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# Parabolic Solar Cooker SK1.4 with Structure of Round Steel

Open Source Appropriate Technology (OSAT) Documentation
http://solarcooking.wikia.com/wiki/Dieter_Seifert

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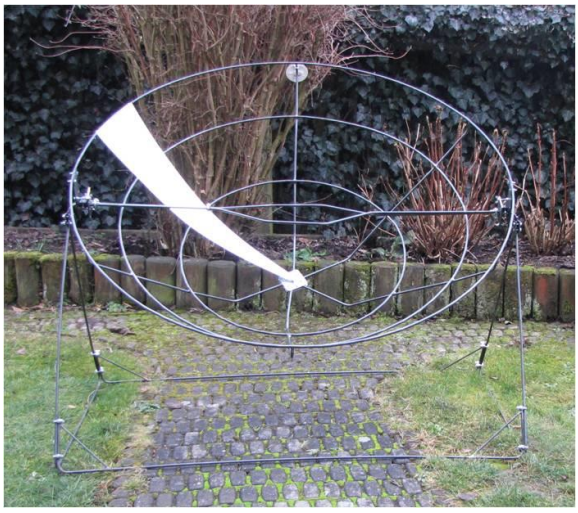

## 1. General Remarks about the Parabolic Solar Cooker SK1.4

The Parabolic Solar Cooker SK1.4 was developed by Dr. D. Seifert for a pilot project of INTERSOL, Salzburg/Austria and the Jesuit Refugee Service (JRS) for manufacturing in Afghanistan. The documentation of the SK1.4 is freely available (Open Source Appropriate Technology - OSAT). Of course, liability is excluded.

Use of solar energy combined with efficient cook stoves (like Ben 2 and Ben 3) and with thermos technology (cooking with retained heat, e.g. thermos baskets and thermos flasks) makes possible to reduce traditional firewood consumption to 1/10 (see D. Seifert: How to Overcome the Firewood Crisis, p. 15)[1]

The Solar Cooker SK1.4 consists of the reflector, made from 24 reflector sheets, and a supporting structure, made of 8 mm round steel for the reflector carrier and for holding the pot or pan reliably in the focal area (pot support not shown in the picture above). The devices for production are described in Annexes C and D.

SK1.4 is designed to be produced in a modest workshop using small manufacturing devices D1 to D9. Each of the devices corresponds to at least one work station when the cookers are mass produced. The workshop is to be equipped with electric equipment for simple welding work and for drilling holes up to a diameter of 17 mm. Because the components to be bent are made of round steel with a diameter of only 8 mm (diameter of 4 mm for the embedded pot support), the bending devices are simple and the bending with a tube as lever is easy. Device D9 serves for welding a precise Reflector Carrier to which the 24 reflector sheets are attached with plastic-coated wires.

With the exception of the reflector material (highly reflecting aluminium with a thickness of 0.4 or 0.5 mm), usually the material for the production of the SK1.4 is locally available.

[1] Links see: http://solarcooking.wikia.com/wiki/Dieter_Seifert

**Main Data of SK1.4**

- Diameter of the reflector: 1,4 m (aperture surface 1.54 m²)
- Maximum diameter of the pot: 28 cm; content 12 liter; easy one-step pot access
- Net power: approx. 0.6 kW. With clear sunshine (about 800 W/m² direct irradiance), cooker protected against the wind, 6 liters of water can be boiled in about 60 minutes. In the International ECSCR Solar Cooker Test[2] in Almería/Spain the SK-cooker with a reflector diameter of 1.4 m boiled 48 liters of water per day.
- Maximum achievable temperature of the pot content (edible oil): approx. 200 ° C (ECSCR test: 198 ° C)
- Weight of the reflector: 3 kg (highly reflecting aluminium with 0.5mm thickness):
- Weight of the components made of steel: approx. 14.5 kg (total weight of SK1.4 approx. 17.5 kg)
- Orientation to the sun about every 20 minutes
- Applicable for cooking, baking, frying, conserving, producing juices and other tasks (see 5.).
- Cooker for families and, in a modular way, for small institutions.

## 2. Description of the Components of SK1.4

A General View of SK1.4 is shown in Annex A. Components are numbered in the list of parts under "Pos" (Position). The drawings in Annex B show the position of the components in a circle. In the text, the components are indicated by their position numbers in parentheses. Example of the axis in the list of parts:

| Pos. | Number | Name | Ring diameter | Date of drawing./ standard | Material | Thick-ness or diam. | Width | Length | Cross section | Weight | Total weight |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **4** | 2 | Axis | | 1/2018 | round steel | 8 | | 1689 | 50,3 | 0,662 | 1,324 |

The axis (4), Pos 4, consists of 2 equal parts (“Number”= 2) made of 8 mm round steel, each with a length of 1689 mm and a calculated total weight of 1.324 kg.

Annexes C and D contain descriptions, drawings and lists of parts for the devices D1 to D9 for serial production. It is intended that the solar cooker SK1.4 can be produced locally in a pleasing manner. A feature is the use of 8 mm diameter round steel, which can be bent by hand with a 50 cm long steel tube as a lever, using simple bending devices. The following explains the drawings of the components of SK1.4 in Annex B.

**(1), (1a), (1b) Reflector Sheets**
The 24 Reflector Sheets (1), (1a) and (1b) are attached to the Rings (5), (6) and (7) with 4 Wires (16). The result is a reflector with 1.4 m diameter. The reflector sheets are fastened together with the central screw of the Central Connection (15). There are 4 Reflector Sheets (1a), (1b) provided with cutouts for the passage of the Axis (4) through the reflector. The material used is highly reflection aluminium sheet with 0.5 mm thickness. In a low-corrosion environment, anodized high-gloss aluminium is sufficient. In damp, aggressive environments, highly reflecting aluminium with ceramic coating for outdoor use is recommended.
If the reflector sheets are provided on the mirror side with a protective film, this film must not be exposed to the sun, because then the bond is gumming and the film can be removed only with great difficulty (with hot water, etc.). The reflector sheets with protective foil must therefore be stored in the cardboard until the film is removed.

**(2) Vertical Stands**
The supporting structure of the SK1.4 consists of two Vertical Stands (2), which are screwed with 8 Rope

[2] GTZ: Moving Ahead with Solar Cookers. Eschborn, March 1999, page 30 (pdf in the internet)

Clamps (20) with the two Bases (3). The stands are (optionally) reinforced with Stiffeners (2a). Instead of using rope clamps, the connection may be welded.

**(3) Bases**
The two Bases (3) are reinforced with Basis Stiffeners (3a). These are welded to the Bases (3) as shown in Annex B, Fig. 3.

**(4) Axis**
Axis (4) consists of 2 equal parts, which are horizontally bent in the middle so that the pot support (9) can be placed. At the ends, the two halves of the Axis (4) are bent vertically so that they can be screwed to the Vertical Stands (2) with the aid of the Axis Fasteners (10). The Hook (9c) is improving the connection of the vertical stand and the axis.

**(5) (6) (7) Rings of the Reflector Carrier**
The three Rings (5), (6) and (7) are welded together by 6 Ring Connectors (8) to produce the Reflector Carrier. Main Ring (5) and Second Ring (6) consist of two ring halves, which are welded butt. On the main ring the Fasteners (11a) for the bearing plate are welded opposite. They are attached to the Bearing Plates (11) with two hexagonal Screws (18) and Nuts (17). The position of the Bearing Plates (11) is in the middle between two arms of the star of the Welding Device D9.

**(8) Ring Connectors**
The Ring Connectors (8) are symmetrically welded by 60° to the three rings and joined at the middle ends with the two Central Connections (15), so that the ends touch the inserted Washers (15a). A stable Reflector Carrier is created, although round steel with only 8 mm diameter is applied.

**(9) Pot Support**
The pot (or the pan) is held in the SK1.4 by two Pot Supports (9) and a Triangle (9b), which are placed in the middle of axis (4). The parts (9) and (9b) are made of 4 mm round steel. They are suitable for pots up to 28 cm in diameter with a flat or curved bottom. The ends of the pot supports can be bent tightly, so that they are durably connected to the axis. Triangle (9b) can be welded to the two pot supports. But it can also be connected to the pot supports with rope clamps (4 mm, M5). Than the three parts of the pot holder can be made of aluminium or stainless steel.

**(10) Friction Clutch[3] at the Axis**
The drawing Fig. 8 of Annex B shows the Bearing Plate (11) which is screwed to the Connecting Plate (11 a) of the Main Ring (5) and which is pivotably mounted on the Axis (4). The parts are arranged symmetrically on both sides of the SK1.4. It is also shown the friction clutch, consisting of the Friction Ring (13) made of black polypropylene, the two Friction Ring Holders (14) and the Pressure Plate (12). The Friction Ring (13) is shaped in an oval form during installation and is pressed firmly against the axis. It has a length of 25 mm and in the initial state an outer diameter of 25 mm. The shaping of the Friction Ring (13) takes place by tightening the 40 mm long screws on the Friction Ring Holders (14). The Pressure Plate (12) is clamped with minimum 2 screws, so that it presses the Friction Ring (13) to the Bearing Plate (11). This creates a friction clutch, so that the reflector stops in its position after pivoting. Wing nuts can be used instead of the hexagon nuts.

[3] In early versions of the SK design, the inclination of the reflector was fixed with a string attached to an edge of the reflector carrier and to a strut of the vertical stand. To stress the string only on tension, the center of gravity of the reflector must be below the axis. The Bearing Plate (11) should then only have a length of 160 mm instead of 172 mm.

Otherwise an wrench with 10 mm wrench size is required for adjustment. When maintaining the SK1.4, this screw connection is readjusted.
To improve the connection between the axis and friction ring, the axis strengthener (9a) is placed on the axis and it is rigidly connected to the axis through the formation of the friction ring (13). To strengthen the connection a Rope Clamp (21) is mounted on the axis outside of the friction clutch.
A friction clutch is mounted symmetrically on both sides of the SK1.4. Therefore all parts of the friction clutch are duplicated.

**(11), (11a) Bearing Plates and Fasteners of Bearing Plate**
At the Fasteners (11a) at the Main Ring (5), the Bearing Plates (11) are fixed with hexagon Screws (18). Two holes, each with a diameter of 4 mm, are provided in the bearing plate for the passage of the wires for fastening Reflector Sheets (1a) and (1b) at the Bearing Plate (11). For all other fixations, wires with a length of 70 mm are used.

**(12) Pressure Plate**
The Pressure Plate (12) is provided with a 17-mm hole for the passage of the axis, as well as the bearing plate[4]. The pressure plate presses the Friction Ring (13) in axial direction.

**(13) Friction Ring**
The Friction Ring (13) is made of a commercially available cold water PP-pipe of black polypropylene with an outer diameter of 25 mm and with 20 mm inner diameter.

**(14) Friction Ring Holders**
The Friction Ring Holders (14) are used for shaping and for rigid attachment of the friction ring on the Axis (4) and the Axis Strengthener (9a). The friction ring holders have the same dimensions as the Axis Fasteners (10) and the Fasteners (11a) for the bearing plates. Therefore, 14 equal parts are used for the SK1.4. The Axis Strengthener (9a) improves the connection of friction ring and axis.

**(15) Central Connection**
The ends of the six Ring Connectors (8) are clamped between the two Central Connections (15), made of sheet steel (60 mm x 60 mm x 0.75 mm). In the center of the central connections, a hexagon screw M6 x 40 is fastened, to which the small ends of the reflector sheets are connected. Three Washers (15a) with 40 mm outer diameter are placed between the central connection on the central hexagonal screw to secure the 20 mm spacing of the ends of the ring connectors from the center.

**(16) Wires for fixation of the Reflector Sheets to the Reflector Carrier**
Each of the 24 reflector sheets is fixed to the Rings (5), (6) and (7) with 4 wires. Thus 96 wires are needed. The attachment to the Main Ring (5) is made with 2 wires on the outer edge of the reflector plate to avoid bending up of the corners. The dimensions of the reflector sheets shown in Annex B, Fig. 1, are calculated so that the sheets do not overlap on the exterior. The sheets are therefore attached to the main ring abutting each other, starting with the four Reflector Sheets (1a) and (1b) at the two Bearing Plates (11). The attachment without overlap in the outer reflector region has a number of advantages, in particular, the mounting of the reflector is simplified and material is saved. Four 140 mm wires are needed to attach Reflector Sheets (1a) and (1b) at the Bearing Plates (11). All other wires can be cut in half so that they are 70 mm long.

[4] If there are problems with drilling 17mm-holes in steel plates, the bearing plate and the pressure plate may be made from aluminium.

**(17) Hexagonal Nuts**
Instead of the usual simple hexagonal nuts (DIN 934) hexagon nuts with locking teeths may be used, because they simplify the installation. One hexagon wrench is sufficient when mounting the screws, because the toothing replaces the countering with a second wrench. For the connections with hexagon bolts M6 x 40 according to the assembly drawing in Annex B, Fig. 8, of the friction clutch, the screws are fixed with additional hexagon nuts, so that the assembly and adjustment is facilitated. For adjusting the contact pressure of the friction clutch minimum 2 screws on each clutch are needed, for which a wrench with size of 10 mm is required. The nuts at the exterior of Pressure Plate (12) may be replaced by wing nuts (DIN 934).

**(18) Hexagon Bolt M6 x 20** and
**(19) Hexagon Bolt M6 x 40**
The screws require a thread that extends to the screw head. Galvanized screws and nuts are recommended.

**(20) Rope Clamps 8 mm**
The Rope Clamps (20) have two M6 threads and are used to connect the Vertical Stand (2) with the Basis (3) (see photo). The clamps are fixed with hexagon nuts. In addition, two Rope Clamps (20) can be attached to the axis to increase its stability. The disc of the Shadow Indicator (22) is fastened to the reflector carrier with a Rope Clamp (20), see Annex E.

**(21) Rope Clamps 10 mm**
A Rope Clamp (21) with M8 threads is placed next to the Pressure Plate (12) on both sides of the axis to increase the stability of the friction clutch (see Annex B, Fig. 8). The larger dimensions of the two rope clamps are caused by the Axis Strengthener (9a). A wrench with 13 mm wrench size is required for the attachment.

**(22) Shadow Indicator**
A white disc with 70 mm diameter can serve as Shadow Indicator (22) for orientation of the reflector. It can be made of a spring cover of an electrical junction box. The plastic springs are cut and 2 holes of 6.5 mm diameter with a distance of 15 mm are provided at the outer edge of the disc. At these holes, the shadow indicator is fixed with a Rope Clamp (20) on a middle Ring Connector (8), so that the disc is perpendicular to the Main Ring (5). The shadow of the two nuts of the rope clamp is used to align the reflector (see 5.).

# 3. Safety Instructions

Of course, the safety measures for the workshop work have to be strictly considered, especially the use of protective gloves, goggles, welder equipment, see, for example: General Shop Safety Rules wmich.edu/engineer/ceee/edcsl/pdf/f212_safety_rules.pdf.

When bending the round steel bars, take care that a bar can spring back. The spring energy storing bar must therefore not be released freely, but the bar must be kept on the entire deflection. Otherwise, there is a danger especially when twisting a bar in the vice.

# 4. Assembling and Testing of the SK1.4

## 4.1 Assembling the Frame

The two Vertical Stands (2) are rigidly connected to the Bases (3) with 8 Rope Clamps (20), if not connected by welding. Attention should be paid to the correct position of the vertical stands, touching the flat floor.

**4.3 Pre-assembly of the Axis**

The two Axis Halves (4) are screwed together with two Rope Clamps (20) next to the pot holder. The parts are attached to the axis on both sides in the following order: Pressure Plate (12), Friction Ring (13), Bearing Plate (11). The Bearing Plates (11) are screwed to the outside of the Fasteners (11a) at the Main Ring (5), see Appendix B, Fig. 8.

**4.4 Mounting the Axis to the Vertical Stands** (done by 2 persons)

In Annex B, Fig. 8a, there is a drawing of the connection between Axis (4) and Vertical Stand (2). At first both upper Axis Fasteners (10) are mounted tightly to the upper ends of the vertical stand, enclosing two Washers (15b) with an outer diameter of 24 mm. The pre-assembled axis is inserted by two persons into the space between the upper ends of the vertical stand. The second set of axis fasteners is mounted below the upper set. Hook (9c) is enclosed, which causes a strong connection of the axis and the vertical stand.

**4.5 Final Assembly of the Axis with the Friction Clutch**

The attachment of the friction clutch determines the position of the reflector on the Axis (4). The reflector is in a centered position. The drawing in Appendix B, Fig. 8 shows the friction clutch. First, 2 screws are fastened with 2 nuts on a Friction Ring Holder (14) to facilitate the mounting of the holding plates. The Friction Ring (13) is shaped at the correct position on the axis with the Friction Ring Holders (14) and pressed strongly against the Axis Strengthener (9a) and the axis. Subsequently, the Pressure Plate (12) is pressed evenly with at least 2 Screws (19). To facilitate the adjustment of the friction clutch, these screws should be attached to the baring plate (11) with nuts. Finally, the Rope Clamp (21) is attached to the axis. The procedure is duplicated on the opposite.

**4.6 Preparation of the Reflector**

The Central Connections (15) of the reflector carrier are mounted and provided with a central screw M6 x 40 (19). The protective foils on the highly reflecting side of the reflector sheets are removed.

**4.7 Assembling the Reflector**

The reflector carrier is attached by the axis to the vertical stand and can be brought to the desired position with the friction clutch. The reflector is mounted in a location without direct solar radiation to avoid disturbing reflections. Assembling starts with the four Sheets (1a) and (1b) at the axis passages. The sheets are arranged next to each other on the Main Ring (5) (no overlap on the outer edge of the reflector) and fixed to the rings with Wires (16). They are bent hairpin-shaped, inserted through the holes of the reflector sheets, guided around the rings and twisted by hand, without pliers. The protruding ends of the installed wires should not be cut off, so that the connection can be released again if necessary. The wires should only be twisted 2 to 4 times. Each reflector sheet is placed with its 8 mm hole on the central screw.

When attaching the reflector sheets to the rings, make sure that the reflector sheets have a smooth parabolic shape. The wires must therefore be mounted only by hand and the reflector sheets must not be corrugated.

After assembling all 24 sheets, the sheet pile in the center is pressed together with a nut on the central screw.

**4.8 Final check**

- All rope clamps and hexagonal screws are strongly tightened.
- The reflector can be pivoted easily. The friction clutches hold the reflector position without taking action at the nuts of the pressure plate.
- The shadow indicator is perpendicular to the main ring.
- The reflector sheets have a smooth parabolic shape.

**4.9 Function Test**
A method to check the shape of the reflector: The observer stands about 5 meters in front of the reflector which is aligned to his eyes. A black pot with black lid is situated in the pot support. If the shape of the reflector is correct, the reflector should appear completely black to the observer.
Than the reflector does not dazzle, because the incident rays are concentrated to the pot.
On a clear day, 6 liters of water can be boiled in about 1 hour.

# 5. Operation and Applications of SK1.4

At first the SK1.4 is pre-aligned to the sun with the shadow of the vertical stands. Then the two shadows on the shadow indicator (22) run symmetrically parallel to the centerline of the white disc. The sun-oriented reflector creates traces (images) of reflection in the form of white "sun-flames" on a black pot in the pot support (9). These "sun-flames" should envelop the bottom part of the pot. At low altitudes of the sun, the inclination of the reflector is steeper than an inclination with exact orientation to the sun`s position.
The inclination of the reflector (according altitude of the sun) should be adjusted using these white reflection images on the pot, thus avoiding that the lid is heated instead of the pot content[5]. This corresponds to different shadow lengths at the disk, depending on the altitude. With some experience, the optimal orientation of the reflector can be found easily with the two shadow lines at the shadow indicator, without observing the pot.

Operation and Applications of the SK1.4 comply with the instructions for the known SK designs, shown in the cookbook[6], in the videos and in the lectures by Imma Seifert. This also includes safety instructions (avoidance of being dazzled etc.).

# 6. About Series Production of SK1.4

Annexes C and D contain the documentation for the manufacture of the components of SK1.4 (descriptions, drawings, parts lists).

**6.1 Required workshop equipment**
The basic equipment required includes a sturdy vice and stand drill, as well as flat and round files and a steel brush for cleaning the welds and deburring the parts. The round rods can be cut by hand or with motor-driven equipment (band saw, circular saw, cut-off machine) to the required length. The thin wires (140 mm long) can be halved with a side cutter, because 70 mm wires are sufficient for most of the connections. The length of 140 mm is required only for fixation of the Reflector Sheets (1a) and (1b) on the Bearing Plates (11).

**6.2 Welding device D9 for the Reflector Carrier**
By the Welding Device D9 the rings and ring connectors are held in a precise position, so the required accuracy of the reflector can be achieved. The parts are attached to the device and fixed in place with weld points. Then the reflector carrier is taken out upwards from the welding device. The welds are completed without the device having good accessibility to all places. The welding device for the reflector carrier has a diameter of approx. 1.5 m. It also serves to control the dimensions of the components. If necessary, the bends are to be corrected.

[5] For baking the heating of the black lid may be desired.
[6] http://solarcooking.wikia.com/wiki/File:Parabolic_solar_cookbook_-_Imma_Seifert.pdf

### 6.3 Bending Devices

The bending devices are threaded onto a stable worktop, denoted (X) in the device drawings. A sufficiently large work area next to the device is necessary. The 8 mm round steel is bent using a 50 cm long steel tube with 12 mm outer diameter and 1.5 wall thickness. Because the bending devices are very simple, a separate device can be provided for each component. For corrections the vice is applied.

### 6.4 Reflector Sheets

Drawing Fig. 14 in Annex D shows the fragmentation of reflector material (highly reflecting aluminium), which is unrolled from a coil. It is urgent to ensure that the curvature created by the coil on the reflector sheet coincides with the direction of curvature in the reflector; no trough-shaped reflector sheets!
In a simple way of production, parallelograms are sharply scored using a utility knife and a template (stencil) for each two reflector sheets and then broken at the score line. For this purpose, the reflector plate is bent at a sharp edge of the table by about 90 °, so that the scribe is outside. Then the parallelograms are halved so that the trapezoids for the reflector sheets are produced.
Instead of working with the template, the use of a guillotine shears is advantageous. Initially, parallelograms are produced. Then they are divided into two reflector sheets. The exact cuts are secured by stops on the guillotine.

The set of 24 trapezoids is rounded at its sharp corners on the compressed stack with a flat file. Then with a drilling device the 4-mm holes (possibly 3-mm holes) are drilled for the wire attachment.
If using Reflector Sheets from “Sun & Ice”, 4 holes with 4 mm (or 3 mm) diameter must be drilled (in addition to the existing holes) at the centerline of the reflectors for attachment of the reflector plates to the Second Ring and the Third Ring of the Reflector Carrier. For this purpose, a sheet metal template is advantageously used, with which the upper reflector plate of the sheet set is provided with the four grain points for the holes. The reflector sheets are pressed and drilled together.

## 7. Notes on OSAT

The present documentation of SK1.4 is provided by the author as Open Source Appropriate Technology (OSAT) for free use. Liability is excluded. Further information should supplement the documentation as additional annexes.

References to OSAT contain publications by the author on the internet, particular at http://solarcooking.wikia.com/wiki/Dieter_Seifert.

See also: C. Sinclair: „Open Source Humanitarian Design“ in: WORLDCHANGING – A USER’S GUIDE FOR THE 21st CENTURY. Abrams NY, pages 216-217.