EEL 4911C Senior Design I

Project: Solar Sausage 'B'

Team#: 2

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1. Overview of Design Team

Jimmy Smith, Jr. - Team leader/Project Manager

The Project Manager manages and/or coordinates the tasks of the group as a whole. The PM has the task of delegating roles and making sure the group is performing at a high level. The project manager oversees all operations of the group to make sure everyone knows what to do and when a task or deliverable is due.

Technical Area: Circuit design, microprocessor programming, power

Morgan Bublitz - Lead Mechanical Engineer

The lead mechanical engineer is in charge of the mechanical design of the project. The lead ME keeps in close contact with the lead ECE and is in charge of knowing all of the details of the design and will present valid options for the team to decide on. The lead ME keeps all design documents.

Technical Area: Energy Research and Experimentation 32

Aileen Ulm - Lead Electrical Engineer/Secretary

The lead electrical engineer is in charge of the EE and CE design of the project. The lead EE keeps in close contact with the lead ME and is in charge of knowing all of the details of the design and will present valid options for the team to decide on. The lead EE keeps all design documents. The lead EE keeps all records and reports.

Technical Area: Power, Energy

Jonathan Melton & Xiaoxiang Gao - Electrical Test Engineers

The Electrical test engineers will insure all electrical components work in a synchronized fashion and will test all prototypes.

Technical Area: Power, Photo Voltaic, Energy

James Harrell & Madanha Chibudu - Mechanical Test Engineers

The mechanical test engineers insure all design specifications are valid and will support the system functionality and will test all structure prototypes.

Technical Area: Pressure Systems, Water Pump Design / Thermo Fluid Design

2. Needs Assessment

2.1 Problem Statement

The purpose of this project is to design a complete and working prototype of a Solar Sausage. The end product will prove to produce a cheap and simple way to create electricity and potable drinking water for underdeveloped countries. The goal is to create a sound structure for the Solar Sausage; in order to increase the efficiency of the overall system the pressure measurements, tracking of the sun, and a PV cooling system must be controlled and implemented by the design team. Addressing the inefficiencies in the pressure regulating process will be the most important aspect of this design process.

2.1.1. Background / Context

The Solar Sausage, in simpler words, is an "inflatable solar energy collector". The end result is a parabolic trough concentrator that uses a PV generator to purify water. A research team here at Florida State University has come up with a cheaper and lighter way to capture energy from sunlight. The Solar Sausage heats liquids to a high temperature via focused solar energy, any application that requires heat generation can exploit the process created by the Solar Sausage, including electrical generation and water heating.

2.2 Statement of Needs

The Solar Sausage system has many different aspects involving several needs. There needs to exist a structural system that can support the Solar Sausage, there are several different approaches when building this structure, the team will agree on a specific design later in the process.

In order to optimize the amount of sunlight being received by the Solar Sausage the team will need to configure a tracking mechanism that will provide information of the sun's location in regards to highest influx of sun rays.

A major need for this design project will be to create highly efficient pressure controls. If the pressure in the chambers is not exact the entire system will not operate at acceptable levels. The ability to alter pressure levels via simple circuits will be important for the overall design.

During the process of building the prototype for the Solar Sausage, avenues for the power utilization system will be discussed throughout the team. There will need to be a system that harnesses the power created most efficiently.

In order to keep the Solar Sausage system cool, a cooling system running through the photo voltaic solar panels will be imperative. This water will need to be pumped, and run across the bottom side of the panels. Using aluminum as the material on the back will allow for easy cooling due to the conductivity. Once the water is pumped through the system it will run back through to the pump to be reused.

The water supply being used for the Solar Sausage needs to be purified in the end product. A system will be created in which the water that is pumped for the cooling will be the same water that will be put through a pasteurization process. The water will first be filtered, then pasteurized. If the team decides to filter the water via heat generation the water will need to be heated at 70°C for 10 minutes, or 60°C for an hour.

The Solar Sausage does not require an intensive waste disposal system. The waste collection will be taken care of when maintenance is required for the filter, this will require minimal human interaction and the waste is such that it can be emptied into nearby water.

Naturally the Solar Sausage will result in a low cost and low maintenance overall system. Once the prototype is built very little human interface will be needed. Depending on the reflective material, this will need to be replaced between every 2-5 years. Along with this, the filtration system will need to be replaced once the filter is no longer providing clean water.

2.3 Statement of Wants

An option for the cooling system would be to avoid water cooled PV panels during the electric generation. This is something that has been mentioned as a road to be taken. However, the main customer has mentioned that the use of cooled water for the PV panels would work fine.

In order to catch more of the sunlight throughout the day, there was an idea of using 2 to 3 Sausages close together to make this happen. More details would have to be looked into to see if this would actually increase the efficiency of the system.

Looking at angles of the solar sausage in comparison to the PV panels should help cut down the amount of 'lost rays' when the light enters the Solar Sausage. The customer would like to see if it is possible to accept more sunlight into the system.

Another option for the system, is to create an independently supported tube for the water purification process.

2.4 Supporting Information

The Structural system for the sausage will support the Solar Sausage along with the rotating tracking device and balloon pressure controls. The power utilization system must be cheap, user-friendly, and environment-friendly. The PV Cooling system is a must; however, a water cooled system can cause some problems. The plumbing pipe for the water cooled system causes less light rays to enter the sausage, and make it harder for the tracking mechanism to operate properly. The Use of 2-3 sausage is a want generated from the drawback of the water cooling system. If one can come up with a more efficient cooling system then there only needs to be one sausage with the proper tracking mechanism. Optimization of captured sunlight is a want; however, it is not as big of a deal as 1 and 2. Physics proves that the curvature of the sausage causes loss of Sun rays; therefore, some of this is inevitable. The Water Supply and Purification system, and Waste Disposal system have also caused problems with the operation of the tracking mechanism and rotation of the sausage. This is why there is a want for an independently supported tube for the water purification. Low cost for the overall design and maintenance is the most important need of this project, because the Solar Sausage should be implemented in developing countries.

2.4 Operational Description

The main feature of the Solar Sausage is its ability to harness solar energy from the sun to create cheap electricity via a PV generator. Using this focused solar energy, anything that requires heat generation can be accomplished. The pressurized polyester Sausage surrounds a reflective material that runs through the center, which creates a top and bottom chamber. The pressure inside the top and bottom chamber of the Solar Sausage will be adjusted in order to make sure that the focused light is being received at optimum levels. Due to the materials, only about 66% of the sun's rays are being absorbed for energy use. In order for the system to operate efficiently the PV generator must be cooled with cold water; in combination with the other elements of the Solar Sausage this water can be purified and decontaminated to make potable drinking water for underdeveloped areas of the world.

Having the ability to read/judge pressure levels from a pressure gauge will be a huge factor when the subject of maintenance comes about. If these pressure levels are off by the slightest the whole system will be void. A design idea is to include a programmable microcontroller with the ability to sense where the pressure levels are and alter them accordingly if need be.

The requirements section below will go into more detail regarding what specific elements of the system will be accomplished. The water pump for instance is needed in order for the Solar Sausage to cool the PV panels and pasteurize the water.

The Solar Sausage is very sensitive to weather conditions. It tends to collect a lot of dew in the mornings, therefore a humid/wet environment would not be ideal for long term use. The system does not respond well to wind or heavy rain storms either, these weather patterns can change the pressure around the Solar Sausage immensely, throwing the entire process off course. Ideally, the Solar Sausage system should be implemented in a dry/hot area of the world; this specific climate will help keep the Sausage stable with the least amount of variables affecting it.

3. Requirements Specifications

3.1 Performance Requirements

3.1.1 Pressure Gauge

The pressure gauge needs to be able to have a variable sensing when the pressure of the Solar Sausage is a very low, slightly low, ideal, slightly high, and very high. Each pressure sensor would be powered by the PV panel on the device and be able to trigger the pump or overpressure valve to turn on to a specified duty via a microcontroller. The pressure gauge would be able to utilize existing pressure regulating attachments. This pressure gauge should also have a maintenance schedule similar to the rest of the apparatuses of the solar sausage.

3.1.2 PV Panel Heat Exchanger

The PV panel heat exchanger should be able to be attached to existing PV panels made for the solar sausage. This material should have a mass large enough in accordance with its thermal conductivity to allow enough heat to be absorbed and transferred to the flowing water through the material. The cooling channels should be circular as this would facilitate the maximum amount of heat transfer. The number of cooling channels would be dependent on the temperature of the PV panels and the amount of heat extraction necessary.

3.1.3 Pasteurization

The pasteurization section would be near the end of the solar sausage after PV panel section thereby allowing the water to be preheated. The sanitizing section of the device should be made of copper since it is a highly thermally conductive material and capable of enduring high temperatures necessary to sanitize water. The receiver tube in this instance should have a critical diameter and wall thickness which would make it capable to heat the inner water to heat to 100 Celsius for a specified distance in order to fully sanitize the water. The diameter and wall thickness of the receiver tube should also be able to withstand the pressure of the water flowing through it.

3.1.4 Water Pump

In order for the solar sausage to turn ground water into potable drinking water, there needs to be a water pump that can pump water from the water source into the collection device for pasteurization. This water pump has a few performance specifications that would be required. The pump will ideally be able to operate with minimal power consumption. If the pump could be ran by steam or heated fluid it would be very energy efficient and would not require many expensive components to operate. The pump would have to be able to withstand high pressures to pump the water efficiently. The pressure parameters would be approximately 100psi. This is assuming a 200ft depth for the well. The water pump also has to be able to withstand temperatures between 50 and 140°C due to the changes in temperature that may occur due to the depth of the water source.

3.1.5 Filtration System

In order for the water to be a suitable consistency, a filtration system would have to be implemented into the design. The filtration process would occur before the water enters the sausage. Since the filtration system will have to be maintained regularly, there would need to be easy access to the internal components. The filtration system could use such materials as burnt stick, sand or rocks to eliminate impurities in the water. In order to ensure quality control, it would be important to have some sort of operation timer that could notify personnel if maintenance is required or filtration materials need to be replaced.

3.2 Constraints

3.2.1 CONS-01

The total cost of the project cannot exceed the designated budget value of $5,000 given by our sponsor. This amount should cover all of the expenses such as materials, sensors, labor costs, filtration system, water pump, pressure gauge, photovoltaic panel, installation, and testing costs.

3.2.2 CONS-02

This project has to be completed within a two semester time window. By the end of the first semester, all engineering drawings of the prototype should be available to the sponsor so that the group can mainly focus on the construction, installation and testing of the prototype in the following semester.

3.2.3 CONS-03

Both the solar sausage and photovoltaic panel are going to have a length that is approximately equal to 10 feet.

3.2.4 CONS-04

The photovoltaic cells to be provided by our sponsor have a power output of $900W/m^2$, which is a controlling factor for how much power is going to be extracted from the PV cells.

3.2.5 CONS-05

The portable water has to go through a filtration and pasteurization process to remove any bacteria or bugs that are present in the water. The water should be pasteurized with temperatures that range from 65°C – 90°C.

3.2.6 CONS-06

The upper hemisphere of the solar sausage has to be filled with a pressure of 0.5psi, while the lower hemisphere must have a pressure of 0.492psi. The system always has to maintain a pressure difference of 0.008 psi.

3.2.7 CONS-07

The current design on the solar sausage limits us to one axial rotation system which requires few moving parts in order to track the sun.

3.2.8 CONS-08

The reflective film material used inside the solar sausage affects the tensions required to tighten both ends of the solar sausage.

3.2.9 CONS-09

Dew, cold, and humid climates are not suitable conditions for the solar sausage. This limits us to only marketing our product to dry regions of the world.

3.3 Interface Requirements

At high temperatures, higher pressure values will be seen in the upper and lower hemispheres of the solar sausage; values that are not consistent within an ideal environment. At low temperatures, lower pressure values are significantly lower than the initial values of .5 psi and .492 psi in the upper and lower hemispheres respectively. Dew in the morning would be a huge factor because it creates a layer of condensation on the outer regions of the solar sausage along with the decrease in pressure. Also, with the layer of condensation that has formed, it alters the ideal index of refraction that is valid for the solar sausage.

The end-users' job would be very trivial. The end-user would only have to check on the pressure sensors to see if they are working properly, maintain the filtration system, and change out the reflective film(about every 2-5 years). Maintaining the filtration system is vital in utilizing the potable water that has been pasteurized by the solar panel.

The implementation of the solar sausage with other systems would be very complex. Utilizing a valve system that is controlled by a microcontroller would be very complex. In addition with the valve microcontroller implementation; pump controlling, deposit/waste system, cooling system, pasteurization of the water would also be complicated because the flow of fluids would only go one direction.

4. Preliminary Test Plan

Testing is a main part of the engineering design process. Without testing and specific testing parameters one would not know if the product was working efficiently or as the designer intended. Releasing faulty products to the general public is a big violation of engineering ethics. In order to make sure engineers are sustaining a high code of morals the testing process is implemented

4.1 Objective

The objective of testing is to ensure that each part of the design is working to its capability without endangering the environment, user, and/or both.

4.2 Features to be Tested

1. Interface
2. Pressure Sensor
3. PV Cooling System
4. Voltage and Current Output
5. Water Purifying
6. Sun Tracking

4.3 Tests to be Conducted

4.3.1 Conversion Test

The conversion test is one that will test to make sure the power is converting from DC to AC properly. Since Photovoltaic panels generate DC power todays modern world could not use it; however, once the power is converted to AC then it can be used in a modern household. An inverter should be placed in the design somewhere to convert the power.

The test conducted to ensure the proper power conversion will be simply hooking up a multi-meter in the correct places to determine the current, voltage, and power supplied by the PV panels. The optimal and ideal power converted by PV panels is$900\frac{W}{m^2}$. Since this is ideal and does not take into account the resistance of wires, inverter, etc. then the expected value is slightly below this.

4.3.2 Interface Test

The interface test will ensure that even in extreme weather conditions that the sausage still works, or is safe from major malfunction in severe weather storms. This test will also ensure that no major meltdowns happen while the maintenance worker is maintaining upkeep on the product.

The interface test will be conducted in all possible weather conditions at a particular geographical location. This will ensure that the pressure and all things will be ok when a major storm is on the horizon and the temperature drops about 20 degrees in 10 minutes (this is one example of many to be conducted in this testing phase).

4.3.3 Water Purifying Test

Water Purifying is a test that is of great importance to this project. Water purification is a key role in this project. Since this project is mainly supposed to generate cheap power and purify water for a developing country or developing region in a country. Without water purification this project is not as effective in a region as it could be.

In water purification the water will pass through a few filters and then be pasteurized. The pasteurization process will ensure that all parasites are killed off and the water that comes from unreliable sources is clean enough to drink. This test will be completed by the environmental engineers on this project. This test will test the amount of different toxin levels in the water and assure that it passes the Red Cross standards for consumable water.

4.3.4 Pressure Sensor Test

The sausage has 2 different pressures enclosed in the top and bottom chambers. The difference in pressures are separated by a single reflective lens. With pressure only able to be different by at most 0.008 psi there is a need for some type of pressure regulator.

There is a very complex pipe and Hg liquid system in effect now that bubbles in air as needed in the chamber. A more efficient system is currently in the R&D phase, and will contain a microcontroller that will test the pressure, then open and close valves to maintain a regulated pressure.

4.3.5 Performance Test

Performance test. The performance test will be a final test to ensure that all pieces of the sausage are working in perfect (or some variation thereof) harmony. This consists of a few final tests that will be conducted before the beta process begins. Once the final project is put together then various tests and monitors will be linked together to test all things above to ensure that all things are working superbly.

4.3.6 Sun Tracking Test

Sun tracking is vital to the PV panels. Sun rays travel in a parallel fashion in Earth's atmosphere. Optimization of the solar panels at all times while the sun is visible is important. If the sun is rising and the panels are not facing the east then one can easily assume that not much power will be generated until the sun reaches the top of sky. There are solar tracking devices that are already out there and widely used in existence today. There is no need to reinvent the wheel; therefore one of these may be "reverse engineered" (legally of course), or one may be purchased. Either way we will need to ensure its operation is up to standard. Placing some PV panels on the tracker outside in the sun for a few days and tracking its accuracy to the sun will be a great test!

4.3.7 PV Cooling Test

As one can imagine, PV panels get extremely hot from taking on so much sunlight and generating electricity from that sunlight. Cooling these panels is a necessity. This necessity is currently being met by a couple of pipes running along the bottom of the solar panels to ensure the panels are at an operable temperature; however, another type of cooling mechanism is also still in development. There is a slight problem with two pipes running along the bottom of the solar panels.

The new way of cooling has not been finalized just yet; however, the group is close to coming up with a great alternative. Testing this new cooling method will be done by simply placing a few temperature sensors throughout the solar panel and running them at extremely high energy demanding times.

4.3.8 Beta Testing

Beta testing is a common term that many non-engineers know. Beta testing simply means that the consumer will test the product out to ensure that it satisfies all of their needs, and most of their wants. If this test is passed then the product is then moved on to mass production and implemented worldwide.

5. Conclusion

The Solar Sausage poses many constraints such as the environment from which the team will be able to test in. The Solar Sausage was designed for severely dry conditions in 3rd world nations. Due to the fact that the Sausage will be tested in the humid, rainy conditions of Florida; the dew and/or condition will pose a problem. Not to mention the fact that high winds during hurricanes and/or thunderstorms will pose a major problem to the conditions of the sausage.

The interface of the sausage will be very strenuous with the implementation of the valves, actuators, cooling, waste, and purification system should be trivial to the end-user. Pressure sensors to control the upper and lower hemispheres will only need to be maintained about once every 3 months. The waste system will need to be exchanged about once every 3 months as well. The end-user will also need to change out the reflective panel between 2–5 years.

Testing of the Sausage will be conducted in stages. With each implementation of a new system a new testing procedure will need to be done. Performance testing of the system will be done after every new system is implemented to make sure that the overall system performs up to par. Sun tracking testing will have to be implemented during the peak hours of the day. PV cooling and beta testing will be conducted simultaneously to ensure that each component is synchronized.

In conclusion, the Solar Sausage Project 'B' poses many obstacles for the design team. Analyzing the customer's needs and wants provides a valuable insight as to how to initiate this project. Developing a prototype based on photovoltaics to provide electricity and potable water via sunlight is fundamental in helping in the cause for more renewable energy and its sources.