Small Cooker

1. Changes to the Proposal

The small cooker team decided to complete the construction of the small cooker and its reflector set and to test that small cooker. The team worked on the design details of possible solutions for a new oven of the same size and general shape with a better method of placing and securing the glazing.

2. Tasks

a. Finish construction of the small cooker

We covered ⅗ the height of the small cooker interior with black-painted plates. The plates are meant to absorb the light that enters the cooker and convert it to heat. The other ⅖, initially covered with reflecting plastic sheets, kept acting as the sunlight reflection agents. The plates were not adhered directly to the oven wall. Instead, they were supported by wood blocks and reinforced by adhering the wood blocks to the oven interior.

b. Finsh construction of the reflectors.

A frame with 8 panels had been constructed last semester to act as a reflector system to bring more sunlight into the cooker for conversion to heat. The sunlight available at our latitude (roughly 42 degrees north) in the winter is small and the collector allows more sunlight to be gathered. The plywood panels of the reflector set were covered with a shiny, highly reflective plastic material. The frame was adjusted to fir the top or window opening of the new cooker and simple latch system to hold the reflector inplace was designed and built.

c. Testing.

A series of tests were performed on days when the sun was available.

Each test included the small cooker, several temperature sensors connected to different parts of the oven, and a data logger recording temperatures read from the sensors.

- Test 1

Three sensors were used: one attached to a black plate, one to the pot of water inside the oven, and one left outside to measure ambient temperature. The additional sunlight-capturing frame made by the previous team was not added to the oven.

- Test 2

Since sunlight was interrupted frequently in the first test by the passage of clouds. I attached the extra frame to the oven. I also covered the frame with reflecting materials in order to better collect incident sunlight.

- Test 3

Several changes occurred in this test:

1) Since Ithaca’s sunlight gets disrupted a lot by clouds. I have decided to add a pyranometer to report solar energy simultaneously with the temperature sensors. This is to see if temperature in the oven has a positive correlation with the sunlight intensity. A pyranometer provides a measure of the intensity of energy available as visible light and infrared (400nm to 1100 nm) in kwatts per square meter (kw/m^2).

2) A different data logger was introduced by Mr. Bond to accommodate to the pyranometer.
3) Temperatures are measured from five, instead of three testing spots. This is to determine whether there are differences between the temperatures at different positions inside the oven.
4) Because water has a high heat capacity, it acts as a “heat sink” that prevents the oven from heating quickly. Hence, water was taken out halfway through the test.
5) Testing time was shortened considering the slow increase in temperature in previous tests at the beginning and the end.

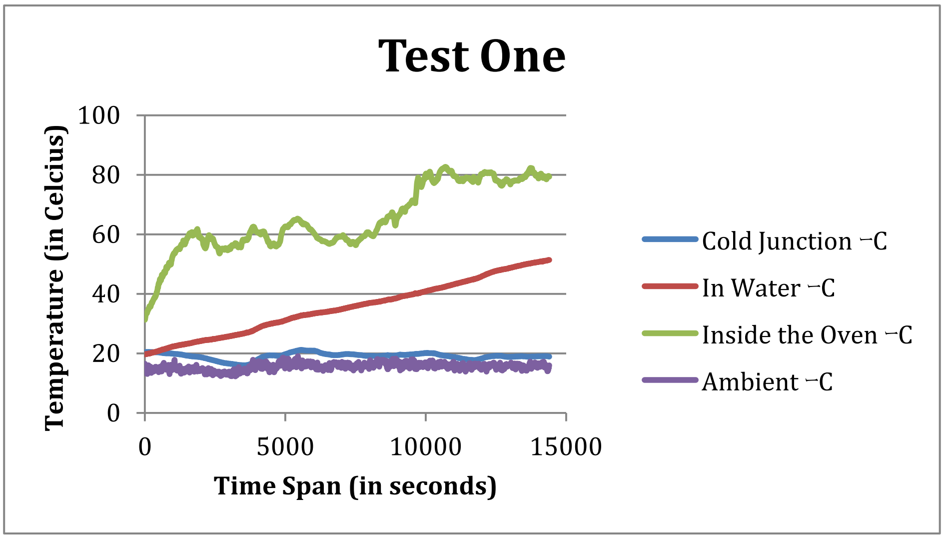
d. New glazing design

The design objective was to be able to install the glazing without using an extra frame (like a window frame that must be inserted in a heavy bracket) so that heat leaks associated with the interface between the two frames can be reduced. The design was done by AutoCAD. Other than solving the glass-fitting problem, I had to make sure that the design is physically possible.

3. Results and Conclusions

- Test 1

Amount of Water: 2L
Testing Time: 4 hours
Maximum Temperatures: Air: 19.1°C / Oven: 82.68°C / Water: 51.39°C

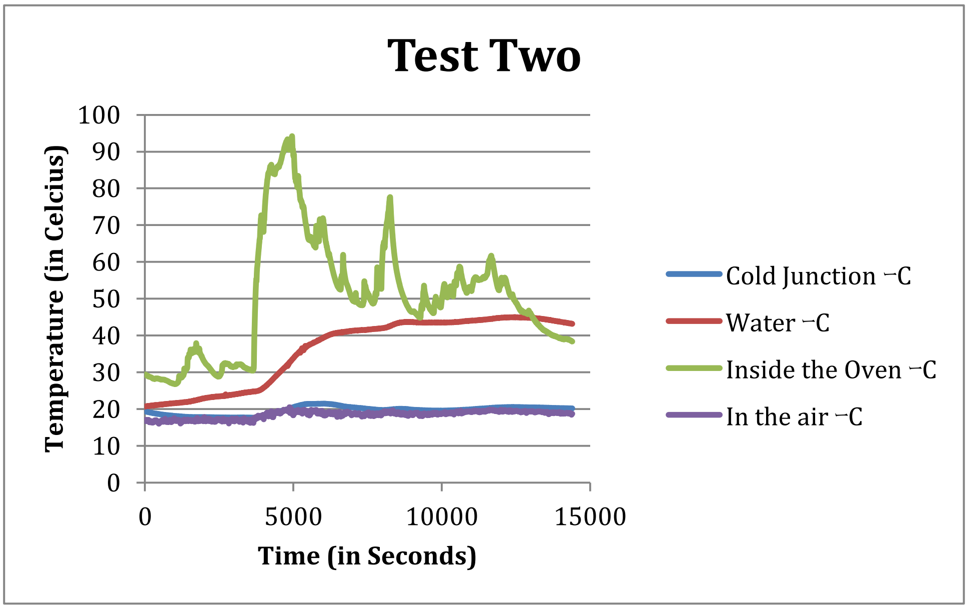


Temperature inside the oven never went above 100 degrees, because clouds frequently disturbed the sunlight. Therefore, reflecting frame was added on the second test. The temperature of the water in the oven did rise from roughly 20 degrees C to roughly 50 degrees C.

- Test 2

Amount of Water: 2L
Testing Time: 4 hours

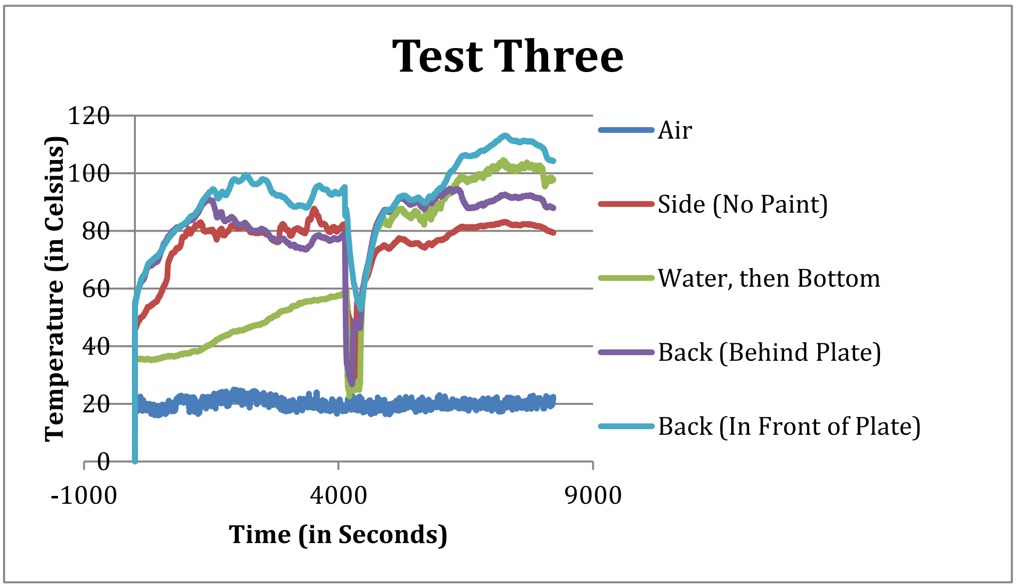
Maximum Temperatures: Air: 20.49°C / Oven: 94.18 °C / Water: 45.03 °C

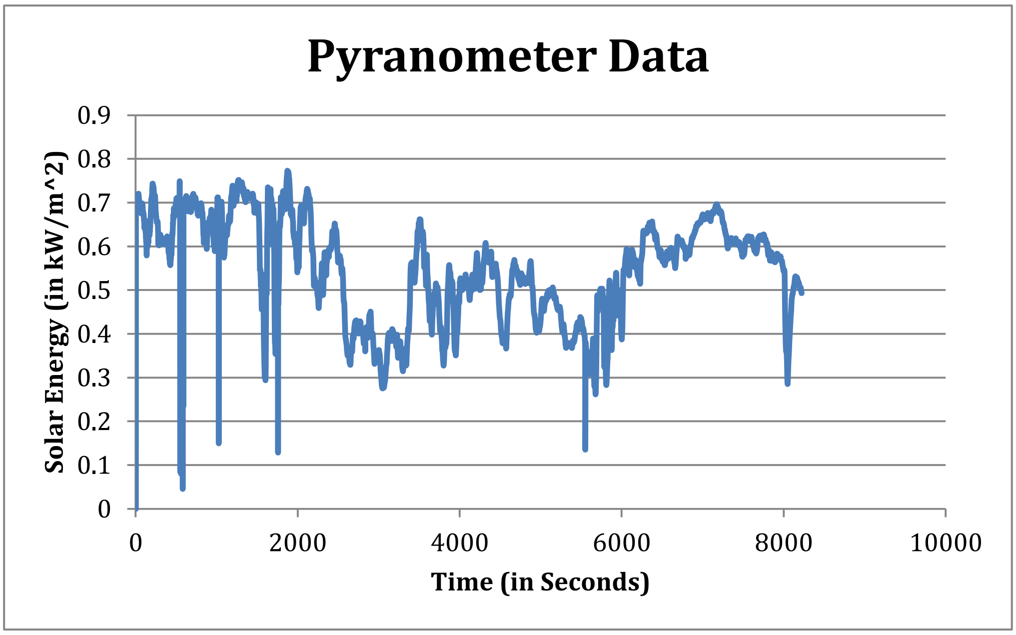


As shown in the chart, temperature in the oven started dropping at about 1.5 hours into the experiment, which corresponded to the weather change. However, several facts can be told from the data: 1) With the reflector, the temperature inside the oven went above 90 degrees before the weather turned bad; 2) when temperature started dropping, the water temperature droped much more slowly than the oven temperature because water has a much higher energy capacity than air; and 3) There is some correlation between temperature increasing speed and sunlight intensity, which is why a pyranometer was used in the third test.

- Test 3

Amount of water: 1L (Taken out at 12:07pm, 60 minutes into the test)
Testing Time: 137 minutes
Maximum Temperatures: Air: 24.95 °C / Side: 87.74 °C /
Water, then bottom: 104.64 °C /
Dark painted plate at the back: 113.03 °C /
Between plate and oven interior: 104.64 °C



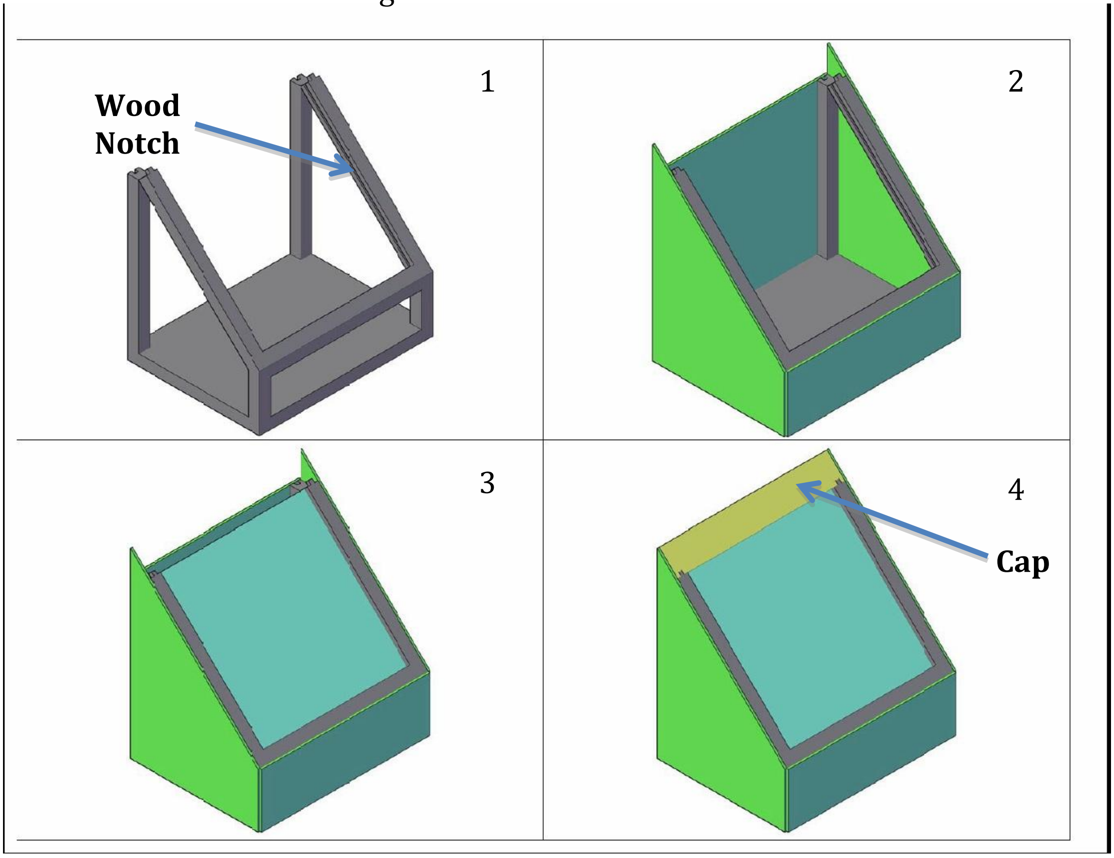


In the middle of this test, the pot of water was taken out of the oven, and quite obviously in the chart, the temperatures in the oven increased faster **even** under lower sunlight intensity than the first half of the experiment. The dip in the middle of the chart was a mistake of mine, I paused the experiment to take out water and reinforce some tapes that went loose in heat, but the machine did not stop recording data. Fortunately, the experiment ran long enough to recover from this temperature dip. The black plate at the back of the oven went to the highest temperature, while temperature on the side (area without paint) had the lowest temperature. Divide the experiment in two parts and look separately at each part, there is a positive correlation between sunlight intensity and temperature in the oven.

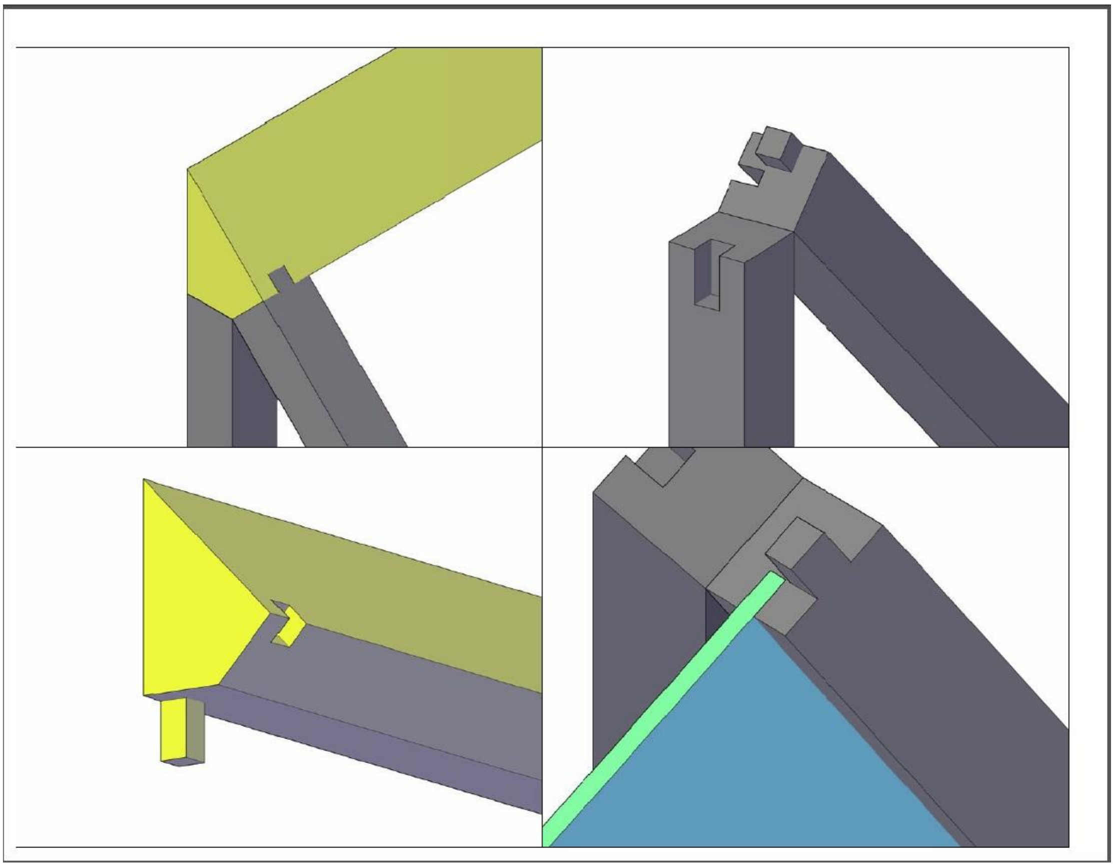
Three conclusions can be drawn after the three tests: 1) The water serves as a heat sink that prevents the oven from heating up quickly enough; 2) the temperature increase in the oven is positively related to sunlight intensity; and 3) Temperature on the dark-painted parts of the plates are higher than the temperatures behind the plate and than on the non-painted parts. Also, it is worth noticing that neither the wood glue, nor the industrial tapes can serve as a good adhesive agent under temperature above 50 degrees Celsius. (These conclusions are all pretty obvious. I think it is more important to conclude that even with substantial cloud cover and low light conditions, there was a 30 degree heating of the water in the pot. Later tests showed that there was a fairly small amount of energy being gathered (.6 to .7 kW/m^2). A calculation of the amount of energy that is being captured and converted would be useful here as an indicator that the cooker is working.)

- Design

To get rid of the extra frame, we can directly fit the glazing through the oven frame as shown in the figure below:



This picture also shows the assembling process (in order with the numbers). Before assembling, a wood notch is drilled around the angled frame to fit the entire glass piece. Then, at the end of assembling, a wood cap will be added to the top (yellow part). The difficulty of this assembling process is to fit the wood cap onto the base frame. Most of the options will be physically impossible. Below is the final version of the fitting details:



4. Anticipations

Next semester, I will continue working on the small cooker subteam. The main tasks are to improve the current design and start building the new oven.