Enhancement Of Energy Efficiency With Modeled Design Of Concentrated Solar Power Technology Using Parabolic Dish And Trough

D.Kameswara Rao, Dr.K.Sudhakar Reddy, Dr. V.V.Subba Rao

Abstract: Energy transition from conventional to renewable sources of energy is yet to be realized in spite of several successful alternate energy production methods and installations. It is difficult to point more than one or two examples of a modern industries obtaining the bulk of its energy from sources other than oil, coal, and natural gas. The prospects for large-scale production of cost-effective renewable electricity / thermal energy remain to be generated utilizing either by the wind energy or certain forms of solar energy. Concentrates solar power (CSP) approach is the one of best advanced method to enhance the efficiency in solar thermal /electricity technology. Concentrate solar power (CSP) has great potential demand in world thermal and electrical energy needs. This presents the presents the work of scaled down models of parabolic dish, parabolic trough solar concentrators by utilizing the tapped heat from sun to utilize thermal and electrical application like water heating , drying along with its study of variations in temperature and pressure. Scaled down model was developed by using less cost materials like aluminum sheet for support TV dish (as parabolic dish), copper tube for conducting heat to the working fluid (water), wood, reflective sheet for proper reflection of sun's heat onto a desired area. By using working fluid with good conductive materials and heat exchanges can increase efficiency of modeled system. We can suggest the best parameters of potential capability of extracting and utilizing the suns energy using concentrated solar power technology with new and research innovation methods. Solar energy systems can be used for a extensive variety of applications and give significant benefits, therefore, they should be used whenever possible.

Keyword: PCM, CSP, Renewable Energy, Solar thermal , parabolic Dish , Trough

1. INTRODUCTION

The sun is a sphere of hugely hot gaseous substance with a diameter of 1.39 X 10^9 m. The solar energy strikes our planet a mere 8 min and 20 s after departure the monster furnace, the sun which is 1.51 X 10^{11} m away. The sun has an valuable blackbody temperature of 5760 K and the central region temperature was superior and it is projected at 8.1 X 10^6 to 40.0 X 10^6 K. The total energy sun's output is 3.8 x 10 ^{20} MW which is equal to 63 MW/m^2 of the sun's surface. This energy radiates outwards in all directions. Only a small fraction, 1.7 x 10^{14} kW, of the total radiation emitted by the sun is intercepted by the earth. With this small fraction it is estimated that 30 min of solar radiation falling on earth is equal to the energy demand of world for one year. The world energy demand is increasing day by day near 7 to 9 % each year. The solar power systems in the market can be divided as Direct and indirect solar power i.e direct solar power refers to a system that converts solar radiation directly to electricity using a photovoltaic (PV) cell. Where has the indirect solar power system that converts first the solar energy in to heat and later converted in to electrical energy, as in the case of concentrated solar power (CSP). In general in the CSP plant, sunlight is focused on a heat exchanger, is used to impel the turbine. Due the inefficiency of these it requires a very high capital cost.. The typical efficiency of a CSP is about 15%.The highest efficiency of a silicon cell(PV) is 20%.On the other hand, Concentrating Solar Power (CSP) technology is now acquiring an rising interest, particularly if build with thermal energy storage.

- *Authors name : 1.D.Kameswara Rao, Asst .Professor , MGIT, Gandipet , kameshd@rediffmail.com*
- *Co-Author : 2.K.Sudhakar Reddy, Professor, MGIT, Gandipet, mct@mgit.ac.in*
- *Co-Author : 3.V.V.Subba Rao, Professor, JNTUK College of Engineering , kakinada*

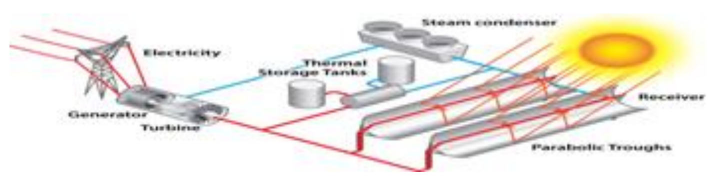


Fig 1.0 *Typical CSP Plant layout*

CSP (concentrated solar power) used in a solar thermal power plant to generate power even in night by using molten salt as heat absorbing fluid (so it's dispatchable), CSP really competes with the other thermal power plants like natural gas, coal, other fossil fuels that supply dispatch able electricity. CSP produces electricity by using thermal energy, instead of to burning fuel . CSP can harvest a pretty much enormous supply of sunlight to stock up and deliver solar thermal energy as shown in Fig 1.0. In contrast to a finite fuel such as gas or coal or uranium that must be extracted from beneath the earth to consume it by burning it to generate electricity. CSP is solar power that can be switched on when needed like in the evening, before sunrise, or at whatever time the regional grid needs power. Solar thermal plant will respond to new demand within the same day. The starting speed is limited only by the time it takes to start the turbines, as it does with other thermal power plants, approximately 20 minutes. The ability to store the solar energy thermally make CSP a disruptive renewable technology and it makes the energy grid cleaner because it can actively replace fossil energy. Together with the other renewable energy sources, CSP plays a vital cleaner role to supply the power to grid. So

CSP does not compete with PV and it only competes with natural gas.

Fig1.1 *Renewable power market, global, installed capacity share by power-generating source (%),* 2010, 2017, 2020

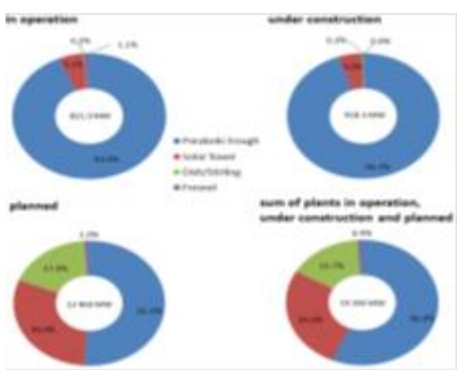


Fig1.2 *Different soalr thermal power Technologies(in%)*

World is focusing on getting clean & renewable energy sources and decreasing dependence on fossil fuels thermal power plants are needed to adopt new technology to generate steam instead of burning fossil fuels to generate thermal energy.Solar power is a erratic energy source, with energy construction dependent on the sun.Solar energy is more expensive to power production method and less efficient than conventional sources of energy. PV devices manufacturing cost is high because it requires precious metals, some toxic chemicals like cadmium and arsenic, are used in the PV manufacturing process.

2.0 CONCENTRATING SOLAR COLLECTORS

Concentrating solar power (CSP) is a power generation technology that uses mirrors or lenses to concentrate the sun's rays to a small area, in most of today's CSP systems used to heat a fluid and produce steam. The steam that drives a turbine and produces power similar way of conventional power plants. CSP plants can produce power in the evening during peak demand. Can replace the use of fossil fuel plants that emit the greenhouse gases that cause climate change. Advanced storage technology continue the more CSP plants will be able to provide base load power throughout 24 hours. CSP plant can store the heat of solar energy in molten salts, which enables these plants to continue to generate electricity whenever it is needed, whether day or night. Concentrators are of various types produces different temperature ranges with different thermodynamic efficiencies, due to differences in the way that they track the sun and focus light. New innovations in CSP technology are leading systems to become more and more cost effective. These collectors can provide high temperatures more efficiently than flat-plate collectors, since the absorption surface area is much smaller. Mechanical Equipment was required to most concentrating collectors that constantly orients the collectors toward the sun and keeps the absorber at the point of focus.

2.1 TYPES OF CONCENTRATING SOLAR COLLECTORS

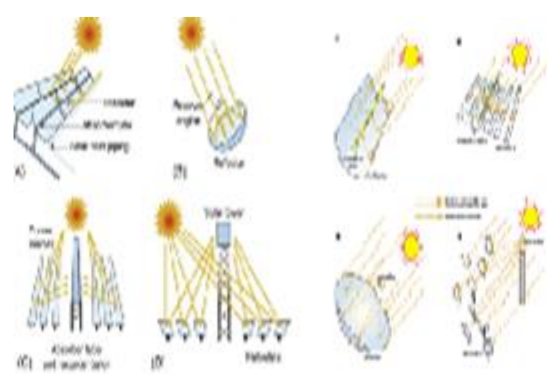
CSP plants can be classified mainly into two groups, based on whether the solar collectors concentrate the sun rays along a focal line or on a single focal point. Line-focusing systems take account of parabolic trough and linear Fresnel plants and have single-axis tracking systems. Point-focusing systems consists of solar dish systems and solar tower plants and include two-axis tracking systems to concentrate the power of the sun. Concentrating solar power technologies exist in four optical types, namely as Parabolic trough , Parabolic dish ,Concentrating linear Fresnel reflector and Solar power tower .In this paper we are discussing the four types briefly and then elaborate upon Parabolic trough and Parabolic dish type later.

2.2 Parabolic Trough Type

Long rows of parabolic reflectors, focus the sunlight 70 to 100 times onto a heat collection element (HCE) placed all along the reflector's focal line. The Sun is tracked around one axis, typically oriented north–south.It is straight in one dimension and curved as parabola in the other two dimensions.

2.3 Parabolic Dish Collector

Parabolic-shaped and concentrate the sunlight onto a receiver mounted at the focal point, with the receiver moving with the dish. Dishes were used to power Stirling engines at 910 °C, to generate steam.



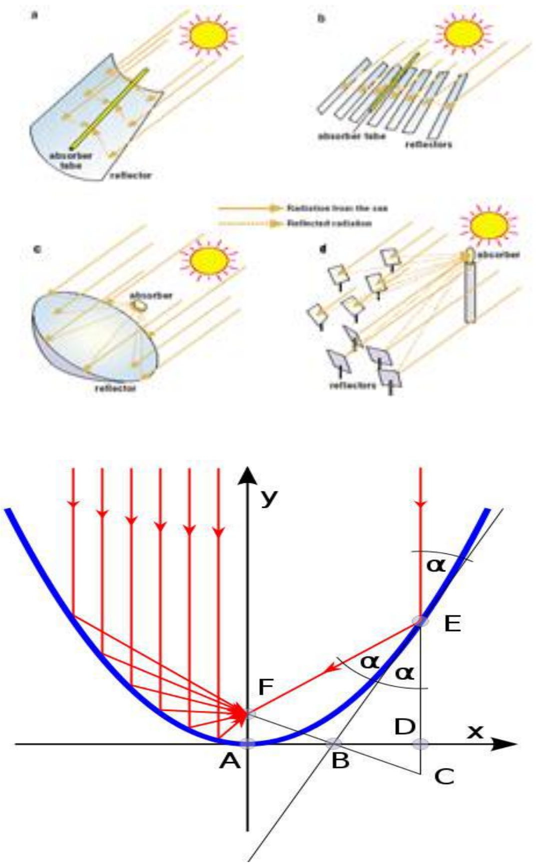


Fig 2.*0 Different types of CSP Plants*

2.4 CSP Plant components

The parabolic trough energy flow in power plant can be a direct solar radiation is concentrated and converted into thermal energy and it is converted into pressure energy or vapor, which is again changed into kinetic energy. The kinetic energy again converted in the power plant as electrical energy. These energy conversion steps are realized in the respective power plant components: The parabolic trough collector and the tracking system are essential for the concentration process. The receiver converts the radiation energy into thermal energy. Heat transfer medium and thermal storage are carriers of the thermal energy. The steam generator has the function to convert the thermal energy into pressure energy of a gaseous medium. This is done by the evaporation of water. The cooling system has the aim to complete the liquid/gaseous-cycle converting the steam back to water. The steam turbine converts the pressure energy in the steam into rotational energy. The electric generator produces the electric energy, which can be supplied to the electric grid. The figure 2.1 shows the mentioned main components of the plant and relates them to their respective place in the energy conversion chain.

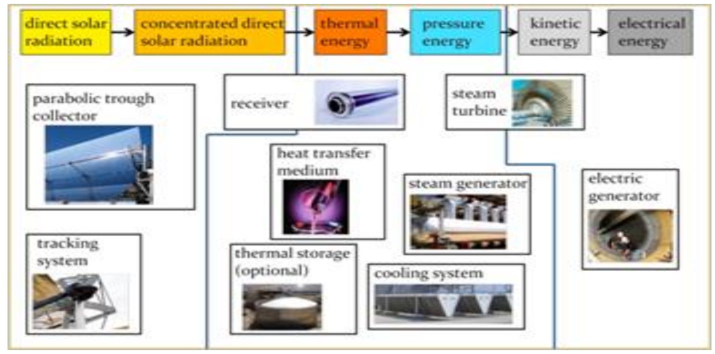


Fig 2.1 *Energy conversion chain in a parabolic trough power plant and corresponding plant components*

3.0 Parabolic trough system :

Parabolic trough power plants gives the main share of the installed concentrating solar power technology. Distinguishing between parabolic trough power plants, Fresnel power plants, solar tower power plants and dish/Stirling systems, the parabolic trough power plants provide over 90% of the capacity of concentrating solar power plant technology. Among the planned additional capacity more than 50% are constituted by parabolic trough power plants. These solar collectors uses mirrored parabolic troughs to spotlight the sun's energy to a fluid-carrying recipient tube situated at the focal point of a parabolically curved trough reflector .

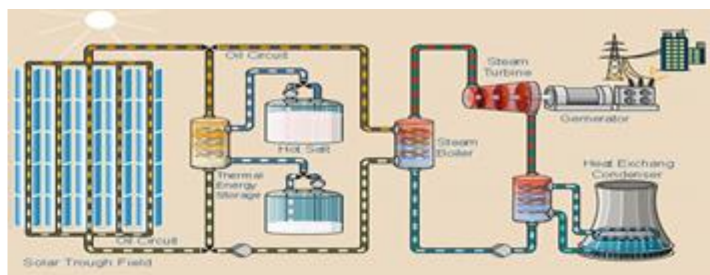


Fig 3.*0 Principle of parabolic trough concentration*

The energy from the sun sent to the tube heats oil flowing through the tube, and the heat energy is then used to generate electricity in a conventional steam generator. Many troughs placed in parallel rows are called a "collector field". The troughs in the field are all aligned along a north-south axis so they can track the sun from east to west during the day, ensuring that the sun is continuously focused on the receiver pipes. Parabolic trough power plants use parabolic trough collectors to concentrate the direct solar radiation onto a tubular receiver.

3.1 Geometry of parabolic trough

The collector, the parabolic trough, is a trough the cross-section of which has the shape of a part of a parabola. More exactly, it is a symmetrical section of a parabola around its vertex. Parabolic troughs have a focal line, which consists of the focal points of the parabolic cross-sections. Radiation that enters in a plane parallel to the optical plane is reflected in such a way that it passes through the focal line as shown in Fig 3.1

Fig 3.*1 Geometry of a parabola*

3.2 Parameters for the geometrical description of a parabolic trough

In order to explain a parabolic trough geometrically, the parabola has to be determined, the section of the parabola that is covered with mirrors, and trough length. The following four parameters are commonly used to characterize the form and size of a parabolic trough: trough length, focal length, aperture width, i.e. the distance between one rim and the other, and rim angle, i.e. the angle between the optical axis and the line between the focal point and the mirror rim.

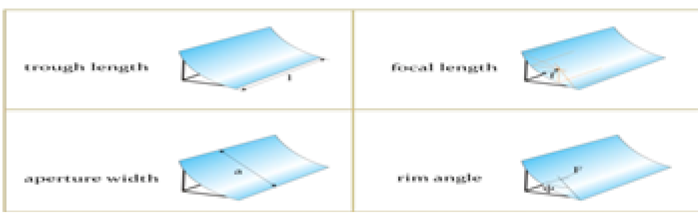


Fig 3.*2 Geometrical parabolic trough parameters*

3.3 Layout of parabolic trough plant

Trough designs can incorporate thermal storage-setting aside the heat transfer fluid in its hot phase allowing for electricity generation several hours into the evening. Currently, all parabolic trough plants are "hybrids," meaning they use fossil fuels to supplement the solar output during periods of low solar radiation. Typically, a natural gas-fired heat or a gas steam boiler/reheat is used. Temperatures at the receiver can reach 400 °C and produce steam for generating electricity. In California, multi-megawatt power plants were built using parabolic troughs combined with gas turbines.

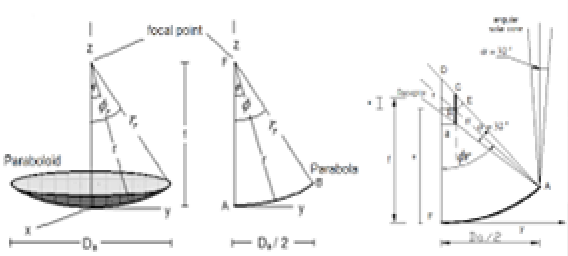


Fig 3.3 *Layout of parabolic trough plant*

A parabolic trough is made of a number of solar collector modules (SCM) fixed together to move as one solar collector assembly (SCA). A SCM could have a length up to 15 metres (49 ft 3 in) or more. About a dozen or more of SCM make each SCA up to 200 metres (656 ft 2 in) length. Each SCA is an independently-tracking parabolic trough. A SCM may be made as a single-piece parabolic mirror or assembled with a number of smaller mirrors in parallel rows. Smaller modular mirrors require smaller machines to build the mirror, reducing cost. Cost is also reduced in case of the need of replacing a damaged mirror. Such damage may occur due to being hit by an object during bad weather.

3.4 Parabolic dish system:

A parabolic dish collector is similar in appearance to a large satellite dish but has mirror-like reflectors and an absorber at the focal point. It uses a dual axis sun tracker. It uses a computer to track the sun and concentrate the sun's rays onto a receiver located at the focal point in front of the dish. In some systems, a heat engine, such as a Stirling engine, is linked to the receiver to generate electricity. Parabolic dish systems can reach 1000 °C at the receiver, and achieve the highest efficiencies for converting solar energy to electricity in the small-power capacity range .The parabolic solar dish is covered with many small mirror reflectors all around its shape to help concentrate the thermal energy into a single focal point were the heat absorber is located producing more overall thermal energy per square meter of dish. These highly polished mirrors can reflect more than 90% of the sunlight that hits them increasing the efficiency of the dish by more than 20% compared to the parabolic trough collector. Mirrors are generally used instead of a single highly polished dish because they are relatively inexpensive, can be easily cleaned and last a long time in an extreme outdoor environment, making them an excellent choice for the reflective surface of a solar dish collector. Also individual mirrors can be easily changed if damaged. As well as the solar dish collector, some form of thermal receiver is required to convert the focused beam of intense solar energy into heat. The solar receiver can be as simple as a small evacuated tube or a more complex solar heat engine, such as a Stirling Engine. Due to the very high temperatures at the focal point, a thermal oil type fluid is generally used instead of water inside the receiver, which transfers the intense heat created by focusing the sunlight on the receiver. Like the trough collectors, solar dish collectors can be used singly or linked together for larger industrial type applications. This type of solar collector can be used in domestic purposes also.

3.4. Geometry of parabolic Dish

The collector's parabola design calculations with a mathematical model was used to find the values that satisfy the design criteria, of concentration ratio diameter and angle of aperture. The terms used are Aperture area (A_a) , Absorber area (A_{abs}) ,Concentration Ratio(C) , Height (h) Diametr (d) and Focal point (f), Radius (R), and load (F)

Fig 3.4*. Geometry of parabolic dish*

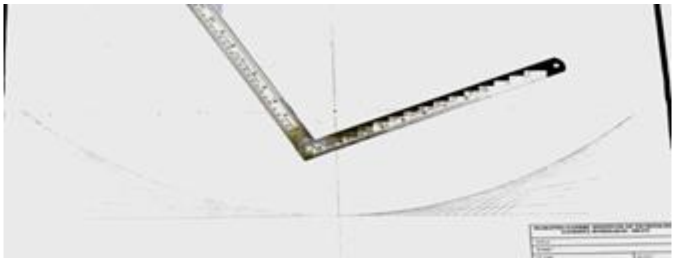


Fig 3..4.1 *Parabolic dish parameters*

3.5 Parabolic dish plant

Parabolic dish plant layout is a series or array of solar dish was placed place in combination of series and parallel. The working fluid is heated in the receiver tank and the heated working fluid from the entire solar dish in the plant is collected and passes through a super heater if necessary. Then, the fluid rejects its heat to water in a heat exchanger and then the water is converted into stream which is made to expand in two stage turbine. Following that, it passes through a condenser and the condensate is re-circulated in a close cycle. If water is directly used as the working fluid, there is no need for a heat exchanger, but the aperture area of the dish must be sufficient enough to convert water into steam at the desired flow rate.

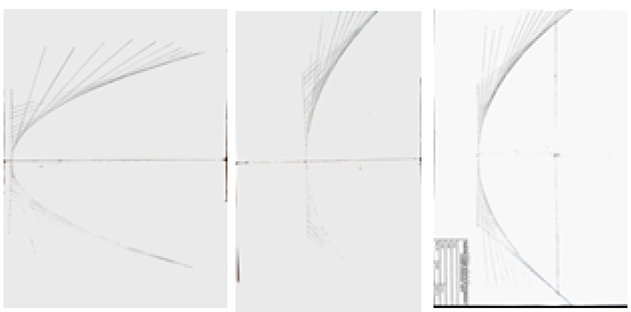


Fig 3.5 *Layout of parabolic dish plant*

4.0 Modelled Design of parabolic Dish:

For the modeling of Dish suitable for this project an unconventional method for drawing the parabola was employed to draw the parabola with the focal distance. The tools required for the construction of the parabola are carpenter's square, drawing board, a nail, a pencil and long ruler. The steps involved are , 1. Draw a straight horizontal line and mark it as x-axis. Then select the desired focal distance perpendicular to the x-axis and mark that point.

2. On a flat surface, with the help of clips make the drawing stable

3.Fix the nail at the focal point of the parabola

4. Mark point at regular intervals on the x-axis

5. With the help of carpenter's square, place the sharp corner of the carpenter's square on the point on the x-axis and with one side of the carpenter's square resting on the nail as a support, draw a line on the lower side of the carpenter's square side

6.Continue to draw line with various points marked on the x-axis and taking the support of the nail

7.Similarly repeat the same process on the other side.

8.The outer most intersecting points will form a parabola .

.

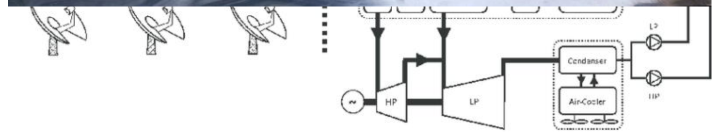


Fig 4.0 *Method to draw parabola with help of carpenter's square*

a)b) c)

Fig 4.1*(a , b & c) Parabola with focal length as 170mm and 58 mm and 160 mm*

The parabola with focal length of 160mm was selected (due to the materials available for the fabrication) which yielded an aperture area of 640mm.

4.1 Fabrication of parabolic trough

Ply wood of thickness 2cm and dimensions of 2m x 2m was chosen and parabolic shape was cut out by tracing the drawing of parabola with focal length 160mm. A groove shape was also cut out to accommodate the copper pipe of 1 inch diameter at the focal point.

4.2 Metal Sheet cutting

The metal sheet used for this project is aluminium of thickness 0.5mm since it was readily available and economical.

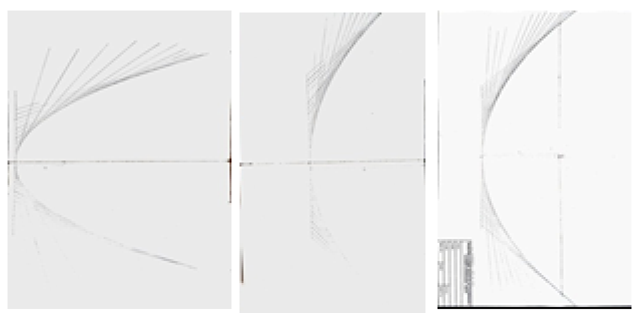


Fig 4.2 *Traced out parabola before carpentry*

Fig 4.3 *Wood cut out in parabolic shape after carpentry*

4.3 Applying solar reflective film

Reflective films made from new optical materials and the central component of high performance concentrators made from stretched membranes. The process of applying this reflective film is by cutting them in strips of desired length and then removing the sticker and applying on the metal sheet.

S.No	Time	Theoretical Temperature (c)	Practial Temperature (c)
1	1	36.85	28
2	2	50.16	35.7
3	3	60.66	46.3
4	4	68.95	51.8
5	5	75.49	54.2
6	6	80.21	58.4
7	7	84.73	60.1
8	8	87.95	65.7
9	9	90.49	68.5
10	10	92.49	70.6

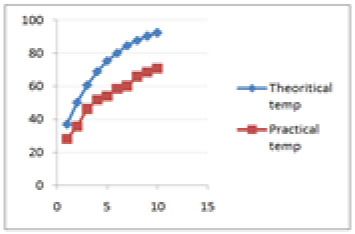


***Fig 4.4** Aluminum sheet*

4.4 Testing of parabolic dish

After setting up the model to concentrate the sun's rays on to the copper pipe and placing the model in direct sunlight we observed the final results .

4.5 Calculation of Parabolic trough system

During the design of trough system some assumptions like Copper pipe temperature and no irregularities in solar radiation due to clouds, wind, etc and the fluid used in the system does not have any impurities which effects the thermal conductivity. No heat losses due to radiation and convection with atmosphere.

Specifications:

Type of focusing : line focusing
Length of the system : 1 m
Material of absorber (pipe) : Copper
Diameter of absorbing pipe : 25.4 mm
Fluid used in the system : Water
Reflecting elements : Reflective film
Temperature of fluid before entering to the system : 20
Density of observing fluid : 997 kg/m^3
Specific heat of water at 20℃ : 4185.5 J/kg K
Convective coefficient of water :5-1000 W/m^2K
Area of absorbing fluid : 0.07665 m^2
Volume of absorbing fluid : 4.6575× $10^{-4}m^3$
Transient conduction equations:

$$\frac{T-T_\infty}{T_0-T_\infty} = e^{\left\{-\left[\frac{hA}{\rho CV}\right]t\right\}}$$

T ,T_0,T_∞ are fluid current , Initial and Exposing temperatures Respectively

h =Convective coefficient of water W/m^2K,
A= Area of observing elementm^2,
ρ = Density of fluid kg/m^3,
C = Specific heat of fluid J/kg K,
V= Volume of absorber m^3,
t= Time sec.

Input data for calculation:

Exposing temperature (T_∞)= 100℃,
Initial temperature(T_0) = 20℃
Convective coefficient (h) = 100 W/m^2K (Assumed),
Density (ρ) = 997 kg/m^3
Specific heat (C) = 4185.5 J/kg K,
Area (A) = 0.07665 m^2,
Volume (V)= $4.675 \times 10^{-4} m^3$.

Temperature of water after 1 min:

Substituting t = 60 sec,

$$\frac{T-100}{20-100} = e^{\left\{-\left[\frac{100\times0.07665}{997\times4185.5\times4.675\times10^{-4}}\right]60\right\}}$$

$$T - 100 = 0.78928 \times (-80)$$
$$T = 36.85℃$$

- The temperature of water after 1 min is 36.85℃.

Temperature of water after 2 min:

Substituting t= 120 sec,

$$\frac{T-100}{20-100} = e^{\left\{-\left[\frac{100\times0.07665}{997\times4185.5\times4.675\times10^{-4}}\right]120\right\}}$$

$$T - 100 = 0.62297 \times (-80)$$
$$T = 50.16℃$$

- The temperature of water after 2 min is 50.16℃.

Similarly,

All temperature is calculated up to 10 min with 1 min deviation & plotted below

Table 4.8 a) Results plotted theoretical vs. Practical for parabolic troughb)Graph between theoretical temperature, practical temperature vs Time (minutes)

These values are theoretical, cannot be achieved by the real systems and can be compared with practical values to calculate the prototype efficiency .Time required to rise the temperature of water by 120℃ when exposing temperature is 150℃:

T=120℃
T_∞=1

$$\frac{120-150}{20-150} = e^{\left\{-\left[\frac{100\times0.07665}{997\times4185.5\times4.675\times10^{-4}}\right]t\right\}}$$

$$\frac{3}{13} = e^{(-(3.9264\times10^{-3})t}$$

t= 373.37 sec

- Time required to raise the temperature of water by 120℃ is 6 min 22 sec.Therefore, the length of the trough system to should be 373 m when the water is flowing in the system with 1 m/sec and flow rate of 0.5m/sec a length of 165m is required.

4.6 Efficiency Enhancement :

The efficiency of the parabolic trough system can be increased by painting the copper pipe with black colour to increase the absorber temperature and also by encasing the copper tube in a glass tube to reduce the convection losses to reflect back longer wavelengths of radiation. We can increase the CSP efficiency by 27% by implementing the solar tracking. In our work copper pipe coated with black colour and achieved an improvement in water 5^0 C.

Time (in minutes)	Degree Centigrade
0	25
2	38
5	49
8	63
10	70

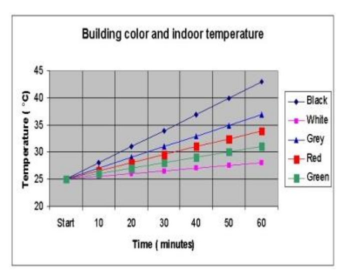


***Table 4.6** showing temperature vs. time for various colours*

5.0 Design and fabrication of solar dish:

For fabrication of the Solar dish the conventional dish with J bracket, Copper coil, transparent pipe and Solar reflective film made with new optical materials were required.

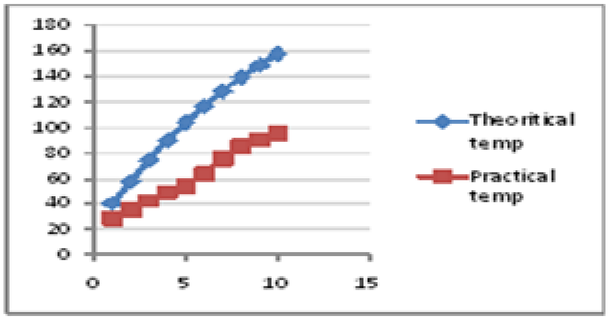


Fig 5.0 *Solar reflective film*

Copper Coil can be prepared by filling sand inside the pipe , select the suitable diameter of pipe to bend and turn the pipe according to the requirement. In this work the copper coil kept at the focal point at a suitable orientation .

Fig 5.1 *Procedure and application of copper coil* *Fig 5.1.1 Copper coil winded*

The copper coil can was painted with black colour to improve the absorber temperature and thereby increasing the efficiency. One end of the copper coil becomes inlet and the other end becomes outlet. The process of applying the solar reflective film is done by cutting the film in squares and rectangles of desired size and then applying it without leaving any air bubble trapped inside.The parts are fixed on a base which is made of ply wood and held in place by screws. The coil is fixated at the focal point of the dish. The transparent pipe is the inlet for the working fluid which is water and blue pipe is outlet.

5.0 CALCULATIONS FOR PARABOLIC DISH SYSTEM

During calculations of parabolic Dish some assumptions are considered like copper pipe temperature was 250℃ (constant) , there are no irregularities in solar radiation due to clouds, wind, etc., Fluid used in the system does not have any impurities which effects the thermal conductivity and no heat losses are considered.

Specifications

Type of focusing : Point focusing
Material of absorbing pipe : copper
Diameter of absorbing pipe : 8mm
Fluid used in the system : water
Reflecting elements :Solar reflective film
Temperature of fluid before entering to the system : 20℃
Density of observing fluid : 997 kg/m^3
Specific heat of water at 20℃ : 4185.5 J/kg K
Convective coefficient of water :5-1000 W/m^2K
Area of absorbing fluid : 0.30 m^2
Volume of absorbing fluid : 4.73717× $10^{-3}m^3$

Transient conduction equation

$$\frac{T-T_\infty}{T_O-T_\infty} = e^{\left\{-\left[\frac{hA}{\rho CV}\right]t\right\}}$$

T ,T_O,$T_\infty$are fluid current , Initial and Exposing temperatures Respectively

h =Convective coefficient of water W/m^2K,
A= Area of observing elementm^2,
ρ = Density of fluid kg/m^3,
C = Specific heat of fluid J/kg K,
V= Volume of absorber m^3,
t= Time sec.

Input data for calculation:

Exposing temperature(T_∞)= 250℃
Initial temperature(T_O) = 20℃
Convective coefficient (h) = 100 W/m^2K (Assumed)
Density (ρ) = 997 kg/m^3
Specific heat (C) = 4185.5 J/kg K
Area (A) = 0.30 m^2
Volume (V)= 4.73717 × $10^{-3}m^3$

Temperature of water after 1 min:

Substituting t = 60 sec,

$$\frac{T-250}{20-250} = e^{\left\{-\left[\frac{100\times0.30}{997\times4185.5\times4.73717\times10^{-3}}\right]60\right\}}$$

$$T-250 = 0.912966\times(-230)$$

$$T = 40.01℃$$

- The temperature of water after 1 min is 40.01℃.

Temperature of water after 2 min:

Substituting t= 120 sec,

$$\frac{T-250}{20-250} = e^{\left\{-\left[\frac{100\times0.30}{997\times4185.5\times4.73717\times10^{-3}}\right]120\right\}}$$

$$T-250 = 0.83350\times(-230)$$

$$T = 58.29℃$$

- The temperature of water after 2 min is 58.29℃.

Similarly, all temperatures are calculated up to 15 min with 1 min deviation & plotted below

S.No	Time	Theoretical Temperature (c)	Practial Temperature (c)
1	1	40.01	28.4
2	2	58.29	34.6
3	3	74.97	42.7
4	4	90.21	49.5
5	5	104.12	54.9
6	6	116.81	64.2
7	7	128.40	76.3
8	8	138.99	85.6
9	9	148.650	90.7
10	10	157.47	95.2

Table 5.3 *Parabolic dish Theoretical and practical Results*

b) Graph B/w theoretical temperaturepractical temperature vs Time

These values are theoretical, cannot be achieved by the real systems. These values can be compared with practical values to calculate the efficiency of the prototype. The practical values can be obtained by operating the proto type near to the assumptions. We can observe ,the values the difference between theoretical and practical values is high because the atmosphere changes lke sun irradiation. Wind effects the convection process which creates a major difference in the system. Temperature of about 200 ^{0} C is achieved and a maximum temperature of 222 ^{0} C has been observed as shown in the figure5.4 Initial temperature of water is 25^0 C and final temperature was obtained after 10 min was 99^0 C. The efficiency of the parabolic dish system can be increased by increasing the absorber temperature by keeping black color paint (absorbs more wave length) the outer surface of the copper pipe and by encasing the copper tube in a glass tube so that the losses by convection of the wind can be minimized and moreover glass has a property to reflect back longer wavelengths of radiation. It was found from other researches implementing solar tracking sun e efficiency could be improved by 27%.The first method was implemented in this project that is painting the outer surface (circumference) of the copper coil with black paint and the other two methods were not implemented.

Fig 5.4 *Temperature at the absorber*

6.0. ADVANTAGES OF SOLAR THERMAL ENERGY

6.1 No Fuel Cost – Solar Thermal Energy does not require any fuel like most other sources of renewable energy. This is a big advantage over other fossil fuels whose costs are growing at a high rate every time. Electricity prices are growing rapidly in maximum parts of the world much quicker than general inflation.
6.2 No Pollution and Global Warming Effects – Solar Thermal Energy does not cause pollution which is one of the biggest advantages. Note the cost are connected with the equipment used to build and transport Solar Thermal Energy system.
6.3 Existing Industrial Base – Solar Thermal Energy uses equipment like turbines and solar mirrors which is made in great scale at low cost by the current Industrial Base and needs no major changes in equipment and materials unlike new technologies such as CIGs Panels.

7.0 APPLICATIONS OF SOLAR POWER

7.1 Concentrating Solar Power (CSP): Concentrating solar power (CSP) plants are utility-scale generators that harvest electricity using lenses /mirrors to proficiently concentrate the sun's energy. The 4main CSP technologies are concentrating photovoltaic systems (CPV), central receivers, parabolic troughs and dish-Stirling engine structures.
7.2 Solar Thermal Electric Power Plants: Solar thermal energy includes harnessing solar power for real-world applications from solar heating to electrical power production. This energy system is also used in building design and architecture to regulate the heating and ventilation in both passive solar and active solar models.

7.3 Passive Solar Energy: It concerns building design to maintain its environment at a comfortable temperature through the sun's daily and annual cycles. Greenhouses Sunspaces and solar closets are another ways of arresting isolated heat gain from which warmed air can be taken.

7.4 Solar Lighting: The usage of natural light to deliver illumination to balance energy use in electric lighting systems and cut the cooling load on HVAC systems. Day lighting features window orientation, exterior shading, include building orientation, saw tooth roofs, light shelves, skylights, and light tubes.

7.5 Solar Power Satellite: A solar power satellite (SPS) is a proposed satellite built in high Earth orbit that uses microwave power transmission to beam solar power to a very big antenna on Earth where it can be used in place of traditional power sources. The benefit of placing the solar collectors in space is the unobstructed view of the sun, unaffected by the day/night cycle, weather, or seasons.

7.6 Renewable Solar Power Systems with Regenerative Fuel Cell Systems: NASA has recognized the special advantages of regenerative fuel cell (RFC) systems to distribute energy storage for solar power systems in space. RFC systems are exclusively qualified to offer the necessary energy storage for solar surface power systems on the moon or Mars during long periods of darkness, i.e. during the 12-hour Martian night or 14-day lunar night. And in the course of applying the NASA RFC Program, researchers recognized that there are several uses in industry, transportation ,government, and the military for RFC systems.

8.0 RESULTS AND DISCUSSIONS:

The main aim of this work is to develop steam using concentrated solar power at suitable flow rates. However, due to scaled down model , it is only developed for domestic purpose to heat water about 75^0 C on parabolic trough and to about 98^0 C case of parabolic dish.Due to unavailable flow rate the amount of water heated is also quite less for the setups and hence the water needs to stagnated and stored in the absorber tubes. The amount of water output from parabolic trough and parabolic dish are 0.4 L , 0.15 L respectively. But, since the temperature in the parabolic dish is in the order of 200^0 C, we can get the heated water at lesser time compared to parabolic trough.

9.0 CONCLUSIONS AND FUTURE SCOPE :

The study presented in this paper is the first step of a wider research project aimed at evaluating the capabilities of concentrating solar technologies designed to supply the heat. The parabolic trough and parabolic dish are light in weight, cheap in construction and portable size. Since it harnesses the heat from the Sun (an unconventional source of energy) the operation cost is zero. We can convert the Sun's rays into usable heated water for domestic purpose free of cost in a better way. Obviously, by increasing the collector area results in an almost linear increase of the thermal energy produced by the solar field. However, in order to effectively use this thermal energy, the increase of the collecting area should be jointed with an increase of the storage capacity will be utilized for industrial purpose. The developed concentrated solar power technologies can be used in a better way for commercial scale power generation, industrial process heat and cooling systems in large scale. This can also be used for Domestic purpose like Hot water collector , Solar steam cooking , Solar ovens/cookers , Solar food dryers , Solar HVAC (heating, ventilating and air conditioning) Renewable source of energy such as solar and wind are becoming increasingly competitive with fossil fuels, and in some countries, accounting for a larger share of electricity production. Currently the concentrated solar power (CSP) cost is high while comparing with PV prices . However, researchers new technologies and heat transfer enhancement using Phase change material (PCM) ,nano material, pins the CSP is still the option of having better thermal energy storage and can supply the power to the grid. Researchers are working digital glass to collect sunlight and developing the compact sized solar thermal power plants that use micro fluidic based solar collector panels that develop electronically modulated invisibility to produce sunlight energetically. In future, the mechanism for solar tracking may be used to decrease the overall cost of and it improves the efficiency of the plant by 22%. .Moreover, there is advancement being made in the material suitable for coating over the absorber , embedding the nano material on the back side of the panel would increase the absorptivity to greater than 0.99 and make a suitable and economical way of applying the coat.

References

[1] Arif, H.M.andSumathy,K.,Renew.SustainableEnergy Rev.,2010,vol.14,pp.1845–1859.

[2] Prakash, J., EnergyConvers.Manag.,1994,vol.35, pp.967–972.

[3] K.S. Sopian, H.T. Yigit, H.T. Liu, S. Kakac and T.N. Veziroglu, 'Performance Analysis of

[4] Photovoltaic/Thermal Air Heaters', Energy Conversion and Management, Vol. 37, N°11, pp. 1657 - 1670, 1996.

[5] D.K.Rao et al "Experimental study of solar thermal PV collectors and its performance efficiency towards Conventional / Modern cooling techniques "IJRAR 2018 Vol5, issue 3 (E-ISSN 2348-1269, P- ISSN 2439- 5138)

[6] Garg,H.P. andAdhikari,R.S.,Renew.Energy,1999, vol.16,pp.725–730.

[7] Hegazy,A.A.,EnergyConvers.Manag.,2000,vol.41, pp.861–881.

[8] Tonui,J.K.,Solar,Energy,2007, vol.81, pp.498–511.

[9] Tiwari,A.andSodha, M.S.,SolarEnergy Mater.Solar cells , 2007, Vol. 91 pp 17-28

[10] ,J.,Lu,J.P., Chow,T.T.,etal.,Appl.Energy,2007, vol.84,pp.222–237.

[11] He, W.,Chow,T.T., Ji,J.,etal.,Appl.Energy,2006, vol.83,pp.199–210.
Chow,T.T., Pei,G., Fong, K.F., etal.,Appl. Energy, 2008.

[12] Mr.Sayaran A. Abdulgafer et al. review article on "Improving the
efficiency of polycrystalline solar panel