Parabolic Trough-Energy Extraction

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Team 14

System Update

Document

Submitted towards partial fulfillment of the requirements for
Mechanical Engineering Design II – Spring 2015

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Introduction (Jairo Rivera)

A parabolic trough is a type of renewable energy used to collect solar thermal energy. Most parabolic troughs are curved and lined with a polished metal mirror. In order to get the maximum energy extraction, the system requires to be portable and track the sun's movement throughout the day and with the changing seasons. Sunlight converted to heat is used to run engines such as a steam turbine or other devices. The current parabolic trough-tracking system is an operable and damage has accumulated on the trough. The last time it has been operated was about 15 years ago and is currently located between the engineering building and the forestry building, in an enclosed area. The client, Dr. Kosaraju, would like to convert the absorbed solar energy into a useful form of energy.

Project Definition (Jairo Rivera)

In order to absorb the most solar energy from the parabolic trough possible, the tracking system must be repaired and damage done to the trough must also be repaired. An overall view of the system is displayed in Figure 1.

Figure 1- Overall system

The tracking system is in need of a new motor to turn the parabolic trough upon its horizontal axis and a control box is also needed to control the motor. A programmable control box is preferred in order to obtain the maximum amount on solar flux throughout the day without having to manually control it. Due to environmental constraints, the parabolic trough must also be mobile so it may not have any obstructions from sunlight. The current inoperable motor and control box is displayed in Figure 2.

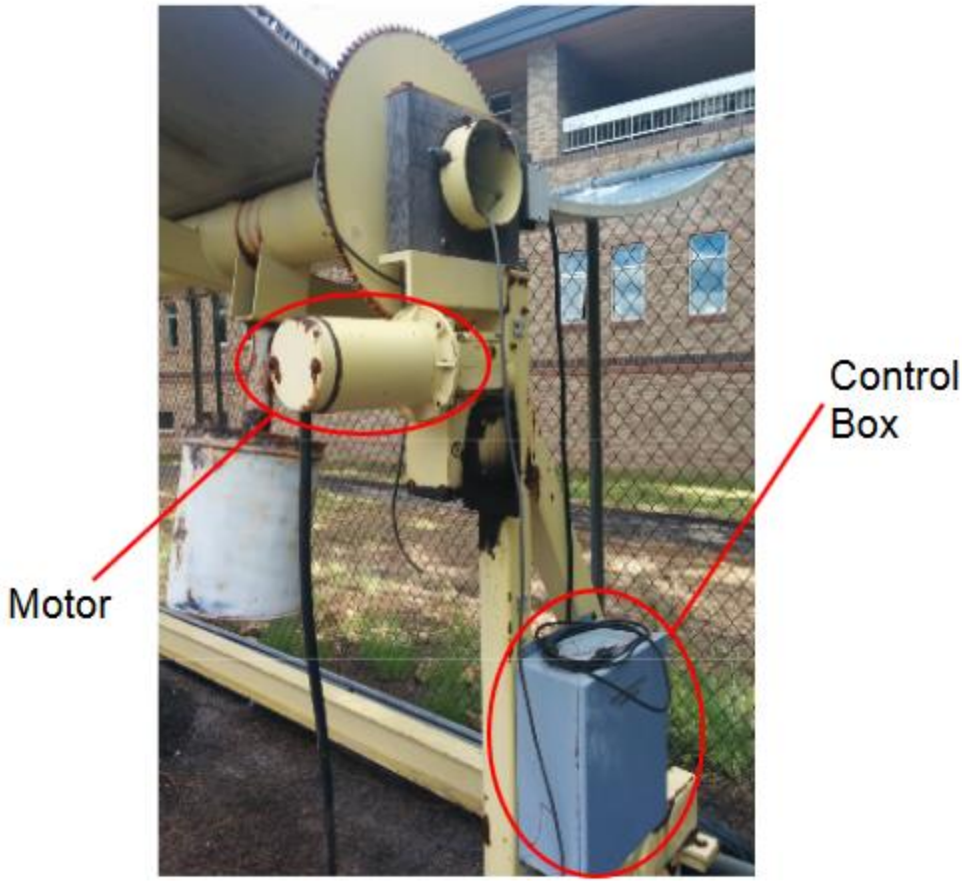

Figure 2- Motor and control box

Figure 3 shows physical damage on the parabolic trough which includes frayed edges, water damage, and holes on reflective surface. The damages on the parabolic trough must also be repaired in order to ensure all areas of the trough are effective and no further damage is accumulated.

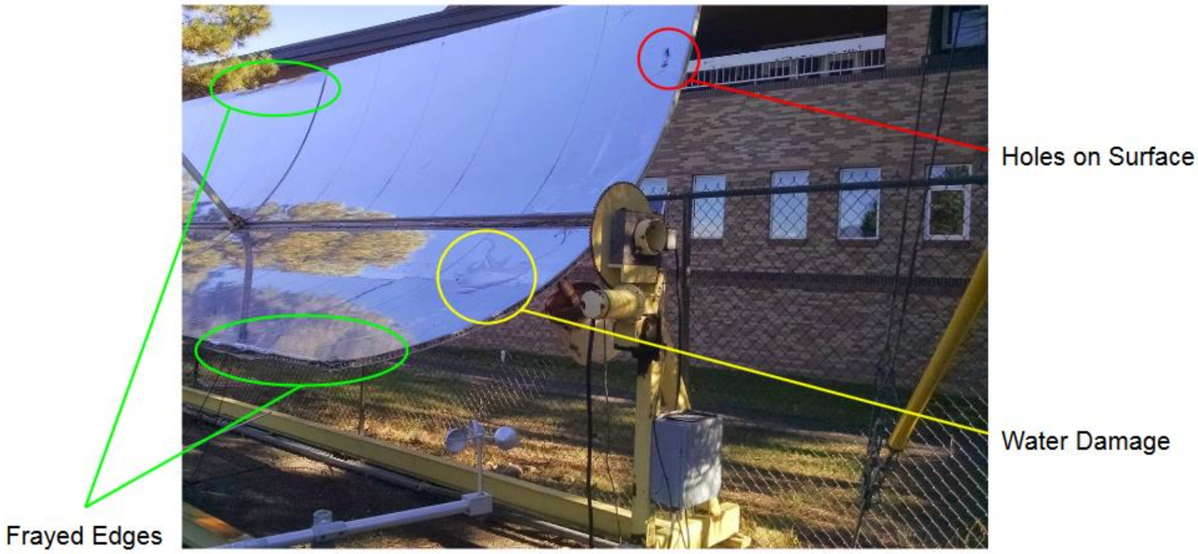

Figure 3-Parabolic Trough Damages

Motor (Robert Blaskey)

One of the most difficult tasks has been finding a replacement for the current motor. The specifications needed for a 3-phase motor are 1 hp for power output, 56C size face, ⅝ inch shaft, and 1700-1800 rpm. The original motor was a DC motor, but DC motors are significantly more expensive than AC motors. For the purpose of rotating the trough, an AC motor would be as efficient to use. Also, there are more control drives available for AC motors. Figure 4 shows the 3-phase AC motor, model VM3645. The list price is $453 from Baldor directly. This motor fits all the specifications we need for the trough to rotate.

Figure 4 - AC 3-Phase Motor from Baldor

Control Box (Robert Blaskey)

Another difficult task was finding a control box that would be compatible with the motor. Most supplied motors have simple control boxes that are on and off switches or just regulate the motor speed. However, the control box needed is a drive that could operate the trough based on programming the control box or setting a timer. The control box found is an AC micro drive made by ABB. The drive has the capabilities of installing programs and comes with a removable keypad to regulate speed. The ABB control box found is supplied from Baldor. It is model ACB330 and is shown in Figure 5.

Figure 5 - The AC Micro Drive from ABB

The specifications are 1 hp of power output, and 230 volts listed at $313. The compatibility of the motor with this control box is being confirmed by Baldor. The drive supplies AC motors and meets all the specifications needed to operate the trough. Once the motor and control box are ordered and arrive, they can be installed along with the chain and gearbox.

Edge Trimming (Daniel Chief)

Due to the trough sitting outside in the environment for so long, the trim around the edges has almost completely broken off. Plastic trim was previously used when the parabolic trough was built, but after over 15 years it has become brittle and aesthetically displeasing. Most of the trim had already broken off, so new trim would be needed in order to seal the edges and also help make the trough look better. Figure 6 shows the previous conditions of the edges when the trough began to be worked on. After measuring the perimeter of the trough, it was decided that 4 feet of trim with a 1 inch channel gap would be needed to enclose all edges.

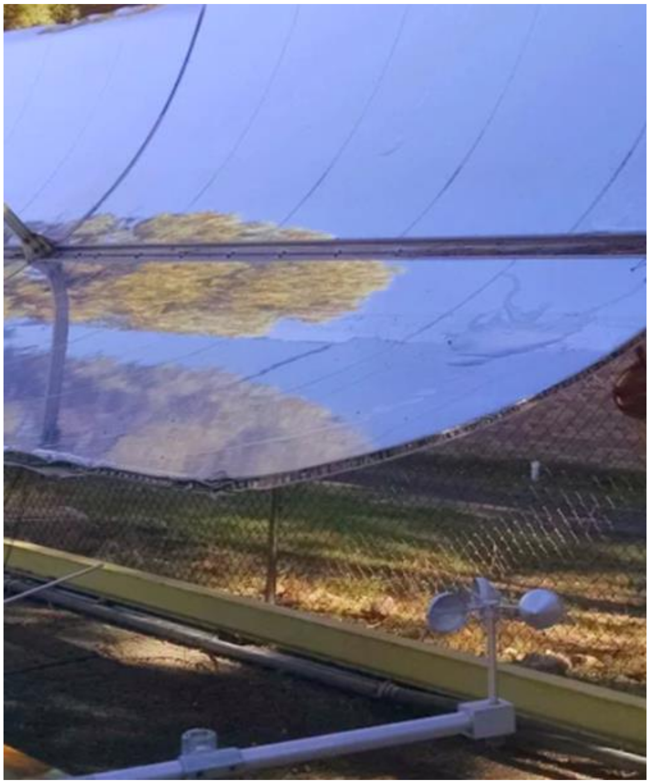

Figure 6 - Initial condition of edges

In order to determine what kind of trim to use, a material that has a long lifespan was desired. Although plastic was previously used, metal became the new material of choice because of the longer lifespan it has over plastic, it was found to be less expensive, and it could also hold down the areas of the edge that were bent, shown in Figure 7. Aluminum specifically was chosen because it is cheap and easy to work with. From Metals Depot, 8ft sections of 1 ¼" length legs, 1 ¼" base width, and ⅛" thickness, giving us the 1" gap needed, were found and were ready to be shipped. Once the material was chosen, ten 8ft sections were ordered to ensure that we would have enough material in case anything during installation went wrong. The total cost of the aluminum trim was $220.38.

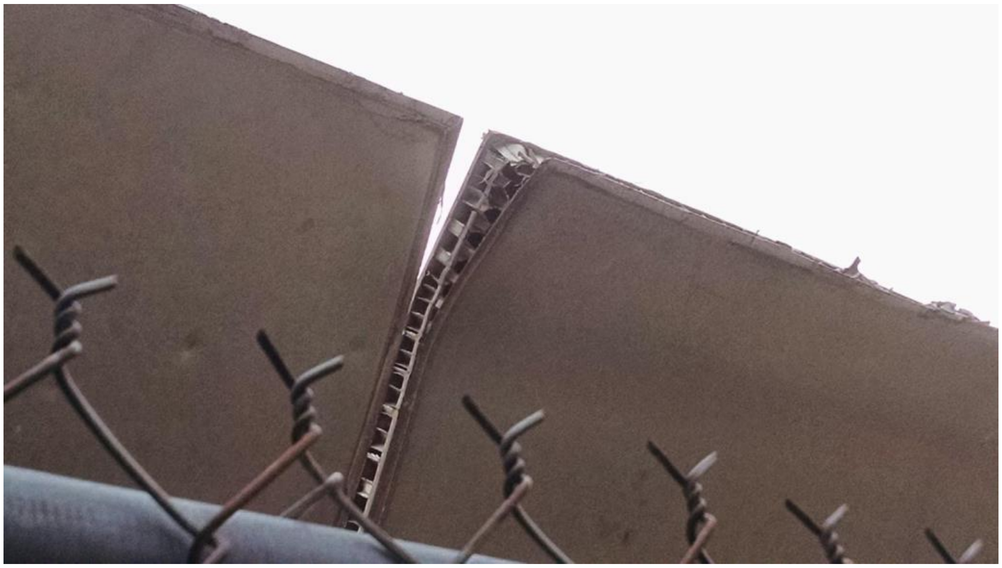

Figure 7 - Bent corner of trough

For the curved edges, a way to install the trim had to be decided since bending the 8ft lengths of aluminum was not possible given the resources available. In order to overcome this, 2 inch sections were cut and installed individually in order to ensure that there would be no gaps in the trim due to the curve. Figure 8 shows how these small segments look on the trough, showing that there are no gaps.

Figure 8 - Installed trim on flat and curved edges

Another concern about the installation of the aluminum trim is that there is a small gap in the center of the trough perpendicular to its axis of rotation, (0.5” on one side, 2” on the other) which does not allow room for sliding the trim on. To overcome this, there were several options to choose from. One way to apply the trim would be to cut the aluminum in half along its length, then applying each half to each side of the trough, and sealing the cut with the adhesive. Another option would be to just lay a material across the gap, such as Mylar, and leave the edge open, but it will still be protected from rain and snow since the trough will always be in its upright position. The only problem with this is that because Mylar is so thin, a puncture in the material would be easy due to the size of the gap. Placing a stronger material underneath for support would solve this problem, but application may be inefficient and alter the reflective surface towards the parabola’s focal point. The third option is to remove one or two of the supports in order to slightly bend the trough and slide the aluminum onto the edge. Because the materials of the trough are already flexible, this option could be simple if the supports are easy to remove, but could be very difficult due to the condition of the corrosion wearing down the supports and possibly losing the supports entirely. Our team chose the third option in order to install the trim along the inner side of the trough as well as shortening the legs of the aluminum trim. Figure 9 shows the trim on the inner side of the curved edge installed.

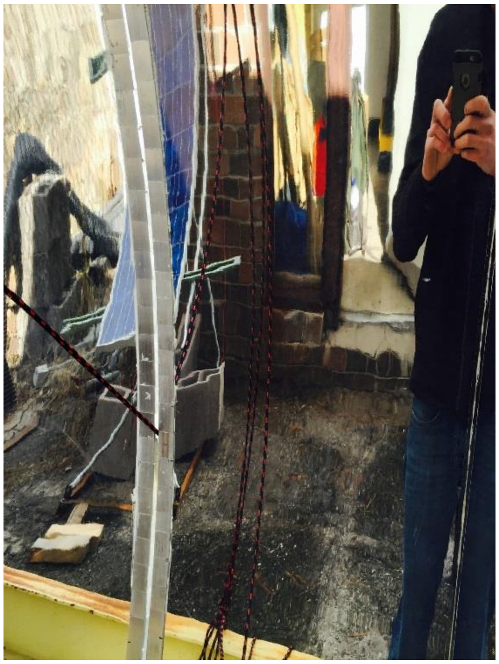

Figure 9- Inner trim installed

While installing, adhesive has also been used to help seal the edges. A construction grade, weather resistant multi-surface adhesive was chosen due to the harsh conditions the trough may experience. This was found at Home Depot for only $2.40 a bottle, with a total cost of $7.20 for three bottles needed.

Material to Cover Damaged Surface (Saad Almonnieay)

Due to the holes and water damage on the parabolic surface, shown in Figure 10, the reflectivity is hindered and will not be at peak efficiency in this current condition. In order to retain an entire reflective surface, something that could be applied to the surface and still be as reflective as what is on there currently was needed.

Figure 10 - Holes and water damage in surface

For this application, Mylar was chosen due to its low cost, flexibility, and most importantly is reflectivity. Another benefit of this material is that it can be used to cover the trim that will be hanging over the reflective surface. This will help maximize the solar energy that will be absorbed. Using Amazon.com, a 100 ft^2 (4 feet wide, 25 feet long) roll was found for $20.00.

After we successfully finished installing the trim to the edges of the trough, we started to apply Mylar to the surfaces to cover the holes in the surface. We recently finished applying Mylar to the damaged surface, so the trough can once again be able to rest in its upright position and the complete surface can be reflective. Figure 11 shows the application of the Mylar onto the reflective surface.

Figure 11 - Mylar applied to parabolic surface

Solar Extraction (Jacob Seitzer)

Once all repairs are made and parts are replaced, the team will be able to begin solar energy extraction from the trough. With all that is left being the motor and control box, this process will be able to begin. Most parabolic solar troughs used today are in large power plants, using the steam generated to power a turbine to generate electricity. Due to the limited space of the solar shack, the limited funds, as well as the lack of need for a steam powered energy system, the team decided this option would be impractical for our needs. After looking through several solar parabolic trough examples and current technology, and with the help of the client, our team has determined that the trough will be used for educational purposes for later students at NAU.

To demonstrate the power of the sun and relate it to heat transfer, the team has chosen to use a simple water heating system for the trough. By installing a large diameter, preferably stainless steel, pipe and running it along the trough at the focal point, we will be able to use that solar radiation to heat water and demonstrate the heat transfer occurring in the system. Although a definite system has not been designed yet, the team has come up with initial ideas about the design.

By storing water in a tank at the inlet, and having a separate tank at the outlet, we can run water from one to the other by using a pump, and use thermocouples to measure the temperature of various component of the system. By storing one tank higher than the other, we will be able to let gravity do some of the work for us instead of using two pumps on each end. In order to design the system, the team will need to decide on what size of pipe, what material to use, and how much water will need to run through to reach a certain temperature, preferably its boiling point. By using what we've learned in our heat transfer course and various other courses, we will be able to determine mathematically the dimensions and volumes that will be needed.

As stated before, no testing can occur until a motor and control box are installed on the trough, which is the next and so far the most important aspect of the project. Once this is done, however, solar energy extraction will be possible.

Conclusion (Christopher Mesko)

The parabolic trough is now portable and can be moved to any location. The gearbox has been professionally cleaned by Coconino Auto Supply and is ready for oil gear oil to be added. The chain required to turn the sprockets has been ordered, but the team is waiting on the motor so the new chain may be installed. All the physical damage on the parabolic surface has been repaired and the trim for the edges has been installed to prevent further damage to them. To install the chain the motor position needs to be determine so we can measure the exact length of the chain. A new location of the parabolic trough has been decided, however, is not a priority and the team will revisit this issue at a later time. The client will have the final decision to move forward with this. Once the motor and control box have been determined, ordered, and installed, the tracking system will be complete and the team will focus on the solar extraction goal for the project.

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