DESIGN AND CONSTRUCTION OF A MINIATURE CYLINDRICAL PARABOLIC TROUGH SOLAR CONCENTRATOR

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ABSTRACT

Over the last few decades, there have been significant changes in the way people use the world’s energy resources. There has been an increasing effort from governments, industry and academic institutions to find alternative sources of energy and to improve energy efficiency. This, plus an ever growing pressure from different sectors of society to reduce carbon dioxide emissions, has motivates the development of emerging technologies to reduce the dependency on fossil fuels and the optimization of existing systems in order to minimize energy consumption. Solar energy is one of the alternative energies that has vast potential. It is estimated that the earth receives approximately 1000W/m² amount of solar irradiation in a day.

There are two ways to produce electricity from the sun. First is by using the concentrating solar thermal system. This is done by focusing the heat from the sun to produce steam. The steam will drive a generator to produce electricity. This type of configuration is normally employed in solar power plants. The other way of generating electricity is through a photovoltaic (PV) cell. This technology will convert the sunlight directly into electricity. Some of the applications of solar energy are power plants, Homes, Commercial use, Ventilation system, Power pump, Swimming pools, Solar lighting, Solar cars and Remote applications. These are the few above applications where the use of Solar Energy can be used. So, there is a need to concentrate Solar Energy.

Here, we are constructing a cylindrical parabolic solar concentrator for concentrating solar energy. The concentrated energy is used for heating the water and thus analyzing the inlet and outlet temperatures of water. A solar concentrator is a device that uses parabolic mirrors to redirect and concentrate the sun’s rays onto a small focal point. They are used in many different applications where solar thermal energy is involved.

Index Terms: Solar energy, Solar concentrator, Parabolic concentrator

1. SOLAR CONCENTRATOR

A solar concentrator is a device that uses parabolic mirrors to redirect and concentrate the sun’s rays onto a small focal point. They are used in many different applications where solar thermal energy is involved.

Solar concentrators can also be used in photovoltaic solar applications to concentrate the sun’s energy onto the solar panel itself. This allows the panel to create much more energy and be more efficient as it is exposed to a much larger amount of sunlight than it normally would be without the collector to redirect the rays directly on the panel.

Solar concentrators are also used in solar thermal power stations around the globe, and they are the most effective way of producing electricity through solar energy. A solar thermal collector utilizes a large array of solar concentrators or mirrors to redirect and concentrate the sun’s energy onto a focal point. This focal point has reach temperatures in excess of 2000 degrees Celsius.

In a solar thermal power station, the solar thermal energy generated at the focal point is then transferred to water to make it boil and create steam. This steam is then used to run a steam turbine to create electricity. Solar concentrated energy seems to be the way of the future, as it is possible to create much more energy in a smaller space than with photovoltaic solar power.

1.1 BACK GROUND

The idea behind a concentrating solar collector is to minimize the heat losses associated with solar collection. In many instances it is desirable to deliver energy at higher temperatures than those possible with flat plate solar collectors. In this case, a parabolic “mirror” concentrates incident solar irradiation onto a much smaller receiver area, greatly decreasing heat loss and maximizing the available energy from the sun. There are many different types of concentrating solar collectors in use today. Concentrators can be reflecting or refracting, cylindrical, spherical, parabolic, and they can be continuous or segmented. Receivers can be convex, flat, cylindrical, covered or uncovered.

One important factor in the analysis of solar concentrators is the concentration ratio. The concentration ratio is defined as the ratio of the area of the aperture of the concentrator to the area of the
receiver that is reflected upon by the concentrator. This is in essence the heart of a solar concentrator. Solar tracking is also necessary for efficient use of concentrating collectors. Without tracking the collector becomes almost useless except for a very short time period once a day. Large scale concentrators today use automated tracking systems that can track the sun on a biaxial path.

1.2 CLASSIFICATION OF SOLAR CONCENTRATOR

The different concentrating concentrators are generally classified as under:

- **Focusing and Non-Focusing type:** Whether the Collector focuses the solar radiation on the absorber or just diverts it. Focusing type collectors are further classified in line focusing and point focusing collector.

- **Tracking and Non-Tracking type:** Whether the Collector is provided with Tracking Mechanism so that it can follow the sun or is of Fixed Orientation. Tracking type is further classified as Single axis tracking and Double axis tracking. Tracking can be intermittent (daily or weekly tracking) or Continuous Tracking.

- **Concentrating Ratio achievable:** Concentration ratio achievable can be between 1 (limiting value for Flat Plate Collector) to 10,000 (Parabolic Dish Collector). Concentration ratio also approximately determines the operating temperature of the collector. In this article the collector that can be compared with Compound Parabolic Concentrator are discussed. They are :

  **Cylindrical Parabolic Concentrator:** It is conventional imaging collector. It focuses the solar energy on a line, through which water flows. The aperture areas vary from 1 – 6m². The concentration ratio is in the range of 10 – 80. Temperature up to 400°C can be obtained. A simple working model is shown in figure.

  ![Figure 1: Cylindrical Parabolic Concentrator](image)

  **Parabolic Dish Collector:** This is similar to cylindrical parabolic concentrator except here the focusing is point focusing instead of line focusing. Hence a very high concentration ratio is achieved. The delivery temperature created by this collector is the highest among all the collectors around 600°C. Figure describes the working of Parabolic Dish Collector. A more sophisticated parabolic collector trough can be designed, that avoids the need to track the sun altogether, by combining two parabolas together, to form the "Compound Parabolic Trough Solar Collector." When this is done, the co-focal point then becomes a co-focal line. If a coolant filled pipe solar energy absorber pipe, or a tubular evacuated tube solar energy absorber tube is co-located at the co-focal line, there will then be a maximum of concentrated solar energy delivered and transferred to the energy absorber tube! Such solar collectors do not need tracking, and require only occasional season angle adjustments (several times a year) are required to keep the aperture perpendicular to the noonday sun, to the maintain maximum power output.

  ![Figure 2: Parabolic Dish Concentrator](image)

  **Compound Parabolic Concentrator:** By selecting non-imaging optics we can thus avoid the need to keep the collector aperture pointed at the sun. Instead, we can collect and concentrate Solar Energy from multiple directions separately or at once. So while the sun moves across the sky, we can still accept and concentrate the Solar Thermal Energy all day using a properly designed compound Parabolic Trough Concentrating Solar Collector coupled with Evacuated (vacuum) tube Solar energy Capture Tubes. Using this type of collector, the output energy of a Solar Energy Capture Tube can be increased by a factor of 4–6 times using a stationary solar collector.

  ![Figure 3: Compound Parabolic Concentrator](image)
**Fresnel Concentrator:** Fresnel lens function is similar to the conventional lens, by refracting the rays and focusing them at one focal point. It generally has two sections; a flat upper surface and a back surface that employs canted facets. The facet is an approximation of the curvature of a lens.

![Figure 4: Fresnel Concentrator](image)

**Hyperboloid Concentrator:** The general design of a hyperboloid concentrator is shown in Figure 3. It consists of two hyperbolic sections, AB and A'B'. The hyperboloid concentrator can be produced by rotating the two dimensional design along its symmetrical axis. The diameters of the entrance and exit aperture are labeled as d1 and d2 respectively. If the inside wall of the hyperbolic profile is considered as a mirror, the sun rays entering the concentrator from AA' will be reflected and focused to the exit aperture BB'. The advantage of this concentrator is that it is very compact, since only truncated version of the concentrator needs to be used. Because of this factor, it is mainly used as a secondary concentrator. An example of application of this concentrator has been developed by Sol Focus, with the intention of reducing the cost of solar electricity.

![Figure 5: Hyperboloid Concentrator](image)

**Dielectric Totally Internally Reflecting Concentrator (DTIRC):**

The first concept of DTIRC was introduced by Ning et al. in 1987. This new class of optical element has the capability to achieve concentrations close to the theoretical maximum limits. There are two ways to produce the DTIRC; maximum concentration method and phase conserving method. Although both methods will create almost identical structure, the first technique offers slightly higher concentration and therefore more suitable for solar application. DTIRC consists of three parts; a curved front surface, a totally internally reflecting side profile and an exit aperture. When the rays hit the front curved surface, they are refracted and directed to the side profile. Upon hitting the sidewall, they will be totally internally reflected to the exit aperture. The front aperture can be a hemisphere, but different designs such as parabola and ellipse have been developed recently. The DTIRC is available either as a three dimensional rotational symmetry concentrator or as a two dimensional optical extrusion, although the earlier design is more favorable.

![Figure 6: DTIR Concentrator](image)

**Flat High Concentration Devices:** The concentrators are able to achieve theoretical maximum acceptance-angle-concentration. Currently, Light Prescription Innovators (LPI) is working closely with UPM to further develop and market these concentrators. These concentrators have two major benefits; they are very compact and offer very high concentration. However, there are some disadvantages of this design. Due to the cell's position, it is difficult to create electrical connection and heat sinking. The cell dimension must be...
designed to be as minimal as possible to reduce shadowing effect.

**Figure 7:** Flat High Concentrating Devices

**Quantum Dot Concentrator (QDC):** Quantum dot concentrator (QDC) is a planar device that consists of three parts; a transparent sheet of glass or plastic made doped with quantum dots (QDs), reflective mirrors mounted on the three edges and back surface, and an exit where a PV cell is attached. When the sun radiation hits the surface of a QDC, a part of the radiation will be refracted by the fluorescent material and absorbed by the QDs. Photons are then reemitted in all direction and are guided to the PV cell via total internal reflection. The total geometrical concentration will be the ratio of the large surface area of glass to the area of PV cell.

**Figure 8:** Quantum Dot Concentrator

### 1.3 Summary of the Advantage and Disadvantage of the Concentrators

To summarize the various design of the concentrator, as the below table shows the comparison of each concentrator, showing the advantage and disadvantage of each design respectively.

<table>
<thead>
<tr>
<th>Type of Concentrator</th>
<th>Advantage</th>
<th>Disadvantage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parabolic Concentrator</td>
<td>High concentration.</td>
<td>Requires larger field of view. Need a good tracking system.</td>
</tr>
<tr>
<td>Hyperboloid Concentrator</td>
<td>Compact</td>
<td>Need to introduce lenses at the entrance aperture to work effectively.</td>
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<tr>
<td>Frennel Concentrator</td>
<td>Thinner than conventional lens. Requires less material than conventional lens. Able to separate the direct and diffuse light - suitable to control the illumination and temperature of a building interior.</td>
<td>Imperfection on the edges of the facets, causing the rays improperly focused at the receiver.</td>
</tr>
<tr>
<td>Compound Parabolic Concentrator</td>
<td>Higher gain when its field of view is narrow.</td>
<td>Need a good tracking system.</td>
</tr>
<tr>
<td>Dielectric Totally Internally Reflecting Concentrator</td>
<td>Higher gain than CPC. Smaller size than CPC.</td>
<td>Cannot efficiently transfer all of the solar energy that it collects into a lower index media.</td>
</tr>
<tr>
<td>Flat High Concentration Devices (RR, RX, RY, RX, and RXI)</td>
<td>Compact, Very high concentration</td>
<td>Difficulty to create electrical connection and heat sinking due to the position of the cell. The cell dimension must be designed to a minimum to reduce shadowing effect.</td>
</tr>
<tr>
<td>Quantum Dot Concentrator</td>
<td>No tracking needed, Fully utilize both direct and diffuse solar radiation</td>
<td>Restricted in terms of development due to the requirements on the luminescent dyes.</td>
</tr>
</tbody>
</table>

### 2. CYLINDRICAL PARABOLIC TROUGH

A parabolic trough is a type of solar thermal collector that is straight in one dimension and curved as a parabola in the other two, lined with a polished metal mirror. The energy of sunlight which enters the mirror parallel to its plane of symmetry is focused along the focal line, where object is positioned that is intended to be heated. For example, food may be placed at the focal line of a trough, which causes the food to be cooked when the trough is aimed so the Sun is in its plane of symmetry. Further information on the use of parabolic troughs for cooking can be found in the article about solar cookers.

For other purposes, there is often a tube, frequently a Dewar tube, which runs the length of the trough at its focal line. The mirror is oriented so that sunlight which it reflects is concentrated on the tube, which contains a fluid which is heated to a high temperature by the energy of the sunlight. The hot fluid can be used for many purposes. Often, it is piped to a heat engine, which uses the heat energy to drive machinery or to generate electricity. This solar energy collector is the most common and best known type of parabolic trough. The paragraphs below therefore concentrate on this type.

The trough is usually aligned on a north-south axis, and rotated to track the sun as it moves across the sky each day. Alternatively, the trough can be aligned on an east-west axis; this reduces the overall efficiency of the collector due to cosine loss but only requires the trough to be aligned with the change in seasons, avoiding the need for tracking motors. This tracking method approaches theoretical efficiencies at the spring and fall equinoxes with less accurate focusing of the light at other times during the year. The daily motion of the sun
across the sky also introduces errors, greatest at the sunrise and sunset and smallest at solar noon. Due to these sources of error, seasonally adjusted parabolic troughs are generally designed with a lower concentration acceptance product.

Parabolic trough concentrators have a simple geometry, but their concentration is about 1/3 of the theoretical maximum for the same acceptance angle, that is, for the same overall tolerances of the system to all kinds of errors, including those referenced above. The theoretical maximum is better achieved with more elaborate concentrators based on primary-secondary designs using non imaging optics which may nearly double the concentration of conventional parabolic troughs and are used to improve practical designs such as those with fixed receivers.

The initial thought was to take the derivative of a circular equation to find the proper incline at different points along the sphere’s inner surface. These inclines would then be rotated about the origin. This was a difficult problem considering the limited resources. A different approach was taken.

After conducting more research on solar energy and solar collection, the decision was made to attempt to build a parabolic trough solar concentrator.

In a parabola all of the incoming rays from a light source (in this case the sun) are reflected back to the focal point of the parabola. If the said parabola is extended along an axis (becoming a trough) the solar rays are concentrated along a line through the focal point of the trough. The focal point of a parabola is located at 1/4a, if the equation of the parabola is \( y = ax^2 \). The parabolic trough selected fit the equation \( y = 0.04167x^2 \) from \( x = -12 \) inches to \( x = 12 \) inches. This equation was chosen to yield a focal point located at 6 inches above the vertex of the parabola, for ease of construction. Initial sketches and drawings are located in below forms.

A mathematical model was developed that would help determine the temperature of the water leaving the parabolic trough, knowing the temperature of the water entering the trough and the amount of isolation absorbed by the receiver.

The frame for the parabola was made out of plywood. It would be attached to a base which would allow for proper angling of the parabolic trough. The entire collector was small enough to allow for easy manual adjustment for solar tracking. The receiver chosen was a simple, 19mm diameter copper pipe. Copper was chosen because of its high thermal conductivity and it is relatively inexpensive. The water source was planned as a reservoir located above the trough, with gravity assisted flow through the trough, to another reservoir used for collection of the heated water. These were going to be fifty gallon drums. But, based on the location of testing, a simple garden hose was used with a compression fitting to attach the hose to the copper pipe. This proved to be easier and more efficient, as well as significantly less expensive.

A piece of Acrylic glass material was used for the reflective surface. A reasonably priced piece of Acrylic glass material was found at a website called OnlineMetals.com. A 40 inch by 30 inch piece of Acrylic glass material, .020 inch thick was selected. With the design stage complete construction began.

### 2.1 DESIGN OF CYLINDRICAL PARABOLIC TROUGH

The initial plan for a solar concentrator was to use a semi-spherical surface covered with many small sections of mirror to form a segmented, spherical concentrator. Referring to the optics section of a University Physics textbook it was found that the focal point of a spherical mirror would be located at a distance of half of the radius of the spherical section, directly above the vertex of the sphere. Quite some time was spent on trying to find a way to orient the small mirror sections at the proper angles about the inner surface of the sphere.

### Designs Sketches:

Figure 9: A parabolic trough is shaped as a parabola in the x-y plane, but is linear in the z direction

Figure 10: A diagram of a parabolic trough solar farm (top), and an end view of how a parabolic collector focuses sunlight onto its focal point.
2.2 MATERIALS USED

Materials used in this project are classified into two categories. They are as follows

1. Concentrator Material
2. Receiver or Absorber Material
3. Ply wood Material
4. Nuts and Bolts
5. Washers and Nails

2.2.1 Concentrator Material

(Poly methyl Methacrylate) (PMMA) is a transparent thermoplastic often used as a lightweight or shatter-resistant alternative to soda-lime glass. Although not a type of familiar silica-based glass, the substance, like many thermoplastics, is often technically a type of glass (a non-crystalline vitreous substance) and historically has often been called acrylic glass. Chemically, it is the synthetic polymer of methyl methacrylate.

PMMA is an economical alternative to polycarbonate (PC) when extreme strength is not necessary. Additionally, PMMA does not contain the potentially harmful bisphenol-A subunits found in polycarbonate. It is often preferred because of its moderate properties, easy handling and processing, and low cost. Non-modified PMMA behaves in a brittle manner when loaded, especially under an impact force, and is more prone to scratching than conventional inorganic glass, but modified PMMA can achieve high scratch and impact resistance.

2.2.2 Receiver or Absorber Material

We plan to use a 19mm outer diameter copper pipe as our receiver. The pipe will be spared with Black heat resistant paint to maximize the energy absorbed by the copper pipe. Copper will be used for its high thermal conductivity. The pipe will be placed at the focal point of the parabola through spanning the entire length. The water will be run through the copper pipe while the temperature of the water will be measured at the inlet and outlet of the pipe. A simple siphon will be used to provide the water flow with an upper reservoir large enough to allow ample time for testing the pipe connecting the copper pipe will be flexible tubing PEX tubing also 19mm dia. Our first idea for the upper receiver A is used to use a large camp cooler be to attempt to keep the reservoir temperature at a constant level, hopefully this will be large enough for our purpose. The lower reservoir is not as important just a tub to collect the water for retesting purposes.

Figure 14: skeletal structure of methyl methacrylate

Figures 11, 12 & 13: Design Sketches of Parabolic Concentrator
2.3 CONSTRUCTION

The plan for construction consisted of the following. Based on the initial design sketches materials were bought at Home Depot. A five foot long piece of 19 mm diameter copper pipe, a carpenters square, measuring tape, and three boxes of different types of screws (1.25 inch wood screws, 2 inch wood screws, and 0.5 inch screws) were purchased. The dimensioned pieces of wood were brought from the wood. To build the base of the solar collector two partial triangles were cut from the plywood and the partial triangles are placed on two wooden frame supports. Next the frame is built according to the design profile. To build the frame we used Mild Steel strips of half inch thickness. Those strips are bent into the shape of required parabolic form using Tin Smithy Tools and Bench Vices. To make them retain at their required original shape of parabola , we have welded the bottom of the three Mild Steel strips to the steel rods maintaining equal gap between two consecutive Mild Steel strips. This frame which is built is attached to the two partial triangles by using Bolts and Nuts. The provision has been made to rotate the whole setup according to the Sun’s incident angle. The setup is adjusted manually according to the different positions of the Sun.

To attach the Acrylic sheet to the frame, it was cut into the proper size rectangle using the hangar’s sheet metal cutter. The Acrylic sheet’s polished side was protected by a plastic film. This film was left on the Acrylic sheet until immediately before testing. Next the Acrylic sheet was manually bent down into the parabolic frame and attached. Some trouble was encountered here because the Acrylic wasn’t rigid enough to hold a consistent shape between the two frame pieces.

At the focal line of the Cylindrical Parabola, the copper tube of 19 mm diameter is placed so that the whole Solar radiation which falls on the surface of the parabola concentrates on to the copper tube. Two holes are drilled on the either sides of the copper tube for placing the thermocouples. One end of the copper tube is connected to the reservoir containing water using PEX tube. The other end of the copper tube is connected to the reservoir B using the same type of PEX tube. This completes the constructional setup of our project.

Having finished the construction, all that was left was putting it all together. The pieces were brought to the test site, and using the bolts, nuts, and washers the trough was attached to the base. The pipe clamps were loosened to attach the painted copper pipe to the trough. The solar concentrator was ready for testing.

2.4 EXPERIMENTAL PROCEDURE

- Let the water be allowed to flow from the reservoir to the copper tube for some time.
- After allowing the copper tube to heat for some time, the inlet and outlet water temperatures are noted using the thermocouples.
- The readings are taken at an interval of 10 minutes.
- Also the sunlight intensity values are measured by using the Pyranometer along with the inlet and outlet temperatures at the same interval of 10 minutes.
- This procedure is repeated by manually tracking the concentrator according to the sunlight incident angle.

2.5 DEVICES USED

The following devices were used in the project as follows

- Pyranometer
- Thermocouples
- Thermometers

- **Pyranometer**: A Pyranometer is a type of actinometer that can measure solar irradiance in the desired location and solar radiation flux density. The solar radiation spectrum extends approximately between 300 and 2800 nm. The pyranometer only requires a flat spectral sensitivity to help cover this spectrum.

![Figure 15: Pyranometer](image)

- **Working Principle**: A Pyranometer is operated based on the measurement of temperature difference between a clear surface and a dark surface. The black coating on the thermopile sensor absorbs the solar radiation, while the clear surface reflects it, and hence less heat is absorbed. The thermopile is used to measure this temperature difference. The potential difference created in the thermopile owing to the temperature gradient between the two surfaces is used for measuring the amount of solar radiation.

- **Thermocouples**: A thermocouple is a temperature-measuring device consisting of two dissimilar conductors that contact each other at one or more spots, where a temperature differential is experienced by the different conductors (or semiconductors). It produces a voltage when the temperature of one of the spots differs from the reference temperature at other parts of the circuit. Thermocouples are a widely used type of temperature sensor for measurement and control, and can also convert a temperature gradient into electricity. Commercial thermocouples are inexpensive, interchangeable, are supplied with standard connectors, and can measure a wide range of temperatures. In contrast to most other methods of temperature measurement, thermocouples are self powered and require no external form of excitation. The main limitation with thermocouples is accuracy; system
errors of less than one degree Celsius (°C) can be difficult to achieve.

Any junction of dissimilar metals will produce an electric potential related to temperature. Thermocouples for practical measurement of temperature are junctions of specific alloys which have a predictable and repeatable relationship between temperature and voltage. Different alloys are used for different temperature ranges. Properties such as resistance to corrosion may also be important when choosing a type of thermocouple. Where the measurement point is far from the measuring instrument, the intermediate connection can be made by extension wires which are less costly than the materials used to make the sensor. Thermocouples are usually standardized against a reference temperature of 0 degrees Celsius; practical instruments use electronic methods of cold-junction compensation to adjust for varying temperature at the instrument terminals. Electronic instruments can also compensate for the varying characteristics of the thermocouple, and so improve the precision and accuracy of measurements.

**Figure 16: Thermo couples**

- **Thermometers**: A thermometer is a device that measures temperature or a temperature gradient. A thermometer has two important elements: the temperature sensor (e.g., the bulb on a mercury-in-glass thermometer) in which some physical change occurs with temperature, plus some means of converting this physical change into a numerical value (e.g., the visible scale that is marked on a mercury-in-glass thermometer). There are various principles by which different thermometers operate. They include the thermal expansion of solids or liquids with temperature, or the change in pressure of a gas on heating or cooling. Radiation-type thermometers measure the infrared energy emitted by an object, allowing measurement of temperature without contact.

**Table 1: EXPERIMENTAL READINGS**

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3. CONCLUSION

The results achieved using this miniature parabolic trough solar concentrator did not quite match up to the results expected based on the initial mathematical modeling. The mathematical model initially proposed considered perfect conditions and a perfect parabolic trough concentrator. Thermal losses can occur through heat transfer by conduction through the surface of the parabolic trough and into the frame. Heat loss due to convection can also be a major issue on the receiver pipe surface. Fluctuation in wind speed throughout testing likely caused more heat loss than expected. This could be combated by insulating the top surface of the receiver tube, or enclosing the trough using glass or Plexiglas with high transmittance. Better insulation of the back of the reflecting surface would also help with the heat lost due to conduction.

The shape of the parabola may also not have been perfect due to issues during construction, such as imperfect jigsaw cutting, sanding of the frame, and mounting of the Aluminum. These could all affect the amount of incident radiation on the copper receiver tube and thus the amount of heat transferred to the
concentrator fluid. These thermal losses likely reduced the amount of useful solar gain for my concentrator. Therefore the temperature gain received in testing is significantly lower than predicted with the mathematical model. Despite the thermal losses experienced the solar concentrator did heat the water fairly consistently throughout testing. The project is a general success through the processes of designing, building, and testing.

4. FUTURE SCOPE

A study done by Greenpeace International, the European Solar Thermal Electricity Association, and the International Energy Agency's Solar PACES group investigated the potential and future of concentrated solar power. The study found that concentrated solar power could account for up to 25% of the world's energy needs by 2050. The increase in investment would be from 2 billion Euros worldwide to 92.5 billion Euros in that time period. Spain is the leader in concentrated solar power technology, with more than 50 projects approved by the government in the works. Also, it exports its technology, further increasing the technology's stake in energy worldwide. Because of the nature of the technology needing a desert like area, experts predicted the biggest growth in places like Africa, Mexico, the southwest United States.

With correctly concentrating the sun light on to the focus line of the Cylindrical Parabola, It will be possible for us to generate the steam that will be useful for running the Steam Engine. And it can be used for pre-heating purposes in Power plants. There has to be an Automatic Tracking system for the change of the face of the Cylindrical Parabolic surface according to the Sun's position.

ACKNOWLEDGEMENTS

The satisfaction that accompanies the completion of any task would be incomplete without naming the people who made it possible whose constant guidance and encouragement made the work perfect.

We consider a great pleasure and privilege to have the opportunity to carry out the dissertation under the esteemed guidance of Dr. K. Vijaya Kumar Reddy, Professor, Mechanical Engineering Department, for his constant encouragement, intellectual interaction, inspiration, help and review of entire work during the course of work is in valuable.

We are thankful to Dr. M. Srinivas Rao, Professor, Head of the Department, Mechanical Engineering for his support.

We are thankful to Dr. A. Jaya Laxmi, Coordinator, centre for energy studies, Mechanical Engineering Department for her support.

We are thankful to my Family and Friends for their support and encouragement without which this project wouldn’t be a success.

REFERENCES


