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A RESEARCH:GLASS TUBE TYPE SOLAR COOKER

IMPROVEMENT OF SPEED & EFFICIENCY OF COOKING USING EVACUATED TUBE

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Abstract— ***The box type and parabolic solar cookers are commonly used for cooking of food in the noon. Among them, box type solar cooker is more popular due to its simplicity of handling and operation. The cooking applications of Glass Tube Type Solar Cooker have their applications in increasing the rate of evaporation of waste water, in food processing, for making drinking water from brackish and seawater. It produces a high temperature around 200°C and the food gets cooked in less time. Solar cooker must constantly be realigned with the orbiting sun for maximum effectiveness. Glass Tube Type Solar Cooker concentrates light to a larger surface, so it is slightly more tolerant for marginal errors of alignment.***

Keywords- Evacuted Tube; Design and analysis; litreture survey; performance and testing;result and features

I. INTRODUCTION

All good engineering design starts with a clear understanding of the project's needs, goals, budgetary constraints, material constraints, performance tolerances, and criteria for judging the effectiveness and success of the final product. Once all of these design specifications are clearly understood, the process of actually designing the product may begin. (Note that in the "real world" any or all of these specifications usually change many times throughout the design process. For project in Glass Tube Type Solar Cooker, we will clearly defined but are likely to change during we work on the project.) One possible approach to producing a solar cooker would be to design and build an actual Solar Cooker, within the limits of the design criteria. We would then test the Solar Cooker and measure the Performance Index that we achieved with my first design.

Another approach would be to use Design of Experiments (DOE). Using DOE, we could (hopefully) identify the most important factors in a solar cooker, and then make good decisions about the levels to test them at. Once these values are chosen, we could build all of the cookers needed to test a full-factorial combination of these factors and levels. Then, using the resulting DOE predictive model, we could build additional cookers and test them, until we achieve the desired Efficiency. Again this could take a very long time.

II.LITERATURE SURVEY

A. Solar Steamer, an Evacuated Tube Indirect Solar Cooker without reflectors:

The Solar Steamer invented by Heinz-Joachim Muller uses no reflectors but concentrates the solar energy by creating steam from a relatively large collector area and applying it to a smaller cooking area. Allows the design of a split system where the thermal solar collector can be placed at some distance (e.g. on the roof) apart from the place of cooking (e.g. in the kitchen). The cook is not exposed to the sun shine and can use the steamer in a convenient position. In its technical design the solar steamer makes use of the availability of standard evacuated tube solar collectors which are available from China at low cost.

B.Venugopal Indirect Cooker

In India, Venugopal (1978) proposed a very promising variation, wherein he attached four reflector boosters to the flat plate collector. The whole assembly was on a wheeled platform for easy mobility. The insulated box had a separate chamber for keeping the milk hot. This cooker was designed for the roadside tea vendors. Another variation was reported from Iran (GATE 1979), where the unit was larger and the absorber/heater was kept outside the house.

III.DESIGN & DESCRIPTION

Fig 1Design

Fig-1 Shows the sketch of heat exchanger unit for Glass Tube Type Solar Cooker. The working of the system is based on principle of free convection. The experimental set-up contains the following components:

(a) Evacuated Glass Tube Collector

Material Used: The Concentric Borosilicate glass tube with coefficient of thermal expansion (3.3×10^{-6}°C).

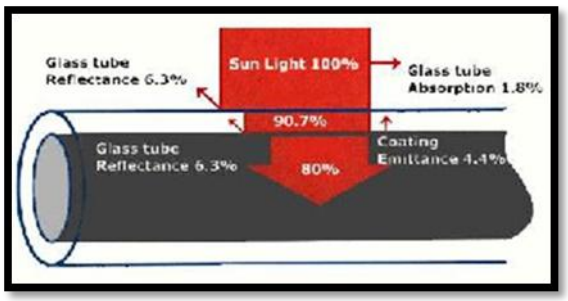


Fig2 Evacuated glass tube

Inner Glass tube is coated with Magnetron sputtering Hi-Tech

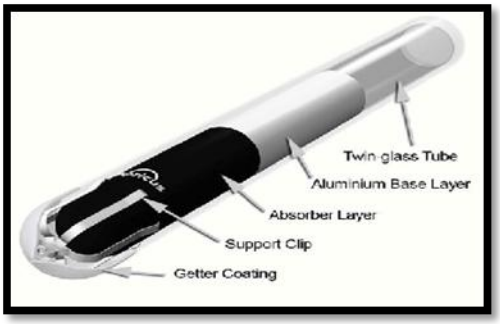


Fig. 3 Evacuated glass tube

(b) Reflector

Material Use: Aluminum foil or Tin

Fig4 Reflector

(c) Holding Frame

Material Use: MS Structure with special coated

Fig 5 Holding Frame

(d) Tube Holder

Material Use: Bended Tin Plate

Fig .6Tube Holder

(e) Isolation Cap

Material Use: Polyurethane with 30 kg/m^3 density

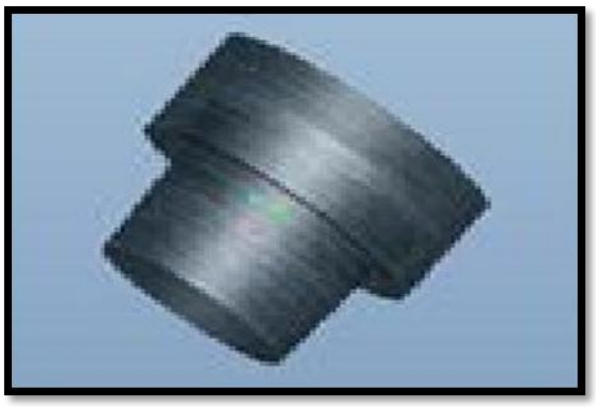


Fig .7Isolation Cap

IV.MANUFACTURING & ASSEMBLY

Tube: Evacuated tubes absorb solar energy and convert it into heat for use in water heating. There are several types of evacuated tubes used in solar thermal collectors. Apricus collectors use the most common "twin-glass tube". This type of tube is chosen for its reliability, performance and cost effectiveness.

SR.NO.	SPECIFICATIONS	
1	LENGHTH	1800MM
2	OUTER DIA.	120MM
3	INNER DIA.	95MM
4	WEIGHT	4KG
5	MATERIAL	TEMPERED GLASS
6	SELECTIVE COATING	CU\SS\AL N
7	ABSORBTANCE	95%
8	EMMISIVITY	5%
9	VACCUME	5X10-3 PA
10	THERMAL EXPANSION	3.3X10-6 DEG 'C
11	HEAT LOSS	0.8W/M2DEG'C

Fig 8 Tube & Spacification

Each evacuated tube consists of two glass tubes made from extremely strong borosilicate glass. The outer tube is transparent and allows sunlight to pass through with minimal reflection. The inner tube is coated with an aluminum nitride (Al-N/Al) coating. This selective surface is excellent at absorbing solar radiation with minimal reflection losses. During the manufacturing process, the air contained in the space between the two layers of glass is pumped out, while the top of the tubes are exposed to high temperatures. This fuses the two tubes together into a single evacuated tube. This "evacuation" of the gasses forms a vacuum, which is the most important factor in achieving the high performance of the evacuated tubes. Why a vacuum? As you would know if you have used a glass lined thermos flask, a vacuum is an excellent insulator. The vacuum eliminates a physical connection between the two glass layers of the tube which means there is nothing to transfer thermal energy so the heat cannot escape! This is important because once the evacuated tube absorbs the radiation from the sun and converts it to heat, we don't want to lose it!! The vacuum helps to achieve this. The insulation properties are so good that while the inside of the tube may be 150ºC / 304ºF , the outer tube remains within a few degrees of the ambient air temperature. This means that evacuated tube water heaters can perform well even in cold weather, when flat plate collectors perform poorly in these conditions due to heat loss. Individual evacuated tubes are inserted into a manifold of either 10, 20 or 30 tubes in order to form a complete collector. When oriented toward True South, a passive tracking effect is achieved in the collector due to the round absorption surface, meaning the collector is absorbing the sun's radiant energy throughout the day and not just when the sun is directly overhead. In an East West orientation, a similar effect is achieved as the sun rises and falls across the sky over the course of the year.

Reflector: A method of manufacturing monolithic glass reflectors for concentrating sunlight in a solar energy system is disclosed. The method of manufacturing allows large monolithic glass reflectors to be made from float glass in order to realize significant cost savings on the total system cost for a solar energy system.

The method of manufacture includes steps of heating a sheet of float glass positioned over a concave mold until the sheet of glass sags and stretches to conform to the shape of the mold. The edges of the dish-shaped glass are rolled for structural stiffening around the periphery. The dish-shaped glass is then silvered to create a dish-shaped mirror that reflects solar radiation to a focus. The surface of the mold that contacts the float glass preferably has a grooved surface

profile comprising a plurality of cusps and concave valleys. This grooved profile minimizes the contact area and marring of the circular glass surface, reduces parasitic heat transfer into the mold and increase mold lifetime. the disclosed method of manufacturing is capable of high production rate sufficiently fast to accommodate the output of a conventional float glass production line so that monolithic glass reflector can be produced as quickly as float glass production can make sheet of float glass to be used in process.

Aluminum box: Aluminum is usually alloyed – it is used as pure metal only when corrosion resistance and/or workability are more important than strength or hardness. Aluminum is use A wide range of household items, from cooking utensils So, we can make aluminum box used for solar cooker because it is corrosion resistive material and thermal efficiency of aluminum is high. Cooking boxes are coated with highly heat absorbing coating.

Fig 9 Aluminum box

Parabolic Reflector: The reflector can made from Glass mirror and aluminum foil .one disadvantage of a parabolic reflector is that the solar energy is concentrated in a very small area, which may be too small for a particular purpose.

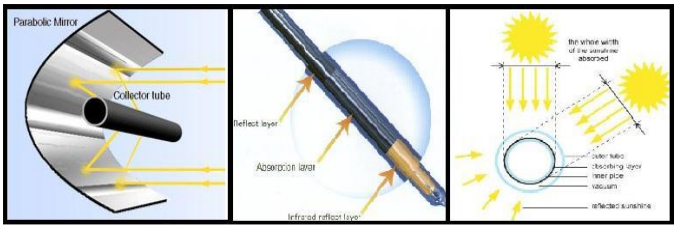


Fig 10 Reflector

Isolation cap: A rubber bush is a type of vibration isolator. a ring made of resin. It provides an interface between two parts, damping the through the bush. A common application is in vehicle suspension systems, where a bush made of rubber separates the faces of two metal objects while allowing a certain amount of movement.

Tube holder: The tube holder is a piece of laboratory equipment that is used to hold tubes. They are made out of metal and are used by squeezing the handles to open the other end, and inserting the test tube.

Test tube holders are typically used when heating the test tube is necessary, or for when caustic materials are being handled.

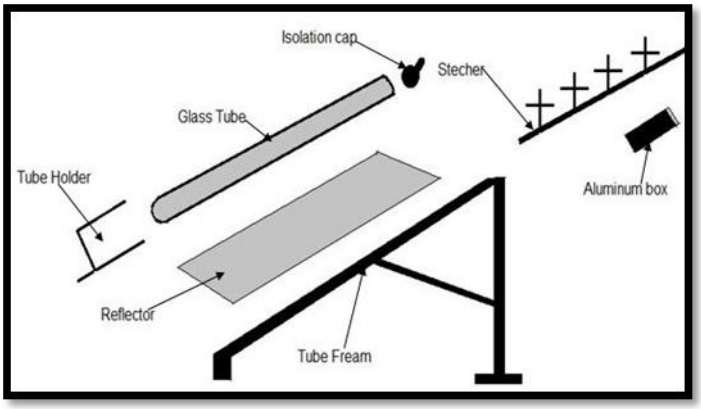


Fig 11-Assembly

V.WORKING & EXPERIMENT DETAIL

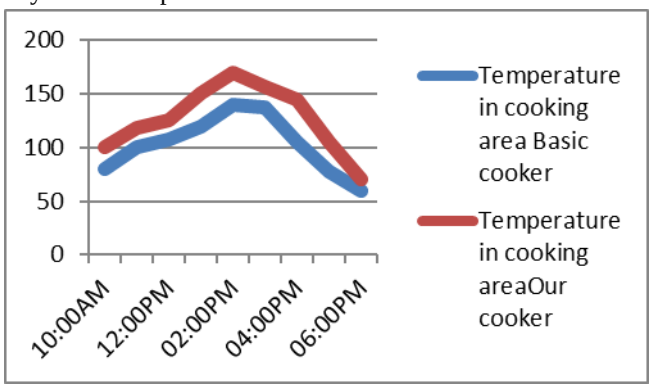
The large diameter vacuum tube (120mm OD) houses a separate sealed glass tube inside (triple cavity), which displaces most of the interior liquid volume. The resulting fluid space allows for only one gallon of vegetable oil to perform the heat transfer function to the heat retention cook box. The steel cook pan, housed within the insulated cook box, is specially designed to integrate with the glass vacuum tube. A silicone coupling hose (120mm ID) is band clamped to both the glass tube and the cylindrical portion of the steel pan outer dimensions. Tests have indicated that the unit, placed in the sun at 8:30am will achieve a cooking temperature (300° F) by 9:30am and cooking, water pasteurization and autoclaving can be readily achieved throughout the remainder of the solar day. The heat retention cook box and the thermal mass of oil and food within, permits cooking to continue through prolonged cloudy intervals and allows deliverer of hot cooked food as late as 10pm. Cook times are similar to an electric stove making this device a true solar appliance. An example is the 15 litter stove-top autoclave, which can achieve the required 17psi steam pressure within 40 minutes of placement within the insulated cook box. Frying, baking, boiling and steaming have all been successfully accomplished.

The experimental vessel of any shape is considered. The calibrated thermocouples (Cu-Constantan) were inserted at various positions of the experimental system. For the experimental purpose water was inserted as heat absorbing material. Surface temperature of Absorbing material at max is considered constant. Later the raise in temperature of water inside it is measured for specific time period. These parameters are sufficient to calculate the Performance Index or

the Efficiency. Further changing the parameters like angle, size, materials etc. the max efficiency can be achieved. To evaluate thermal performance of the experimental system, experiments were conducted and the results were reported.

A.Experimental results

Temperature readings remain high throughout the day when compared to conventional solar cooker.



Graph 1 Experimental results

B. ***Equations***

The cooking power and sensible efficiency can represent the thermal efficiency of the solar cooking unit. The sensible or heating-up power represents the rate of sensible energy used to heat up a certain mass of water, and the latent cooking power is the rate of energy needed to boil a certain mass of water in the pots. The sensible cooking power is expressed as: **P = Mw Cw ΔT/dt**

The average sensible efficiency is determined as the sensible energy used in heating divided by the average incident solar flux on the collector plate,Havg , times the collector area, *Ac* . It is expressed as: **η = Mw CwΔT/Ac Havg**

Nomenclature:

Ac= Area of collector, (m 2)
C = Specific heat, (kJ/kg °C)
Cp = Specific heat of HTF, (kJ/kg °C)
D = Diameter of the cylinder, (m)
H = Solar insulation, (W/m 2)
Havg= Average solar insulation, (W/m 2)
K = Thermal conductivity, (W/m 2 °C)
L = Length of the cylinder, (m)
M = Mass, (Kg)
P = Sensible cooking power (J)
t = Time, (sec)
dt = Time interval, (sec)
T = Temperature, (°C)
ΔT= Temperature difference, (°C)

C. ***Compare to other cooker***

	Box Type	**Parabolic Type**	**Glass Tube Type Solar Cooker**
Max. Temperature (Approximant)	165ºC	230ºC	200ºC
Initial Cost	2500	4000	1500
Volume Occupied	Moderate	More	Less
Heating Time	More	Moderate	Less
Efficiency	50%	65%	80%

VI. ADVANTAGES & APPLICATIONS

Advantages:

- Efficiency (η) is more than all previous models.
- Initial Installation cost is Minimum.
- Volume occupied is Minimum.
- Cooking is quick.
- Max. Temperature is very high.
- Simple to handle and transport (frame is foldable).
- Lifespan is about 15 years.
- Heating from all directions leading to fast preheating.
- Evacuated tube absorbs heat very efficiently from all directions supported by reflector to absorb maximum of solar heat.
- Vacuum jacket minimizes the heat loss leading to fast and efficient cooking with high pressure.
- The tube can hold pressure up to 1MPa.
- Very less chance of accident as the coefficient of thermal expansion 3.3*10-6 °C.

Applications:

- Oil, which is what most people currently use to power their homes, is not a renewable resource. This means that as soon as the oil is gone, it is gone forever and we will no longer have power or energy.

- Solar cells make absolutely no noise at all. They do not make a single peep while extracting useful energy from the sun. On the other hand, the giant machines utilized for pumping oil are extremely noisy and therefore very impractical.
- Solar energy creates absolutely no pollution. This is perhaps the most important advantage that makes solar energy so much more practical than oil. Oil burning releases harmful greenhouses gases, carcinogens and carbon dioxide into our precious air.
- Very little maintenance is required to keep solar cells running. There are no moving parts in a solar cell, which makes it impossible to really hurt them. Solar cells tend to last a good long time with only an annual cleaning to worry about.
- Solar panels and solar lighting may seem quite expensive when you first purchase it, but in the long run you will find yourself saving quite a great deal of money. After all, it does not cost anything to harness the power of the sun. Unfortunately, paying for oil is an expensive prospect and the cost is still rising consistently. Why pay for expensive energy when you can harness it freely?
- Solar powered panels and products are typically extremely easy to install. Wires, cords and power sources are not needed at all, making this an easy prospect to employ.
- Solar power technology is improving consistently over time, as people begin to understand all of the benefits offered by this incredible technology. As our oil reserves decline, it is important for us to turn to alternative sources for energy.

VII. CONCLUSION

Thermal energy obtained from **Glass Tube Type Solar Cooker** can be transported to any comfortable place or cooking as its assembly is foldable and very easy to assemble for use. This phenomenon can be successfully applied for off-place cooking at moderate solar insulation. The reasonably high insulation decreases the cooking time to a very minimum value.

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