Solar Reflector and Support Frame

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Introduction

Collecting and producing clean energy has been a focus of engineering advancement since it was discovered that modernization is polluting the environment. In the move to produce clean energy Dr. Kent Udell has patented an evacuated tube that will use heat from the sun to run a refrigeration cycle capable of producing heating and cooling. In order to maximize the heat absorbed from the sun, as much heat as possible must be focused on the evacuated tube. Much like using a magnifying glass to start a fire, our goal is to build a parabolic trough that can focus around 12 ft² of solar radiation onto a 4” collection tube. The main goals set for our design team were to build a frame able to support a 200 lb. glass tube and construct a parabolic trough capable of tracking the sun’s daily movement.

Design Requirements

The main goals set for our design team were to build a frame able to support a 200 lb. glass tube and construct a parabolic trough capable of tracking the sun. In order to achieve the goal of 12,000 BTUs of cooling, the parabolic reflector must rotate at least 60 degrees in each direction in order to absorb the required solar radiation. To calculate the dimensions of the reflector, future heat absorption tube, as well as accompanying wind loads. An electromechanical system was designed, capable of reflecting angle. To calculate the dimensions of the reflector needed to achieve our goal, the equation h = a²/16f was used where h = trough depth, a = aperture of trough, and f = height of focal point to trough. With those values it was determined the parabolic trough needed to be 4.8’ deep to achieve a focal point of 2.5’ above the trough.

Wind loads were also considered while designing the trough. From 2007-2017 Utah has only had one instance were wind speeds exceeded 75-mph. The resulting drag force calculations were performed using a 75-mph wind load on a 3’ x 4’ trough is 1355 N or equivalent to 305 lbs of force.

2. Rotation System

Using two stepper motors controlled by gyroscope feedback the trough will stay perpendicular to the sun during tracking hours and reset to the morning start position at the end of the tracking cycle. The overall mechanism of the rotation system is to deliver the power from the motor through electronic control to two pulleys. The forces required to rotate the trough 60 degrees and the normal forces acting through the bar supporting the trough are represented in the free body diagram blow. It was calculated that the maximum required torque of the motor in the rotating system is about 7.14 kg. As a result, a motor that can generate 9 kg-cm was chosen.

3. Solar Reflector

In order to maximize efficiency, a parabolic solar reflector was designed to reflect solar radiation onto an absorption tube with a low reflectance angle. To calculate the dimensions of the reflector needed to achieve our goal, the equation h = a²/16f was used where h = trough depth, a = aperture of trough, and f = height of focal point to trough. With those values it was determined the parabolic trough needed to be 4.8’ deep to achieve a focal point of 2.5’ above the trough.

To determine the size of the parabolic trough it was assumed a solar radiation input of 1000 W/m². The calculation below uses the radiation input of the sun and the efficiency of the system to solve for the area of the trough.

4. Future Heat Absorption Tube

The heat absorption tube (provided by Dr. Kent Udell) will consist of an inner steel tube filled with ammonia infused sodium chloride that will act as refrigerant. Surrounding the steel tube will be an evacuated glass tube that will reduce heat loss to the environment.

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