How to build a solar cooker with parabolic reflector in 3 parts

In 3 Youtube films https://youtu.be/9Q_VzJ3P4wc
https://youtu.be/s34NRYzmL6c
https://youtu.be/cSrxndJZOjE

I show you how to build a solar cooker with a parabolic reflector. This pdf document contains in blue letters all necessary details including a material list, which makes the construction easier for you. There are also versions of this document in other languages. First, some general informations:

It is a solar cooker with a parabolic reflector of just over 1 m^2 of caption area, which corresponds to a theoretical output of about 1 kW. The production requires several materials and quite skilled craftsmanship in dealing with these materials and tools. It must be worked exactly, therefore, all the dimensions of this construction manual are given in millimeters.
The solar cooker is suitable for use in tropical areas with low cloudiness during daytime (preferably between 10 am and 3 pm), e.g. in northeastern Brazil, North Africa or the Sahel. During the cooking process, the cooker and the reflector must be re-aligned periodically (approximately every 20-30 minutes) to the sun. This is one of the main differences to the Cooking Box whose construction is describet in the document www.cumaru-pe.com.br/data/documents/Sonnenkocher-fur-tropische-Gebiete.pdf (in German, sorry)

Note: The use of the cooker with parabolic reflector involves risk of burns and damage to your eyes !!!

The cooker described here serves to cook in a single pot with or without a cover. This pot must have at least on its outside a mat black surface on its bottom and sides.
To construct the parabolic reflector, we first have to make a negative mold from cement. This shape can then be used for the production of several equally large reflectors. The relatively deep bowl shape chosen here has the advantage that the pan is slightly protected from the wind by the upper part of the reflector, and both the pot and the

reflector are easily accessible for the cook. This in turn has the disadvantage that there is a risk of glare and burns for clumsy persons and objects in the vicinity of the focal point. One does not expect a great heat development in the middle of an "empty" space.
The reflector presented here will have the shape of a shallow bowl which will have a diameter of 1'210 mm and a depth of 360 mm. The focal point will be 250 mm above the reflector base.
Before you start buying the materials, providing the tools and building the cooker, I recommend that you read this instruction manual completely so that you do not experience any unpleasant surprises. Inform yourself also about possible alternatives and risks of construction and operation, e.g. on the following website:

http://cumaru-pe.com.br/english/renewable-energy/
especially in the following documents

http://cumaru-pe.com.br/data/documents/Sonnenkocher-mit-Parabolspiegel.pdf and
http://cumaru-pe.com.br/data/documents/Sonnenkocher-fur-tropische-Gebiete.pdf

The net working time for the construction of the solar cooker (without the time for the procurement of the material) amounts to scarcely more than two days. However, longer waiting times must be counted between the individual work steps, so that for the production of the first digester about two weeks must be estimated.
It is advisable to start (as shown in the films) not with the frame, but with the negative mold of the parabolic reflector.

Note: For people who want to make a larger and more efficient solar cooker, I have calculated the mold values for a cooker with double power (see appendix at page 10). However, it should be noted that in this case, the other materials and values must be adjusted accordingly. If the parabolic reflector should have another mass, there is a practical tool in Excel format with which the shape of the template can be calculated. The tool can be downloaded from http://cumaru-pe.com.br/data/documents/Calculation-parabola.xls .

Material list for a 1'000 watt cooker:

Number	Material	Length [mm]	Width [mm]	Height [mm]	Diameter [mm]	Volume [Liter]	Surface [m^2]
1	plywood sheet	650	500	ca. 8			
1	plastic tube	360			ca. 10		
	Building rubble or stones or compacted soil					200	
	cement					16	
	Sand					30	
	fine sand					30	
	gravel					50	
	Gypsum					0.5	
	Release wax					0.5	
	Epoxy resin and hardener					3.5	
	Fiberglass weave						5
1	Iron wire	8000			ca. 3		
1	Plastic tube	100			ca. 10		
	Aluminum foil, possibly self-						1.8

	adhesive						
1	steel tube	1100			ca. 20		
2	steel tube	250			ca. 5		
4	Furniture castors						
2	Wood horizontal	1100	20	70			
2	Wood vertical	600	20	70			
2	Wood vertical	600	20	70			
Div.	Screws, nails, small parts						
1	watch chain	1000					
1	Black frosted pan, with cover				max. 220		

tool list

Writing utensils, scale, jigsaw, sandpaper, hand saw, bucket, trowel, shovel, trowel, plastic gloves, brush, scissors, round file, screwdriver, respirator, drill, metal drill, wood drill, welding apparatus, cloths.

Part 1: The negative mold of the parabolic reflector

See: https://youtu.be/9Q_VzJ3P4wc

1. Draw the shape of the template on a plywood sheet.

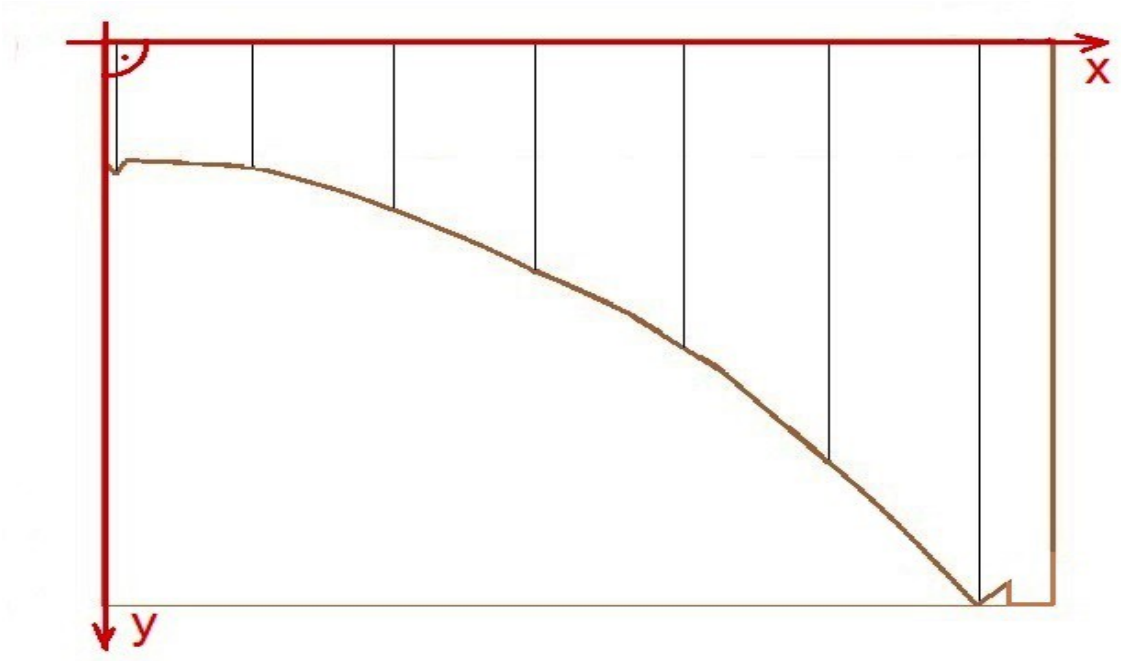
Take a plywood sheet of 650 mm x 500 mm x approx. 10 mm with at least one right angle (90^0). Draw a parabola with the help of the following values (start with the right angle and x-value = 0 at the top left!). The calculations are based on a reflector radius of 60.5 cm (this corresponds to a captured area of 1.14 m^2), a maximum depth of the parabolic reflector of 360 mm and a focal height (distance of the focal point from the bottom of the reflector) of 250 mm. The incision at the right end of the parabola has the purpose that later the negative form is limited by a wall, which gives the parabolic reflector a cleaner edge. In the film I did not succeed because the wall did not hold on the slippery surface. Maybe you'll do better than me.

x [mm]	y [mm]
0	100
5	110
10	100
20	100.23
50	102
100	109
150	121
175	128.9
200	138
225	148.4
250	160
275	172.9
300	187
325	202.4
350	219

x [mm]	y [mm]
375	236.9
400	256
425	276.4
450	298
475	320.9
500	345
525	370.4
550	397
575	424.9
600	454
605	**460****
635	435
636	**460****
650*	**460****

* biggest value for x

** biggest value for y



2. Cut out the template with the jigsaw.

Now saw with the jigsaw along the parabola so that (as shown above) only the brown part remains. Make sure that when sawing, the saw blade is perpendicular to the plywood sheet and the pencil line is preserved

(it is still possible to remove it afterwards, but not to add any material!).

3. Sand the edges with sandpaper.
Now remove any irregularities of the sawn edge up to the pencil line, first with coarse sandpaper, then with fine one. Round off the edges of the saw edge with sandpaper. Tip the axis slightly (at x = 5 mm).

Note: The following working steps take place outdoors, on a shady, flat surface of at least 1.5 m x 1.5 m.

4. Place a plastic tube in the middle and pile stones or building rubble around it so that there remains a space of about 5 cm to the template.
The tube must have a length of exactly 360 mm (this measure corresponds to the later depth of the parabolic reflector) and a diameter of about 8-10 mm. It has the function of an axis around which the template (from step 2) can be rotated. The tube should be placed exactly perpendicular to the surface. It will need about 150-200 liters of building rubble, stones or compacted soil.

5. Cover the stones with concrete so that there remains a space of about 1-2 cm between it and the template.
Weak concrete consists of cement, sand and gravel in the ratio 1:3:5. For the volume of about 90 liters, it takes about 10 liters of cement, 30 liters of sand and 50 liters of gravel. The mass should not be too moist, so that it does not flow too much between the stones. To prevent this, a fine plastic wrap can also be drawn in between stones and concrete. The more accurately the (cheaper) concrete mass is applied, the less (more expensive) cement mass will be needed at step 7.

6. Cover the concrete overlapping with wire mesh or tissue.
This step is expecially useful if the negative mold will be left for a long time, that means for the production of several parabolic reflectors. The mesh or tissue prevents from cracks. It is recommended to place the mesh on the still wet concrete.

7. Cover the mold with a pasty mixture of cement and fine sand and give it the right shape with the mold.
This mass consists exclusively of cement and fine sand in the ratio 1:4, therefore about 6 liters of cement and 30 liters of fine sand. The mixture should be mixed with water that it can be well formed with the trowel and with the template. If necessary, water must be added on site with a broom or sponge. This step can also be carried out without waiting immediately after the mesh has been applied (step 6).

8. Smooth the surface with a trowel.
This step should be carried out only when the mass is already somewhat hardened. Care must be taken to ensure that the inclination of the surface no longer changes. In the film I use a tool made of wood, but better would be one made of steel.

9. Let this mold completely harden on the shade. Sprinkle the surface occasionally with water during the first few days.
Cement hardens better when wetted periodically. This can be done by careful spraying, alternatively by placing wet towels or both. Cement is generally fully cured after a waiting period of 3 months, but for our purposes a curing time of a few days is sufficient. It is not a bridge ....

10. Smooth the hardened surface with a flat stone.
The purpose of this step is to remove any particles that might be protruding from the surface.

11. Any protruding tissue parts can be burned away with a gas burner.

12. Cover the surface of the mold with a thin layer of gypsum and let it harden.
This layer is necessary to fill in the small depressions created by the smoothing (step 8) and the sanding (step 10) of the surface.

13. Sand the surface first with a flat stone, then with fine sandpaper.

The smoother the surface, the less (expensive) release paste is needed in step 15, and the better the parabolic reflector can later be detached from the negative mold (step 19).

14. Free the surface and its environment from dust.
First with broom, then blowing.

15. Apply a thin layer of release wax to the dry surface with a towel and polish it.
Release wax is not easily available everywhere. In case of emergency, a test with heated paraffin wax, grease or silicone or silicone spray can be made.

Note: The mold for the parabolic reflector is now ready. With it many identical parabolic reflectors can be made. You can see how this happens in the next clip.

Part 2: Manufacturing the parabolic reflector with fiberglass

See: https://youtu.be/s34NRYzmL6c

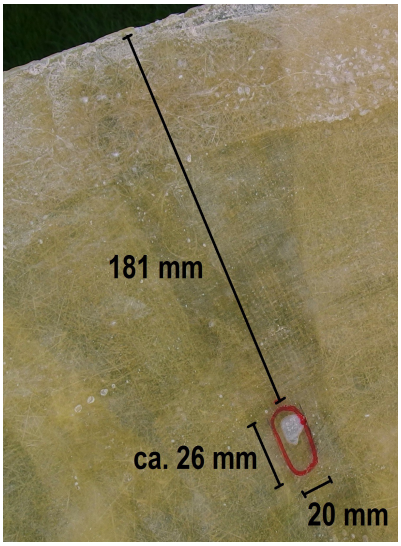
16. Mix epoxy resin and hardener as described in the specification and cover the mold with a first layer.
In total, about 3.5 - 4 liters of liquid are needed. After adding the hardener, the liquid can be processed for approx. 10-30 minutes, depending on the product and temperature. It is recommended not to mix more than one liter at a time. If a flexible bucket is used, hardened remains can be removed and the bucket reused. For mixing a wooden stick is suitable. The application is made with a cheap brush, which must be thrown away after. I recommend the use of disposable plastic gloves.

17. Cover the surface completely and overlapping with fiberglass mat.
The fiberglass mat should be cut into pieces before mixing the resin, because after there will be no time for it. The mat can be pressed with a brush.

18. Repeat the last two working steps. Make sure to reinforce the reflector's edge.
Overall, I recommend 3 layers of fiberglass which can be applied wet on wet. The reflector's edge should be reinforced with an additional layer. In my case, this was not enough, because the reflector remained too flexible even after complete curing. Instead of the subsequent installation of a thick wire near the edge (step 24), this can also be done now.

19. Let the reflector harden for a week and then remove it from the mold.
During curing, the resin changes color and loses most of its flexibility. To remove the reflector from the mold, the edge must first be cut clean with a blade, then carefully raised. Maybe several people are necessary for this, at least a lot of patience and strong nerves!

20. Draw the places where the holes for the axis must be drilled.



The holes have an oval shape because the axis does not cross the reflector wall in a 90^0 angle. The outer edge of the hole is exactly 181 mm from the edge of the reflector, the width corresponds to the diameter of the axis (see step 29). The length of the hole is about 26 mm, depending on the diameter of the axis. With these values, the bottom of the cooking pot will be about 2 cm below the focal point, which means that the focus will be inside the cooking pot. This step must be done as accurate as possible. If the holes are placed in the wrong place, the reflector will not hang in the correct position, or the focus of the parabolic reflector will be outside the cooking pot.

21. Drill one of the holes completely, the other (opposite) for the time being only with a small hole.
With the steps 21 to 23 a possibly incorrect position of the holes can still be corrected.

22. Pass a string or wire through the two holes to check the location of the second hole.
The bowl should hang on the wire so that the bowl edge is horizontal. If this is not the case, the second hole should be moved accordingly.

23. Now drill out the second hole at the corrected point.

24. Attach a plastic tube to the edge of the reflector. If the reflector is not stable enough, it can be strengthened with an iron tube or a thick wire.

When using the solar cooker, this tube will allow the controlling whether the parabolic reflector is properly aligned with the sun: If the sunlight falls freely through the tube to the ground, the reflector is perfectly aligned. It does not matter in which place the tube is attached to the reflector, but it must be in a perpendicular position to the plane which is formed by the edge of the reflector. I recommend a point at 90^0 to the axis, which is near the place where the cook will stand.

25. The two holes for the axis can also be reinforced with fiberglass.

The area between the axis and the edge of the bowl will be more mechanically consumed by the manipulation of the parabolic reflector, therefore reinforcing this position by another layer of fiberglass is justified. Even now, it is advisable to allow the resin to fully cure before the next step.

26. Free the reflector's inside of release wax residues.

Unfortunately, the release wax sticks not only to the negative mold but also to the inside of the reflector. A good cleaning of this surface is a prerequisite for the adhesion of the mirror foil (see next step 27). The cleaning is done first with a blade, then with sandpaper and finally with acetone or gasoline.

Part 3: The completion and use of the solar cooker

See: https://youtu.be/cSrxndJZOjE

27. Cover the inside of the parabolic reflector with reflective aluminum foil.
Overall, an area of approximately 1.80 m^2 is required. In the film, I use a self-adhesive, plasticized aluminum foil, which can be attached well, but has the disadvantage that it melts, if some hot food falls down on it. You can also take extra heavy household foil, but then first apply thinly a suitable glue (contact adhesive, for example) with a brush. Since the surface is curved, the foil must be applied in small parts. I used 42 wedge-shaped parts of 65 cm of length and 2-10 cm width, so that they can be glued together slightly overlapping, followed by 4 parts for the reflector base.

Note: Steps 27-32 should be executed in the shade or with good sunglasses or both, as there is an acute risk of glare and burns.

28. Cut out the holes for the axis and visor.

29. Make an axis out of iron or steel.
The length of this bar is at least 110 cm. It should be so strong that it can withstand its own weight, the weight of the parabolic reflector and the weight of a filled pan without bending. In my (luxurious) case, the axis is made of stainless steel with an outer diameter of 20 mm. In the area of the center, a device is to be welded which allows the setting of the pan. At both ends I drilled holes which allow a fixation of the axis, so that it can not turn.

30. Mount a rotatable rack for axis and parabolic reflector.
This rack can be made of any material. Wood is easier to work with and cheaper than iron, but it needs to be protected from moisture by varnish. The width of the frame is identical to the length of the iron bar from step 29, the height must be at least half the diameter of the parabolic reflector, so that the edge of the reflector does not touch the ground in low sun position. The installation of 4 rotatable wheels will allow the rotation of the rack around its vertical axis. The parabolic reflector is fixed in its position with a watch chain between the reflector's edge and the rack.

31. Align the reflector with the help of the visor exactly in the sun.
Positioning is done by rotating the rack and tilting the reflector. When the sunlight shines through the visor and leaves a round light spot on the ground, the reflector is in the correct position. Now food can be put on the stove. If the pan is also dark in its inside, it is recommended not to use a cover, especially when the sun is low.

32. The exact location of the focus can be checked with a paper or a piece of wood.
The focal point should not be exactly on the axis, but slightly above, inside of the pot.

Appendix: Variants

1. Bigger cooker :
The parabolic reflector can be increased as desired, which increases also its power. With a captured area of 1 m^2 I was able to boil one liter of water within 5 minutes at a relatively low position of the sun.
Here I add the template values for a cooker with double power (illuminated area = 2 m^2). This time the focal point is 350 mm and the axis is 330 mm above the reflector base. Thus, the part of the reflector lying below the axis has about 55% of the total weight, the part lying above the axis about 45% of the total weight, whereby a good hanging of the parabolic reflector is guaranteed.

x [mm]	y [mm]
0	100
5	110
10	100.01
20	100.16
50	101.45
100	106.45
150	115.02
175	120.64
200	127.16
225	134.57
250	142.86
275	152.07
300	162.16
325	173.14
350	185.02
375	197.79
400	211.45
425	226

x [mm]	y [mm]
450	241.45
475	257.79
500	275.02
525	293.14
550	312.16
575	332.07
600	352.88
625	374.57
650	397.16
675	420.64
700	445.02
725	470.29
750	496.45
775	523.5
800	551.45
805	557.14**
830	530
831	557.14**
850*	557.14**

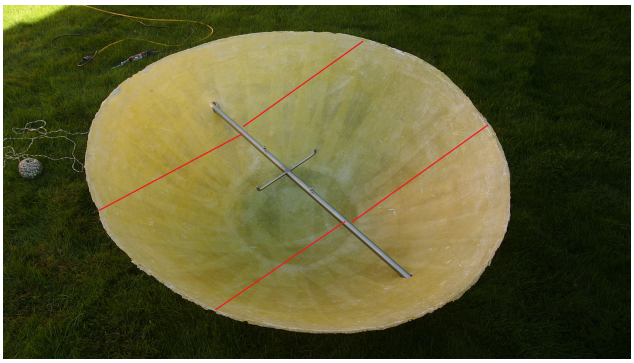
* biggest value for x
** biggest value for y

Of course, with these values for constructing the template, several other measures change:

- Captured area = 2.01 m^2 (instead of 1 m^2)
- Surface of the parabolic reflector = 2.7 m^2 (instead of 1.8 m^2)
- Plywood board for the template = 850 mm x 560 mm (instead of 650 mm x 500 mm)
- Plastic tube = 457 mm (instead of 360 mm)
- Cement = 25 l (instead of 16 l)
- Sand = 45 l (instead of 30 l)
- Epoxy resin = 5.5 l (instead of 3.5 l)
- Fiberglass fabric = 8 m^2 (instead of 5 m^2)
- Aluminum foil = 2.7 m^2 (instead of 1.8 m^2)
- Length of steel tube for axis = 1'800 mm (instead of 1'100 mm)
- Minimum distance of the axis' holes to the reflector edge = 180 mm (instead of 181 mm)

2. Reinforcement of a too flexible parabolic reflector without thick wire

Instead of reinforcing the edge of the parabolic reflector with a thick curved wire or tube (step no. 24), it is perhaps also possible to connect the two low-hanging parts of the reflector's edge to the axis with two wires each. These wires should not come too close to the focal point, so they do not heat or reduce the efficiency of the cooker.



3. Replacement of fiberglass with other materials:
I am trying to replace the more difficult-to-process and environmentally harmful fiberglass and epoxy resin with other materials, e.g. with a mixture of waste paper and fish paste. For this purpose, waste newspapers, fish paste and oil paint would be needed instead of the epoxy resin and the fiberglass mat. The procedure will soon be explained on my Youtube channel.

4. Completely different construction:
If the reflective part of the cooker is sufficiently stable, the reinforcement by fiberglass and epoxy resin can be dispensed. I am developing a mountable and dismountable type of reflector with circular sectors made of highly polished chrome steel sheet. Again: As soon as I have a workable solution, I will introduce it on my side www.cumaru-pe.com.br and report on my Youtube-Channel.

For praise, criticism, expressions of opinion, suggestions: gotobrasil [at] gmx.ch

This document can be downloaded from the following address:

http://cumaru-pe.com.br/data/documents/Solar-cooker-with-parabolic-reflector-construction-manual.pdf

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