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Indirect Two-Stage Solar Concentrating Cooking System

Babu Suraywanshi, Ravi Chitgopkar, Ibrahim Patel, Raghavender Kulkarni Saravanan S

Abstract: ***The objective of this paper publication is a solar radiation concentrating collector with high temperature storing device for domestic and commercial use, primarily for solar cooking. This system is economical, not so difficult to use and maintain and not dangerous. The system should collect energy over 300^{0}C for facilitating cooking, baking and frying. Individual commercial plants can be sized to produce more than 1000 people's meals within a short time. In this technology uses sun-tracking mirrors commonly known as two-stage solar concentrating system sunlight on a receiver at the midpoint of bottom an oil circulating pipes. The massive amount of solar energy in the form of sun rays, concentrated at parallel pipe to produce temperature approximately 250°C to 300°C. The accomplished thermal energy is adapted for mineral oil, which keep back the energy for future use. High temperature water heating is converted to superheated steam, which is adapted to transfer the heat generator. In this fashion thermal energy is converted into concentrating solar cooking systems.***

Index Terms: Mineral Oil, Baking and Frying, Heat-Transfer, Two-stage solar concentrating system..

I. INTRODUCTION

Energy is thought to be a method to enhance the standard of living and increase the production and occupation, in that way verbalizing the local, national and global policies and programs. In our country the energy needs are increasing vigorously, and endemic energy resources are inadequate and are not sufficient for future economic development. Strengthening the energy productivity and lessening the energy intensity of the economy ought to clearly represent the premise of an appropriate energy strategy.

The energy crisis ends up in making better use of latest and renewable sources of energy that alone will encounter the energy problems. So many strategies are adopted to achieve the situation such as energy preservation, use and application of renewable energy technologies shown in fig.1. The applicable plan for the emerging countries like India is to restrain non-conventional renewable energies in huge scale. Renewable energies are having more importance against old energy sources because old energy sources are entrenched with some limitations like magnitude and standard of backup, logistics of shipping and global warming.

The rapidly growing in population has occasioned constant increase of energy requirements. For dealing the increased requirements of individuals, numerous infrastructural services are forthcoming like educational institutions, hospitals, restaurants, roads, and transport facilities. In spite of these, transportation of general public from rural areas to towns and cities put lot of stress and induce high demand for energy. In spite of these, the rapid growth of educational institutions in the environs of the city with hostels, canteens and cafes also consume huge amounts of crude oil for outfitting to the requirements of the people.

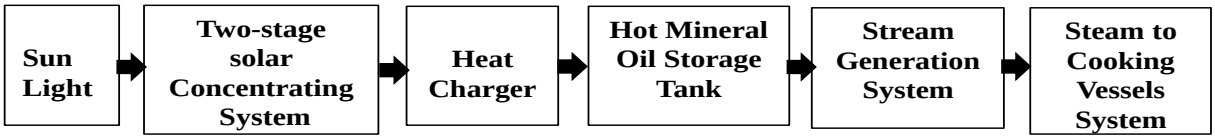

Fig.1: Block diagram of thermal energy storage and steam to cooking system.

Food is the most basic need of human beings. In this contemporary society, food preparation is done using electric power or natural gas. On the other hand, rural communities of some developing countries are still using outmoded way to cook food, to be precise by firewood. As the world is struggling with global warming, rapid climbing of cost and decreasing energy sources, using of firewood possibly will worsen global weather change owing to deforestation. Henceforth, substitute energy supplies are in terrible want and solar energy is well thought-out as the most capable sources of energy in food catering uses. Solar cookers convert solar radiation energy into high temperature to prepare food. Solar cookers are well-thought-out as cleanest means of cooking for the reason that solar radiation energy is a renewable source which is available for free of cost.

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* Correspondence Author
Dr. Babu Suryawanshi*, Prof. Dept. of Mechanical Engg.,Sri TuljaBhavani College of Engg., Maharashtra, India
Ravi Chitgopkar. Asst. Prof. Dept. of Mechanical Engg, Hirasugar Inst. of Technology, Nidasoshi, Karnataka, India.
Dr. Ibrahim Patel, [1]Associate Professor. Dept. of ECE, B. V. Raju Inst. of Technology NarsapurMedak (Dist) Telangana, India
Dr. Raghavender Kulkarni Professor Dept. of ECE, Khadar Memorial College of Engg. & Technology, Devarkonda, Telangana, India
Dr. Saravanan S Professor. Dept. of EEE, B. V. Raju Inst. of Technology NarsapurMedak (Dist) Telangana, India

However, it relies on solar radiation energy to prepare food when the sun is visible. This limits the use of solar cookers only during the day time.

II. STAGE SOLAR CONCENTRATOR GEOMETRY

The solar concentrating system comprises two single-curved mirrors, primary mirror, and secondary mirror, shown in fig. 2, curved in a parabolic shape so that the rays of the sun are reflected and concentrated to a point focus at a location heat charger. The two mirrors have two different focal lengths. The first mirror has elongated focal span and the secondary mirror has a small focal span. The rays of the sun are focused to a line focus by the primary mirror. The secondary mirror, with its plane of symmetry substantially orthogonal to that of the primary mirror, then intersects and concentrates the reflection from the primary mirror so that the total reflected rays converge to a point focus at the target location heat charger. The secondary mirror is positioned a distance not close to the focal point of the primary mirror namely equal to focal span of the secondary mirror.

The viewpoint of the mirrored-beam is the common of the reflecting which seems the identical by way of the angle of the episode beam to the usual. The resulting equation is established:

$$\Phi_I = \Phi_R \quad (1)$$

Fig. 2: Two-stage solar concentrating system

In this the mirrors are parabolic due to which, these are easier and cheaper in manufacturing than a dish; Lunenburg Industrial Foundry & Engineering Ltd. currently uses refined stainless steel sheets as the reflecting surfaces of the parabolic mirror attain the parabolic curvature of the mirror by introducing the pieces of sheet metal into a sheath exactly mass-produced to provide the precise parabolic shape. A sequence of two replications will centralize the sun rays onto a small section, the size of that is determined through the ray-tracing analysis. To melt down the metal, the solar radiation collector is put at the focal area of the system in order to accomplish the supreme spot temperature.

Primary Mirror	
Dimensions (H x W)	
4.9m X 4.9m	
Focal Length	**9.3m**
Secondary Mirror	
Dimensions (H x W)	**2.48m X 4.9m**
Focal Length	**4m**
Inclination of the Secondary Reflecting Mirror Relative to the Primary Mirror	**80^0**
Distance between both Mirrors	**6m**

III. BEAM-TRACING ANALYSIS SYSTEM

It were decided that for the aim of heat charging, the focal space was lesser than a rectangular 3 x 6 of inches on the side, enough energy would be concentrated on a small enough area that it would be likely to achieve a desired spot temperature. That conclusion was made following the observations made after a series of preliminary tests. Having a square target area, 30630, the solar concentrating effectiveness of the 2 steps concentrator is demonstrated as: Power instance on the objective zone separated by means of Power instance on the primary mirror is called the solar concentration efficiency of the two-stage concentrator i. e

$$\textbf{Efficiency} = P_{\text{Target area}} / P_{\text{Primarymirror}} \quad (2)$$

A. Heat loss

Heat energy is transmitted from collector to storing vessel and from that storing vessel to heat exchanging circuit, heat transfers from fluid in the pipe. Meanwhile temperature of the fluid is much higher than diffusive temperature; the fluid loses heat energy to ambient.

B. Heat exchanger

The heat exchanger works to transfer heat from the fluid at higher temperature to the food, at that the food is being prepared shown in fig. 3. The ideal features for the heat exchanger for this application are*:*

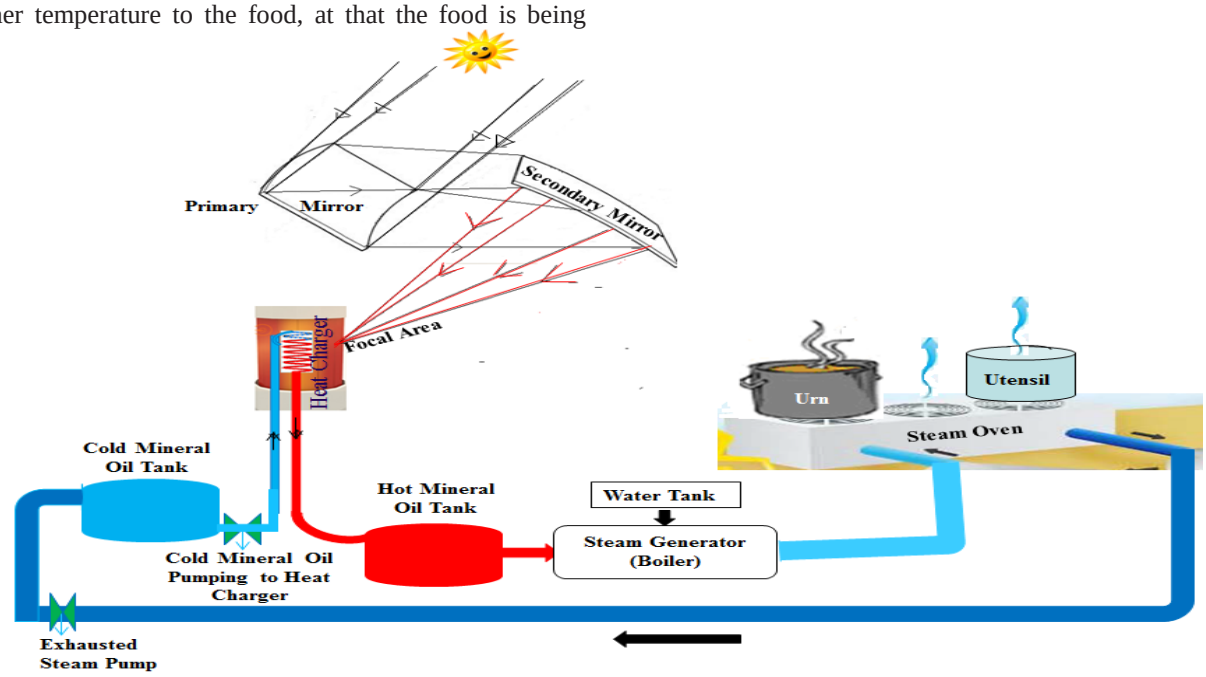

Fig. 3: Ray diagram illustrating the principle of the two sheet mirror solar concentrating system

Temperature variance between the flowing fluid and the food should be increased to have high degree of heat transfer shown in fig. 4.

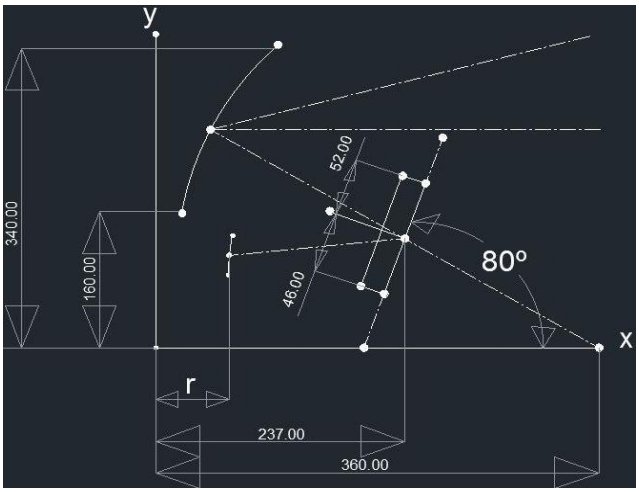

Fig. 4: Diagram of the two-stage solar concentrator supplemented by the prime dimensions.

• For specified temperature variance, design of heat exchanger should be such that the energy movement has to be supreme

•Space of conductive barrier should be maximized

•Pressure drop across the heat exchanger should be reduced to lessen the burden on pump-II

•Its size and dimension has to be flexible with different types of vessels

•Thermal padding should be superb to stop heat loss to ambient.

IV RESULTS DISCUSSION

To find the thermal potency, 1500mls of water can be used and the outcomes are presented in this section. Fig. 5, that shows the experimental information collected: temperature at the recess and outlet of the reflector, temperature at the recess and outlet of the change of state pot, and world sun ration on constant plane of the reflector. At the start, the water temperature was the same as the surrounding temperature (110ºC) and after approximately 20 minutes, boiling started. During the measurement period, there were some clouds and the average solar radiation was 815 W/m^2.

The thermal potency, Eq. (3), is that the quantitative relation of the smart energy necessary to heat up the mass of water within the pot from the 'β' is that the close temperature to 110ºC and therefore the alternative energy incident on the collector throughout a similar amount. This worth of 110ºC has been utilized in the testes to avoid the uncertainty of the beginning of the boiling method.

In this equation, m_w is that the mass of water within the pot in m (kg), μ_p is that the particular heat at constant pressure in (J/g °C), T is that the temperature distinction in (C), t is the time in (second), A_c is the area of the solar collector in (cm^2), and Ψ is that the flux of sun radiation incident within the collector plane in (W/cm^2).

$$\beta = \frac{m_w \mu_p \Delta t_{close-110}}{A_c \int_0^t \Psi dt} \text{ ----------(3)}$$

When the common temperature within the water was concerning 110ºC, the measured values were accustomed calculate the sensible potency, in step with Eq. (3). The value calculated for the reasonable potency was 0.50.

The world wide potency, that has comprises the reasonable and therefore the latent processes throughout heating, is associate degree expression that very closely represent the physical methods. It is stated as,

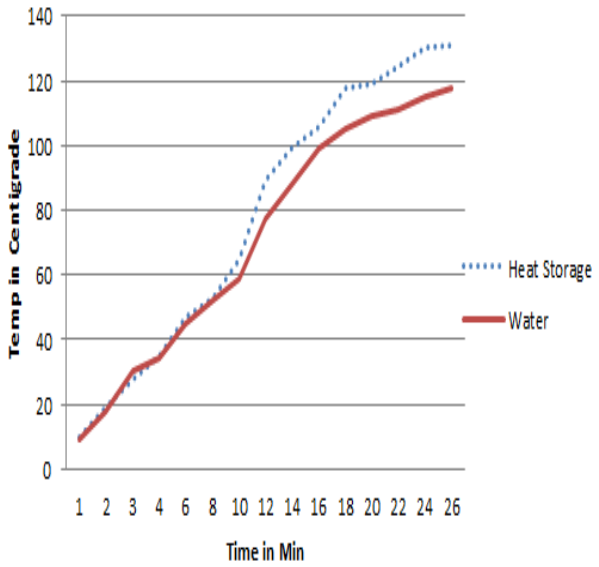

Fig. 5: Evolution of the water temperature during a boiling test.

$$\beta = \frac{m_{w2} \mu_p \Delta T + (m_{w1} - m_{w2}) L_{ef}}{A_c \int_0^t \Psi dt} \text{ -------(4)}$$

In the above equation m_w is the mass of the fluid water inside the pot, the subscripts 1 and 2 mentions to beginning and ending stages of the procedure, and L_{ef} is that the converted heat vaporization in [J/kg C].

Cooking by using temperature storage arrangement is conforming to placing a pot on a plate kept at a uniform heat of about 215^0C. Hence, the impact of the excellence is checked by burning surface, a steaming water test is done with the help of standard electric heating plate, which is shown fig. 5.

The worldwide potency was calculated using Eq. (4). The heating process (sensible and latent) took 22 minutes. After boiling started, the typical temperature within the water remained constant, slightly higher than 100ºC. Once the check finished, about 300g of water were vaporized. The worth for the world wide potency was 0.55and, as expected as, higher as the sensible potency, as the heat transfer procedure in the pot has an advanced coefficient.

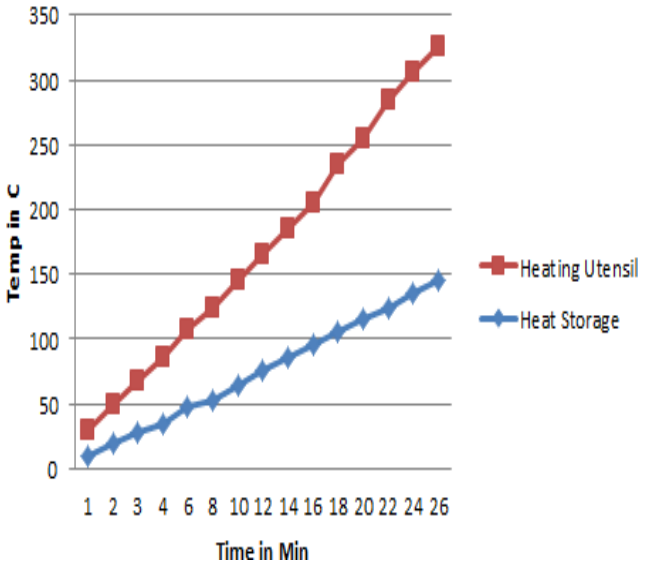

Fig. 6: Comparison of boiling tests at constant hot plate temperature, with different contact qualities

V CONCLUSION

A solar beam-tracing analysis have been experimented on a 2 steps sun ray concentrating is prepared by using 2 parabolic mirrors produced by means of Lunenburg Industrial Foundry & Engineering (LIFE). Solar beam detecting program might be created by Python and therefore the outcomes of secondary reflecting mirror's focal span, the distance secondary reflecting mirror and the bull's eye, and the misplacement of the mirror with the sun was studied. It determines the focal distance of the secondary reflecting mirror contend apart solitarily if it would have questioned for the extreme local solar radiation irregularity that may be accomplished on the aim.

Though, standard of thermal energy transfer might be considerably enhanced with an up grading surface of the thermal energy accumulator. Existing surface of thermal energy collector is uneven and a relationship with a flawlessly flat surface is done. In consonance with the experiments performed on a steam vessel at stationary heat, it is then doable to boil water considerably quicker than with traditional water boiler (Electric geyser).

Such apparatus can have the benefit of catering quickly and being in use during daylight is not there, as far as it has charging. With reference to preparation, this system even now has appreciable cooking period and is economical to old-style boiling methods. It is based on thermal energy accumulator, whose idea is to be made and can be used in a well maintainable way; significantly it is likely to reach the performance of conventional direct solar cookers.

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AUTHORS PROFILE

1) Dr. Babu N. Suraywanshi Working as Associate Professor in Mechanical dept. in Maharashtra Engg. College Nilanga Latur, (Dist), (M.S) India. He has received B. Tech, M. Tech. in Thermal Engg from G.U.G and Ph. D from Rayalseema University. He is having 28 years of teaching and research experience and published 25 research papers in the International conference & journals. His main research interest includes renewable energy and thermal energy

Ravi K Chitgopkar Working as Hirasugar Institute of Technology Nidasoshi Karnataka State India. He has received B. Tech, M. Tech Degree in Thermal Engineering from Gulbarga University Gulbarga. He is having 27 years of teaching and research experience and published 10 research papers in the International conference & journals and his main research interest includes renewable energy and thermal energy

Dr. Ibrahim Patel Working as Associate Professor in ECE department, Padmasri Dr. B.V.Raju Institute of Technology, Narsapur, Medak, (Dist), Andhra Pradesh India. He received his B. Tech. (ECE), (1) M. Tech Degree in Biomedical Instrumentation, (2) M. Tech Degree in DSCE from JNTU Hyderabad. Ph. D from Andhra University. He is having 26 years of teaching and research experience and published 100 research papers in the National/International conference & journals. His main research interest area includes Voice to Sign Language. He received three **"Best Paper Award"** in **ICSCI** – International Conference in **2011,** International Conference on Biomedical Engineering & Assistive Technologies (BEATS-12) in 2012 & best achievement award for "**Speech processing and Synthesis**", one of the chapter has been accepted to include for publication in the book "**Speech Technologies/Book 1"** to be published in Dec. 2013 from **Vienna, Austria European Union.** He is a member of IEEE, ISTE and BMESI, IEEE.

Dr. Raghavendra Kulkarni Professor in ECE department, Khader Memorial College Engg. & Technology. Devarkonda Nalgonda (Dist), Andhra Pradesh, India. He has received B. Tech. (ECE) from Gulbarga University, M. Tech Degree in DSCE from JNTU Hyderabad Ph. D from Mewar University Rajasthan. He is having 29 years of teaching and research experience and published 45 research papers in the International conference & journals. His field of interest is Demand side Image and Speech processing.

Dr. S. Saravanan received the B.E. Degree from Arulmigu Kalasalingam College of Engineering, affiliated to Madurai Kamaraj University in 1999, and M.E Degree from Thiagarajar College of Engineering, Madurai, affiliated to Anna University, Chennai in 2007 and Ph.D degree from Kalasalingam University, Virudhunagar, Tamil Nadu, India in 2015. He is presently working as Professor in the Department of Electrical and Electronics Engineering, B. V. Raju Institute of Technology, Telangana, India. His field of interest is Demand side management; Load forecasting and Power System Operation and control. He is Life Member of ISTE.