Yatakta ısınmak için bitişmek gibi.
7. Tüm yanma izolasyonlu hafif kütleli bölgede olmalı. Isı dışarı kaçmayacak ve kütlece emilmeyecek.
8. Yanma yüksek ısıda olmalı. Isı transferi bunun ardından olmalı.
9. Düşey baca izoleli ve sıcak olunca iyi çekiş sağlar. Baca uzunluğu tam yanma ortamını oluşturur. Beleş ocağın sırrı buradadır.
10. Hava kanalları baştan sona aynı kesit alanına sahip olmalı.
11. Dal besleme ağzı ocak verimine göre olmalı; büyükse soğuk hava girişi artar, hava hızı azalır. Ateşin devamı için hava hızlı karışıma girmeli.
12. Kuru dal kullanın, 2-3 dal radyasyona yeterli. İlk yandıktan sonra çok yüzey alanı gerekmez.

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