Parabolic Trough-Tracking System

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Problem Definition and Project Plan

Document

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Introduction

The current parabolic trough tracking system is an operable. The last time it has been operated was about 15 years ago and it is currently located between the engineering building and the forestry building, in an enclosed area.

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. Steam engines run generators and make electricity. This is an alternative way to make energy.

The team's first objective will be to get the mechanical parts of the system up and running, for example, the motor, gears, and control panel currently on the system. Each subsystem will be concentrated on until the parabolic trough tracking system is operational again

Client Information

The client for the tracking system project is Dr. Srinivas Kosaraju, Professor of Mechanical Engineering at Northern Arizona University. He teaches courses in dynamics, thermodynamics, heat transfer, fluid mechanics, design methods and renewable energy [1]. He did previous research at Florida State University on wind turbine design, modeling and experimental validation.

Background

Solar energy has always been a great source of energy due to its low cost of building the system, operating and the unlimited existence of the sun. However, energy types that come from natural resources are decreasing nowadays and some of them are an unguaranteed source of energy in the future. A solar tracker is a device used for orienting a solar photovoltaic panel or lens towards the sun by using the solar or light sensors connected with the machine [2]. A solid solar tracking system can provide a cheaper way to sustain energy to small firms and houses owners and lower their energy usages.

In our group meeting, we revised the project information given to us from our client. In our meeting we decided the customer needs and devised a project goal as follows. Currently, the tracking system to use the parabolic trough is inoperative. Our goal is to bring the tracking system of the parabolic trough back into service.

Problem Statement

The purpose of this project is to refurbish a parabolic solar panel that also has an automatic tracking system. The unit must efficiently and smoothly track the sunlight in order to obtain the most energy possible. For this project, there are constraints and restrictions that must be followed. Some were directly given, but most were determined by the surrounding conditions and what the team would like to complete for this project.

Objectives for the project are displayed in Table 1 along with a unit measurement.

Table 1: Problem Objectives

Objective	Measurement Basis	Units
Maximize energy extraction	Degree of rotation about its horizontal length	° Degrees
Inexpensive	Costs of repairing damaged parts in the tracking system	$ -Dollars
Expand lifespan of tracking system and parabolic surface	Lifespan	Years

Constraints

Constraints selected for our project are as follows:

- Must be able to control the tracking system using a computer and if possible a smartphone.
- Must be able to withstand up to 70mph winds
- Operate efficiently between -20 and 100 degrees Fahrenheit
- Operate efficiently under changing weather conditions (wind, snow, rain, etc.)

Tracking System Options

There have been various tracking systems used around the world to extract energy from the sun. Parabolic troughs consist of a trough collector, reflectors, heat collection receivers, and a drive or tracking system [3]. According to Amed Rhif, there are three types of solar trackers used, especially in photovoltaic plants [4]. The types of solar trackers are passive, active, and chronological trackers. The parabolic trough, owned by Northern Arizona University, uses an active tracker. An active tracker consists of two motors and gear trains to move the trough to a location that would maximize the energy obtained from the sun. The passive and chronological trackers function based on compressed fluids and rotates 360° per year, respectively [5].

The parabolic trough used uses a single axis solar tracker. There are two methods of tracking, using dual and single axis rotation. The parabolic trough is designed to use single axis rotation, which is the axis parallel to the ground. If a dual axis rotation were used the tracker would rotate based on azimuth and altitude parameters. However, the dual axis tracker is usually used in locations where the sunlight is weaker than other parts of the world.

Pertaining to the tracking and extraction of the parabolic trough, members of the American Society of Mechanical Engineers (ASME) recommend an absorber tube that is located at the focal point of the trough's sunlight reflection [5]. A functional computer program would maximize the focal point using sensors.

Overall the parabolic trough design consists of active tracking, single axis rotation, and an absorber tube. This gives a higher expectancy of the sun's energy.

Testing Environment

In order to test the parabolic trough surface, team 14 will direct a light onto the surface and observe where it is redirected to and how reflect the surface is. The tracking system will be tested in different weather conditions to test if it can be used to adapt to the weather conditions. For example, if debris piles up on the parabolic surface, the tracking system can be used to rotate the through to remove the debris.

Project Planning

Quality Function Deployment Matrix

The Quality Function Deployment (QFD) relates each customer requirement in relation to the engineering requirements and shows which needs depend on each other and can be seen in Figure 1 below.

	Engineering Requirements						
Customer Requirements	Sprocket Sizes	Cost	Weight	Material Strength	Size of Motor	Rotation of Trough	Deflection of Material
Inexpensive	X	X	X	X	X		
Looks Good		X					
Lasts a Long Time		X		X			X
Maneuverable			X				
Low Maintenance				X			
Weather Resistant							X
Easy to Use		X					
Lightweight	X	X	X		X		
Efficient Tracking System	X				X	X	
Units	in	$	lb	Psi	hp	°	in

Figure 1: QFD

Gantt Chart

The Gantt Chart shows the timeline of the tasks of the project. Although the project is in its early stages, a general timeline has been made for the total projected outcome. The generated Gantt Chart for Team 14 may be seen in figure 2. Because our team has not been able to fully assess the current conditions of the parabolic trough, only a general estimate of designing and building can be made at the moment. Once a full inspection is done, further revisions to the project plan/timeline will be made.

Based on what we have seen so far, there is much work to be done to the trough. With it not being used in fifteen years, the wear from sitting outside has taken its toll. Besides its being covered in rust, the motor is essentially useless and there are many tears in the panel itself. The tracking system will also need to be programmed and tested to ensure the maximum amount of energy is being collected. For this, a proper location of the trough will need to be determined. Based on this information so far, the initial design is to be determined by the end of October.

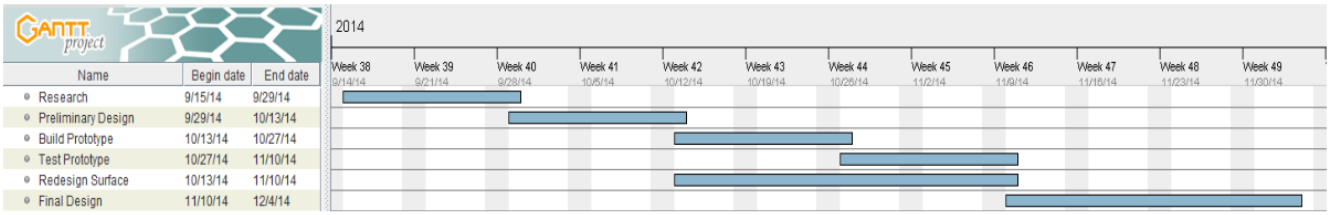

Figure 2: Gantt Chart

Conclusion

Solar energy is a becoming a widespread trend and is increasing throughout the world every day. Using solar power on NAU's campus could greatly increase the efficiency of a certain piece of equipment or become the source of power for something new. The overall goal of this project is to bring NAU's solar tracking parabolic trough back into order using what we've learned so far in our college career and what our customer would like to see done. Based on research of various solar tracking devices and methods, our team will determine what is best for this parabolic trough to maximize the energy extracted from the sun. Although parts will have to be replaced, the workload is possible and will be completed by the end of November. Based on customer requirements, along with what the team has come up with as goals for this project, we have a clear direction of where we would like to go.

References

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