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STEAM ENGINE BY USING FRESNEL LENSES

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Abstract
This project describes a miniature Steam engine made with the boiler and the Fresnel lens from an old starch copper tube solar water heater. It uses boiler as vaporizer to vaporize the water it receives hot water from the solar heater. Then the steam is injected on the mini engine making it twirl.. A wooden case with a copper tubes encloses all the referred devices. Today, most of the electricity produced throughout the world is from Steam turbines However, electricity is being produced by some other power generation sources such as hydropower, gas power, bio-gas power, solar cells, etc. This project deals with steam cycles used in power plants. Thermodynamic analysis of the Rankine cycle has been under taken to enhance the efficiency and reliability of Steam engines. The thermodynamic deviations resulting in non-ideal or irreversible functioning of various Steam engine components have been identified. Steam engines are located at the water and coal available places. Steam is utilized to run the turbines, by using this Fresnel lenses we are increasing the efficiency of boiler. as well the steam engine.

Introduction
A steam engine is a heat engine that performs mechanical work using steam as its working fluid. Steam engines are external combustion engines, where the working fluid is separate from the combustion products. Non-combustion heat sources such as solar power, nuclear power or geothermal energy may be used. The ideal thermodynamic cycle used to analyze this process is called the Rankine cycle. In the cycle, water is heated and transforms into steam within a boiler operating at a high pressure. When expanded through pistons or turbines, mechanical work is done. The reduced-pressure steam is then exhausted to the atmosphere, or condensed and pumped back into the boiler. In general usage, the term steam engine can refer to either the integrated steam plants (including boilers etc.) such as railway steam locomotives and portable engines, or may refer to the piston or turbine machinery alone, as in the beam engine and stationary steam engine. Specialized devices such as steam hammers and steam pile drivers are dependent on the steam pressure supplied from a separate boiler. The use of boiling water to produce mechanical motion goes back over 2000 years, but early devices were not highly practical. The Spanish inventor Jerónimo de Ayanz y Beaumont obtained the first patent for a steam engine in 1606. In 1698 Thomas Savery patented a steam pump that used steam in direct contact with the water being pumped. Savery's steam pump used condensing steam to create a vacuum and draw water into a chamber, and then applied pressurized steam to further pump the water. Thomas Newcomen's atmospheric engine was the first commercial true steam engine using a piston, and was used in 1712 for pumping in a mine. A steam engine is a heat engine that performs mechanical work using steam as its working fluid. Steam engines are external combustion engines, where the working fluid is separate from the combustion products. Non-combustion heat sources such as solar power, nuclear power or geothermal energy may be used. The ideal thermodynamic cycle used to analyze this process is called the Rankine cycle. In the cycle, water is heated and transforms into steam within a boiler operating at a high pressure. When expanded through pistons or turbines, mechanical work is done. The reduced-pressure steam is then exhausted to the atmosphere, or condensed and pumped back into the boiler. In general usage, the term steam engine can refer to either the integrated steam plants (including boilers etc.) such as railway steam locomotives and portable engines, or may refer to the piston or turbine machinery alone, as in the beam engine and stationary steam engine. Specialized devices such as steam hammers and steam pile drivers are dependent on the steam pressure supplied from a separate boiler.

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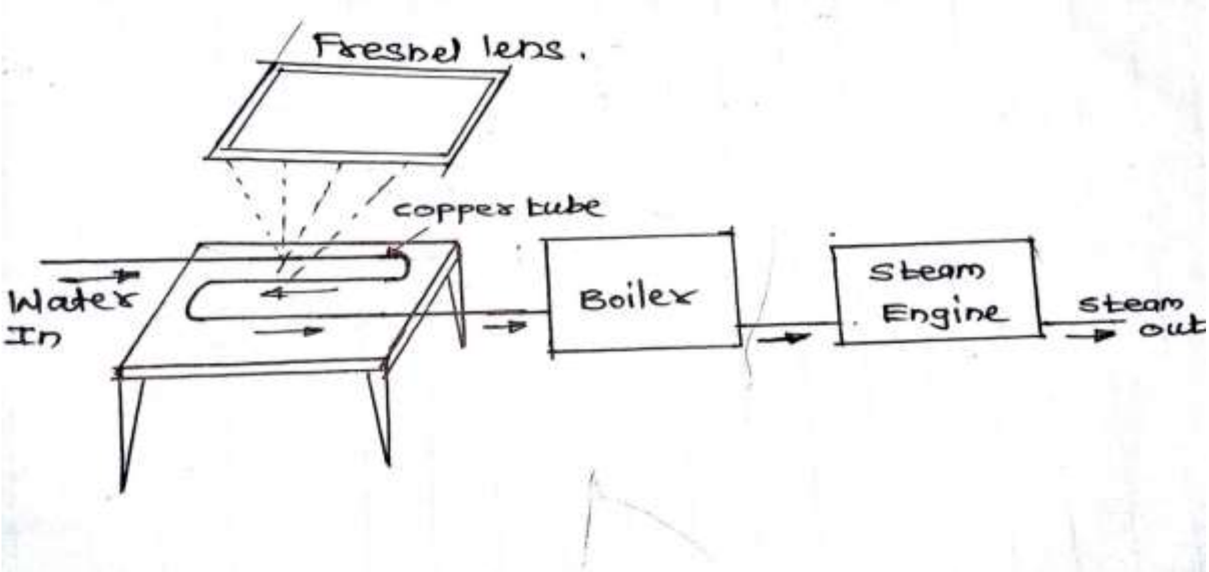

Fig 1:General layout

Need of Investigation

In 1781 James Watt patented a steam engine that produced continuous rotary motion. att's ten-horsepower engines enabled a wide range of manufacturing machinery to be powered. The engines could be sited anywhere that water and coal or wood fuel could be obtained. By 1883, engines that could provide 10,000 hp had become feasible. [4] The stationary steam engine was a key component of the Industrial Revolution, allowing factories to locate where water power was unavailable. The atmospheric engines of Newcomen and Watt were large compared to the amount of power they produced, but high-pressure steam engines were light enough to be applied to vehicles such as traction engines and the railway locomotives. Reciprocating piston type steam engines remained the dominant source of power until the early 20th century, when advances in the design of electric motors and internal combustion engines gradually resulted in the replacement of reciprocating (piston) steam engines in commercial usage, and the ascendancy of steam turbines in power generation. Onsidering that the great majority of worldwide electric generation is produced by turbine type steam engines, the "steam age" is continuing with energy levels far beyond those of the turn of the 19th and 20th century.

Literature review

Joshua Folaranmiet al. [2]presented experimental investigation to the design, construction and testing of a parabolic dish solar steam generator. Using concentrating collector, heat from the sun is concentrated on a black absorber located at the focus point of the reflector in which water is heated to a very high temperature to form steam. It also describes the sun tracking system unit by manual tilting of the lever at the base of the parabolic dish to capture solar energy. The whole arrangement is mounted on a hinged frame supported with a slotted lever for tilting the parabolic dish reflector to different angles so that the sun is always directed to the collector at different period of the day. On the average sunny and cloud free days, the test results gave high temperature above 200°C.

Michael J. Wagner [6] gives an idea about the technical formulation and demonstrated model performance results of a new direct-steam-generation (DSG) model in NREL's System Advisor Model (SAM). The model predicts the annual electricity production of a wide range of system configurations within the DSG Linear Fresnel technology by modeling hourly performance of the plant in detail. The quasi-steady state formulation allows users to investigate energy and mass flows, operating temperatures, and pressure drops for geometries and solar field configurations of interest. The model includes tools for heat loss calculation using either empirical polynomial heat loss curves as a function of steam temperature, ambient temperature, and wind velocity, or a detailed evacuated tube receiver heat loss model. Thermal losses are evaluated using a computationally efficient nodal approach, where the solar field and headers are discretized into multiple nodes where heat losses, thermal inertia, steam conditions (including pressure, temperature, enthalpy, etc.) are individual.

Steve Ruby et al. [7]gives an idea about the viability of producing high temperature industrial process heat from the sun's energy by using parabolic trough solar collection. The installation of a large scale industrial solar thermal system provides an opportunity to evaluate the technical and economic hurdles of similar systems in California. The research was performed through the design, construction, operation, and analysis of a high temperature solar thermal system at a Frito-Lay snack food plant located in Modesto, California. In this installation, high temperature water in excess of 232°C(450°F) is produced by a concentrating solar field, which in turn is used to produce approximately 300 pounds per square inch (20 bar) of process steam. The solar thermal system is intended to improve plant efficiency with minimal impact on day-to-day production operations. Process steam in the plant is used for cooking, which includes heating edible oil for frying, and heating baking equipment. Steam is also converted into hot water for cleaning and sterilization processes.

Design and calculations

Design specification and parameters:
Boiler design is the process of designing boilers used for various purposes. The main function of a boiler is to heat water to generate steam. Steam produced in a boiler can be used for a variety of purposes including space heating, sterilization, drying, humidification and power generation. The temperature or condition of steam required for these applications is different, so boiler designs vary accordingly.

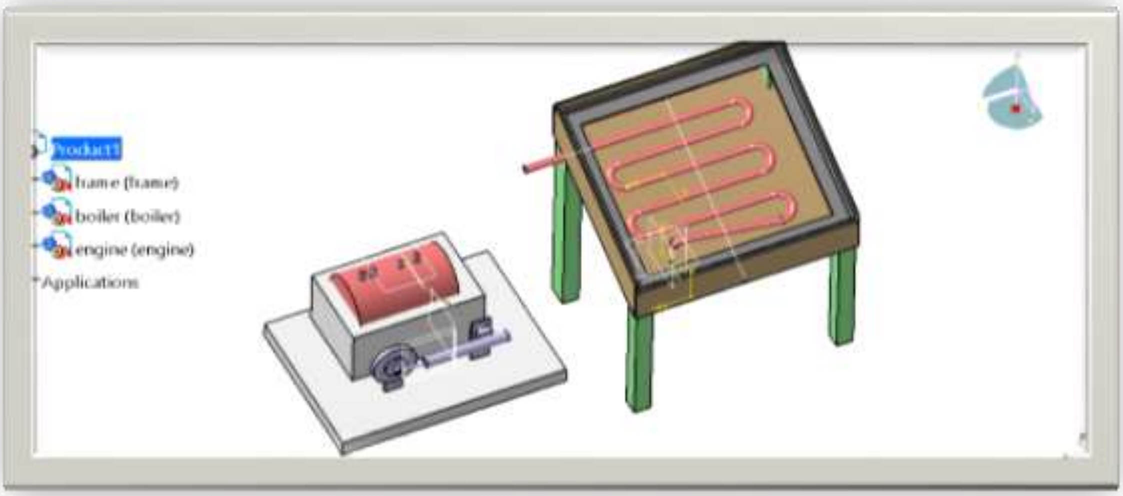

Fig 2: Model creation in catia v5

Boiler specification
Boiler outer diameter: 100mm
Boiler height : 180mm
Boiler outer bosses diameter : 10mm
Volume enclosed by a boiler
Definition: The number of cubic units that will exactly fill a cylinder Try this Drag the orange dot to resize the cylinder. The volume is calculated as you drag. Although a cylinder is technically not a prism, it shares many of the properties of a prism. Like prisms, the volume is found by multiplying the area of one end of the cylinder (base) by its height.
Since the end (base) of a cylinder is a circle, the area of that circle is given by the formula:
area = π r 2
Multiplying by the height h we get,
volume = π r 2 h
where,
π is Pi, approximately 3.142

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r is the radius of the circular end of the cylinder
h height of the cylinder
volume = 3.14 x 50 x 10
volume = 1415.28 liter
Volume of a horizontal cylinder segment
Definition: A shape formed when a cylinder is cut by a plane parallel to the sides of the cylinder.

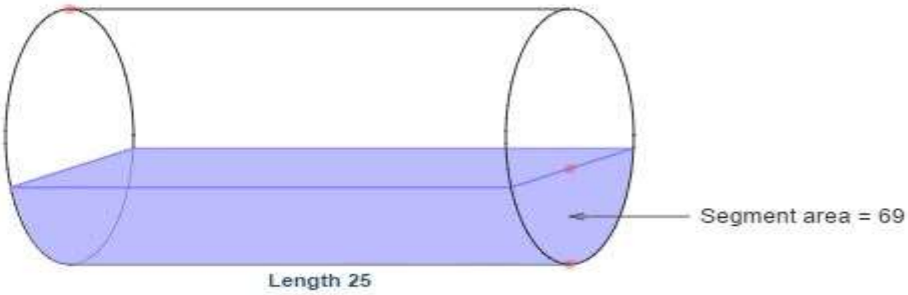

Fig 3: Cylinder

If we take a horizontal cylinder, and cut it into two pieces using a cut parallel to the sides of the cylinder, we get two horizontal cylinder segments. In the figure above, the bottom one is shown colored blue. The other one is the transparent part on top. If we look a the end of the cylinder, we see it is a circle cut into two circle segments. See Circle segment definition for more.

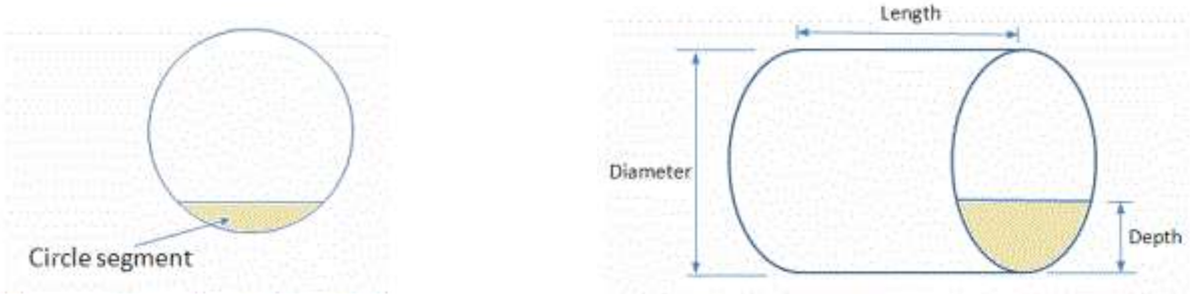

Fig 4: Cylinder segments

Whenever we have a solid whose cross-section is the same along its length, we can always find its volume by multiplying the area of the end by its length. So in this case, the volume of the cylinder segment is the area of the circle segment, times the length. So as a formula the volume of a horizontal cylindrical segment is
volume = s l

Where ,
s = the area of the circle segment forming the end of the solid, and
l = the length of the cylinder.
The area of the circle segment can be found using it's height and the radius of the circle.
See Area of a circle segment given height and radius.
As a formula

$$volume = L\left(R^2 \cos^{-1}\left(\frac{R-D}{R} \right) - (R-D)\sqrt{2RD-D^2} \right)$$

where,
R is the radius of the cylinder.
D is the depth.
L is the length of the cylinder

The result of the cos-1 function in the formula is in radians. The formula uses the radius of the cylinder. This is half its diameter. All inputs must be in the same units. The result will be in those cubic units. So for example if the inputs are in inches, the result will be in cubic inches. If necessary the result must be converted to liquid volume units such as gallons.

Boiler theoretical calculations

Boiler Efficiency: Introduction and Methods of Calculation

It is a well-known fact that the initial cost of boiler is a small part of total costs associated with the boiler over its lifetime. In the operational life of a boiler, major costs arise out of the fuel costs. Ensuring efficient operation of boiler is critical to optimize the fuel costs. It is not always true that a boiler will work at its rated efficiency. Almost all the times, it has been found that the boilers operate at much lower than the rated efficiencies if proper efficiency monitoring is not done.

Boiler Efficiency

Boiler efficiency is a combined result of efficiencies of different components of a boiler. A boiler has many sub systems whose efficiency affects the overall boiler efficiency. Couple of efficiencies which finally decide the boiler efficiency are Combustion efficiency and Thermal efficiency Apart from these efficiencies, there are some other losses which also play a role while deciding the boiler efficiency and hence need to be considered while calculating the boiler efficiency.

Combustion Efficiency

The combustion efficiency of a boiler is the indication of burner's ability to burn fuel. The two parameters which determine the burner efficiency are unburned fuel quantities in exhaust and excess oxygen levels in the exhaust. As the amount of excess air is increased, the quantity of unburned fuel in the exhaust decreases. This results in lowering the unburned fuel losses but elevating the enthalpy losses. Hence, it is quite important to maintain a balance between enthalpy losses and un burnt losses. Combustion efficiency also varies with the fuel being burnt. Combustion efficiency is higher for liquid and gaseous fuels than for solid fuels.

Thermal Efficiency

The thermal efficiency of a boiler specifies the effectiveness of the heat exchanger of the boiler which actually transfers the heat energy from fireside to water side. Thermal efficiency is badly affected by scale formation/soot formation on the boiler tubes.

Direct and Indirect Boiler Efficiency

The overall boiler efficiency depends on many more parameters apart from combustion and thermal efficiencies. These other parameters include ON-OFF losses, radiation losses, convection losses, blow down losses etc. In actual practice, two methods are commonly used to find out boiler efficiency, namely direct method and indirect method of efficiency calculation.

Direct efficiency

This method calculates boiler efficiency by using the basic efficiency formula- η=(Energy output)/(Energy input) X 100, In order to calculate boiler efficiency by this method, we divide the total energy output of a boiler by total energy input given to the boiler, multiplied by hundred.

Indirect Efficiency

The indirect efficiency of a boiler is calculated by finding out the individual losses taking place in a boiler and then subtracting the sum from 100%. This method involves finding out the magnitudes of all the measurable losses taking place in a boiler by separate measurements. All these losses are added and subtracted from 100% to find out the final efficiency. Blow down valve is kept closed during the procedure. This method should be implemented as per the norms provided in BS845 standards. The losses calculated include stack losses, radiation losses, blowdown losses etc.

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Solar heater practical analysis

With Fresnel lenses

Room temperature of water bottle contains water =29℃ After solar heater system, When the water goes through the copper tubes and arrangement The temperature of water goes to 60℃ to 65℃ Total time to rise the temperature from 29 to 65 , 10 minutes and time in clock near about 10am morning Heat transfer is all about the transfer of heat from one point to another. If we consider any system which will be at higher temperature compared to surroundings, there will be transfer of heat from system to the surroundings.

Fig 5: Solar engine with Fresnel lens

Heat transfer is given by

$$Q = m \times c \times \Delta T$$

Where

m is the mass,

C is the specific heat and

Δ T is the temperature difference in K.

Thermal Conductivity of copper tubes is = 399W/mK.

Initial temperature Tcold = 29oC,

Final temperature THot = 60oC,

Area of copper tube,

A = 5.026*10^-5 m2

Thickness= 0.5 mm

$$\text{The Heat transfer Q} = \frac{kA(T_{Hot} - T_{Cold})}{d}$$

The Heat transfer Q = 77.716 w

Without Fresnel lenses

Room temperature of water bottle contains water =29℃. After solar heater system, When the water goes through the copper tubes and arrangement The temperature of water goes to 29℃ to 50℃ Total time to rise the temperature from 29 to 50 . 10 minutes and time in clock near about 10.30 am morning.

Thermal Conductivity of copper tubes is= 399W/mK.

Initial temperature Tcold = 29oC,

Final temperature THot = 50oC,
Area of copper tube,
A = 5.026*10^-5 m2
Thickness= 0.5 mm

$$\text{The Heat transfer Q} = \frac{kA(T_{Hot} - T_{Cold})}{d}$$

The Heat transfer Q = 21.2250 w
Increase in heat transfer rate =\{[Q(with)- Q(without)]/Q(without)\}*100\}
=\{[77.71-21.225]/21.225\}*100\}
=266.12%

Cylinder power and torque calculations

Standard dimensions measure by using standard device
Focal length = 15cm
Crank radius =1.5cm
Height h = 40 cm
Speed n = 495 rpm
Size of box = 36 x 37 cm
We know that

$$W = \frac{2\pi N}{60}$$

W=51.83rad/s
Also torque calculations
T = w x r
=51.83 x 0.015
T= 0.777 N.M

Power calculations

$$P = \frac{2\pi NT}{60}$$

$$= \frac{2 \, x 3.14 \, x \, 495 \, x \, 0.777}{60}$$

P = 40.33 watts
H=40cm=0.4 m
Area Of pipe = 4 x 10 -3
P = ϱ g h A
=1000 x 9.81 x 0.4 x 4 x 10 -3
=3924 Pascal
P = 15. 696 N

Heat Transfer Mechanisms
Heat transfer mechanisms can be grouped into 3 broad categories,

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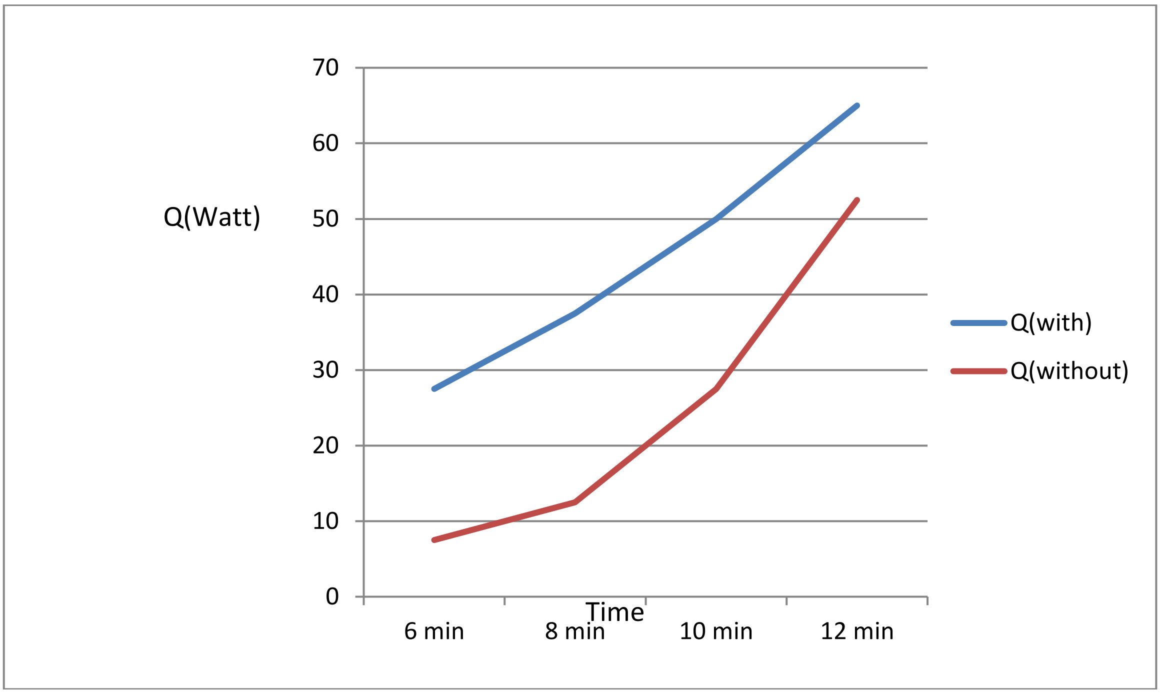
Fig 6: Heat transfer mechanism

One of the biggest uses of electricity, gas and oil is the heating of water in the home, and in offices, schools and hospitals etc. Solar water heating is a very simple and efficient way to grab energy from the sun and use it. Solar water heaters concentrate diffused solar radiation into thermal energy. DIY Solar Water Heating Panel System A solar water system consists of a solar collector and a storage tank. The solar collector is usually a flat rectangular box (1 sqm per person in the household) mounted on the roof so that it faces South (for northern hemisphere dwellers). The box has a transparent cover made of strong glass or plastic through which the sun's rays enter. Inside the solar collector a thin copper pipe snakes up and down and left and right across the box. Behind the copper pipe is reflective foil and then insulation so that the suns energy does not escape. Water or anti-freeze is pumped through the copper pipe and is heated by the sun's energy. The hot liquid is then pumped through a coil of pipe in a standard hot water storage tank/boiler. When cold water enters the tank it is pre-heated by the coil and so less energy is required to heat up the tank of water to a usable temperature by the boiler. Most systems work well even when the ambient temperature is well below zero and can save 20% off your water heating bill even in the depths of winter. A typical system, for example 4sqm of collectors for a household will lead to savings of two-thirds on previous water heating bills and is environmentally friendly. Evacuated Tube Solar Collector Another type of system which is becoming more common thanks to its increased efficiency is an Evacuated Tube Solar Water Heater. This is made up of an array of evacuated double glass-walled tubes which each have a space in the centre containing a copper heat tube. Around 93% of solar energy hitting the tube is absorbed and used to heat water; the remaining 7% is reflected. Thanks to this high efficiency prices for these systems start from just 30 pence per Watt of energy required.

Results and discussion



Graph 1. Heat Transfer Vs. Time

From above graph we conclude that the heat transfer rate by using Fresnel lens is more effective than without Fresnel lenses the violet color line indicate the heat transfer with Fresnel lenses and red color line indicate heat transfer without Fresnel lenses.

Tables:

Table 1. Comparison table for different parameters

Parameter	With Fresnel Lenses	Without Fresnel Lenses
Boiler Efficiency (%)	75	60
Power (mech) O/p (watt)	40.33	40.33
Speed (RPM)	495	495
Time Required for steam engine (Min)	6	12

Conclusion

This will be reduce the total dependency on fossil fuels and other nonrenewable and exhaustible energy sources. As such, deforestation and other environmental populations are reduced to a minimum temperature above 200°C was obtained at base of the absorber. Water boiled faster using the generator than when using ordinary charcoal or kerosene stove. The Fresnel lens collector solar steam generator is very efficient heating equipment to fulfill this requirement. Its increases efficiency of boiler above 25 % . Its increases heat transfer rate (Q) by 266.12%.

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