



Devices for Temperature Measurements in the HotPot Solar Cooker

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Personal Testing Experience

In my water pasteurization tests I used HOBO Stainless Temperature Data Loggers model U12-015 (found on this website <http://www.onsetcomp.com/products/data-loggers/u12-015>). These data loggers have a measurement range of -40° to 125°C (-40° to 257°F), and an accuracy level of $\pm 0.25^{\circ}\text{C}$ from 0° to 50°C and $\pm 0.45^{\circ}\text{F}$ from 32° to 122°F . These loggers have worked very well in my testing since the temperatures are within the compatible ranges (pasteurization temperature being measured as 65°C). The programming options and data logger capabilities have been ideal and allowed for successful testing using these devices.

I have been comparing the time it takes water to reach pasteurization within 2 solar cooker systems set up side by side, each containing a pot and 2.5L of water. To measure water temperature in the middle of the pots rather than on the bottom, I knew the logger must be elevated within the pot. At first metal wire from a coat hanger was used to create a cradle for each logger. but the cradle began to corrode under high temperature. Copper wire was tried next and while that did not corrode, the cradles that I created were not exactly the same, causing temperature variance between the loggers that was scientifically unacceptable. The final decision was to use glass holders (actually votive candle holders) that the loggers rest across horizontally to elevate them to the middle of the pot (shown below). These were purchased instead of constructed from raw materials so they were practically identical and provided consistent measurements between the 2 loggers.



I have had a great experience using these data loggers and recommend them for use in the future. They are easy to work with and provide accurate data during testing. For my experiments the temperature limits were not an issue, but if higher temperatures are to be tested, such as testing overall HotPot temperature when cooking food, other devices may be necessary.

Suggestions for Higher Temperature Testing

- Analog Oven Thermometer
 - To determine the inside temperature of the HotPot, it seems to me that the easiest method would be to affix an analog oven thermometer to the inside of the lid. A different solar cooker I have used called the SunOven contains a thermometer on the inside of its box and makes it easy to know the temperature of the oven. I understand that a concern with the HotPot would be blocking solar radiation that would aid rising temperatures, but it may be possible to use a very small thermometer that would not block much light at all. This would eliminate the problem of having wires leave the lid ajar and release heat, as well as other issues that arise as devices become more complicated. If a small enough thermometer could be made, perhaps it could be set into the glass in the production phase so that it could be easily read without any condensation obscuring the view.
 - Many types of analog thermometers are available depending on size and accuracy level



- Example: http://www.webstaurantstore.com/dial-oven-thermometer-nsf/913THOV20.html?utm_source=amazon-pads&utm_medium=cpc&utm_term=913THOV20
- Dual Oven/Meat Thermometers
 - To simultaneously measure the temperature of the oven and food that is being cooked, there could be the possibility of using a dual oven/meat thermometer. This would allow you to measure both oven temperature and the temperature of the food that is being cooked. Condensation on the lid during cooking may cause difficulty in seeing the thermometer inside, but the lid could likely be shifted to allow enough clear space to see the thermometer.
 - Example: <http://www.kitchencollection.com/good-cook-touch-dual-meat-oven-thermometer>

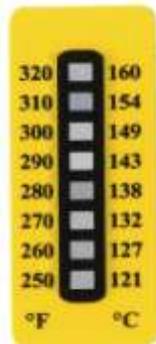


- Infrared Temperature Sensors
 - By using an infrared non-contact sensor, you could test the temperature of the HotPot as a whole since it would read the temperature of the glass. I am unsure of the technical details of heat transfer across the type of glass in the HotPot, but this may be helpful to estimate the temperature at least on the outside and possibly of the HotPot as a whole if you could assume that the temperature is relatively the same between the inside and outside. To most accurately measure the temperature of the inside contents, you would have to remove the cover which has negative effects on containing heat, but would provide accurate information.
 - Many sensors of varying technical caliber are available
 - Example: Fisher Scientific - <https://www.fishersci.com/shop/products/fisher-scientific-traceable-noncontact-infrared-thermometers-3/p-203736>
 - Example: HomeDepot - <http://www.homedepot.com/b/Electrical-Electrical-Tools-Accessories-Electrical-Test-Meters/Infrared-Thermometer/N-5yc1vZboffZ1z1180y>
 - Example: ThermoWorks http://www.thermoworks.com/products/logger/bluetherm_bluetooth_ir.html#Specifications
- Data Loggers
 - Many data loggers have limited applications for solar cooker testing due to low temperature ranges. There are some that have extended ranges that might be of use.
 - Extended Range Submersible Temperature Data Logger
 - <http://www.omega.com/pptst/OM-CP-HITEMP-150.html>
 - Operating Temperature Range: -40 to 150°C (-40 to 302°F)
 - Optional Thermal Shield for Operation up to 250°C (482°F)
 - Under normal operation this logger is able to measure temperatures up to about 300F but with the addition of the thermal shield it could be of more use in measuring high oven temperatures should temperatures go that high
 - High Temp Stainless Steel Data Logger, Model 20615 – DeltaTrak

- <http://deltatrak.com/high-temp-data-logger-20615#overview>
- Range: -40°F to 302°F (-40°C to 150°C)
- Like the former logger, this logger has a range of up to around 300F which could be useful depending on maximum temperature
- Thermocouple Temperature Recorder
 - There are many models available and many that reach high temperature that could be useful in solar cooking
 - Thin wires would cause a gap between the pot and the lid but there might be the possibility of plugging this gap or using extremely thin wires so that the gap does not affect airflow
 - Example:
http://thermoworks.com/products/logger/logmaster_tctemp1000.html#ProductDescription



- Color changing temperature strips
 - These strips could be placed on the outside or possibly the inside of the lid and allow a visual indicator of temperature without high tech devices. The challenge is however that many of the high temperature strips are irreversible so they would only measure maximum temperature one time. This might be helpful when trying to determine the highest temperature the HotPot could ever reach under different circumstances.
 - Example: <http://www.omega.com/pptst/TL-8.html>



- Other reversible strips exist for lower temperatures but I was unable to find any for high temperatures. Perhaps with your industry connections you might have other sources that could be of assistance to find suitable strips if the scientific capability to read such temperatures even exists.

Final recommendations

For my testing purposes the HOBO data loggers worked very well but they would not be suitable for measuring higher oven temperatures. I feel that the simplest and best measurement would be to attach an analog thermometer to the inside of the lid. The oven/meat thermometers could allow measurements of both food and oven temperature at the same time, although condensation may be an issue. The infrared sensors could be helpful to know the overall temperature and more technical devices such as the data loggers could provide more accurate data over longer time periods depending on maximum temperature to be attained in the HotPot. Many devices exist but depending on your desired usage, whether it be for use in a single HotPot for testing purposes or for use in many when they are distributed, there are a range of potential options.

The author: A final year Environmental Studies student at Elon University in North Carolina, focusing on sustainable energy technologies, Hannah Rolland incorporated the HotPot into her University research project on solar cookers. As part of a summer internship with Solar Household Energy, the author researched and presents her independent findings on devices for measuring temperature in the HotPot.

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