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A Review on General Performance Evaluation Techniques and Design of Solar Cooker

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Abstract- Solar energy is one of the environmentally friendly energy sources that has always been available to the human kind and has immense potential to provide free energy to the low socio-economic habitats in rural areas of the developing countries such as India. Out of a range of solar energy applications solar cooking promises to be one of the cheapest, the most popular and having direct impact on the socio-economic development of rural masses of developing countries endowed with abundant solar energy. The presented research work emphasis on the review of the literature work related with design and performance evaluation in of solar cooker for maximum power capacity.

Keywords: Solar cooker, Solar Energy, Performance Evaluation

1. INTRODUCTION

Solar energy has emerged as the most important energy resource options with immense potential because it is renewable, abundant and environmentally conceivable. Its potential has been accepted since the age of composition of mythological books. Sun provides about 1367W/m^2 of energy flux outside the mean interface of earth's atmosphere. However earth's surface receives very less amount of solar energy flux as some portion of it is lost while passing through the air mass. Still the solar energy flux incident on earth's surface integrated over a few days is sufficient to meet the present global demand of energy in a year. It may be utilized fruitfully for a variety of applications in different sectors of human activities. In this research work the extensive literature on the solar cooker is carried out. The paper also tries presented methodologies to the implementation in research work for improving performance.

1.2. Classification of Solar Cookers:

Solar cookers are classified on two basic factors
a) Based on dominant design factors
b) Based on dominant mode of heat transfer.

a. Based on dominant design factors:

Based on the dominant design features they are classified into three categories.
i) Box type (BC), ii) Concentrating type (CC), and iii) Advanced type (AC)

i. Box type (BC)

Sometimes it is also referred to as indirect heating type is shown in Fig 1. 1. It considered to be the oldest one. Horace de Saussure (1784) is considered to be the father of the box type solar cooker. It is the most commonly used solar cooker type and is reasonably convenient to use. It essentially consists of a rectangular enclosure insulated from the bottom and sides and having double glass cover on the top. Solar radiation enters through the top and heats up the black-coated absorbing surface lining the rectangular enclosure of the cooker. The unique property of the glass having low transmissivity to long-wave radiation prevents the heat energy from escaping out. The food to be cooked is put in cooking pots (with outer surface coated black) which are placed on the absorber plate.

Fig 1. 1. Box type (BC) Solar Cooker

ii. Concentrating or Direct Heating Type

The second category of solar cookers developed is those in which the radiation is redirected and concentrated by a reflecting surface. The cooking pot is placed at the focus of the concentrating

surface and is thus directly heated. For this it utilizes multifaceted mirrors, Fresnel lenses or parabolic concentrator to attain higher temperatures. A parabolic concentrating cooker is shown in Fig. 1.2. Normally they heat up quickly. The heat loss is more. To track the sun directional adjustment of the reflector is required at regular interval. Temperatures well above 200 °C can be achieved in such cookers. Various types of reflecting surfaces have been used. These include glass mirrors, aluminium sheet and aluminum foil. The main disadvantage of with these cookers is that they require continuous attention, as a result of which the operator has to be in the sun most of the time [1].

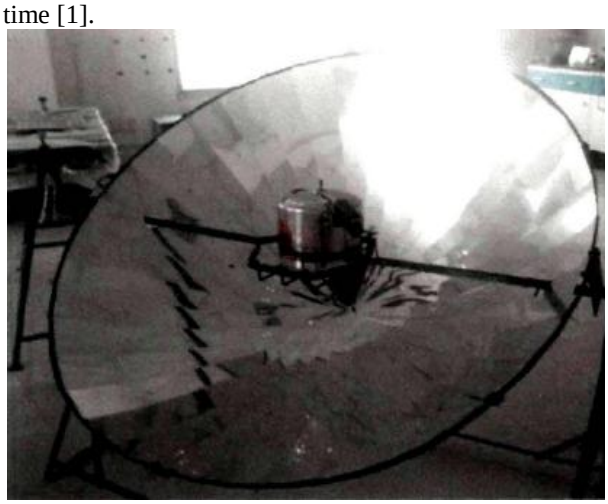

Fig. 1.2. Photograph of concentrating type cooker (CC)

iii. Advanced Type or Hybrid Type Cooker

The third category of solar cooker is the advanced type. This uses a heat transfer fluid to carry thermal energy from the point of collection to the cooking vessel(s). They are suitable for remote energy collection, which is useful for indoor cooking applications, but are comparatively more expensive to produce. The collector of this type of cooker is flat plate type, evacuated tubular type or concentrating type. The advantage of this type cooker is that it yields higher temperature than the box type cooker because of the use of a variety of collectors such as unobstructed concentrating collector, a selectively coated evacuated tubular collector and flat plate collector with booster mirrors. It can, therefore, be used for cooking of large variety of items [2]. In addition to this the cooking area can be at a small distance from the collector and cooking need not be done in the sun. Cooking is also possible in the evening with the inclusion of a storage device.

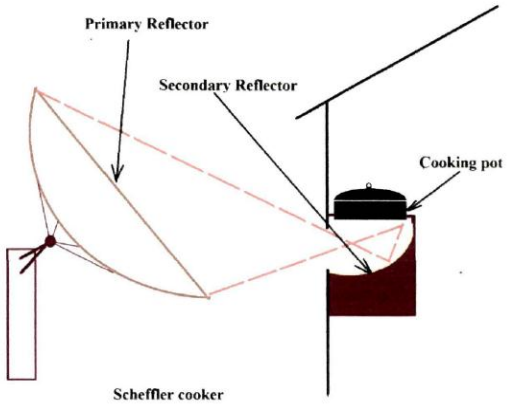

Fig. 1.3: Schematic diagram of Schemer Cooker

b. Based on the Dominant Mode of Heat Transfer

The solar cooker is classified on the basis of heat transfer mode**.**

Type-I: In Box type (BC), the heat is transferred either through absorber plateto pot conductively or through hot air trapped in the cavity convectively. A large portion of the heat is transferred to the cooking pot/surface from the absorber plate by conduction mode as shown in Fig 1.4. So box type or indirect heating type cooker can be called as conduction heating type or simply *conduction type cooker.*

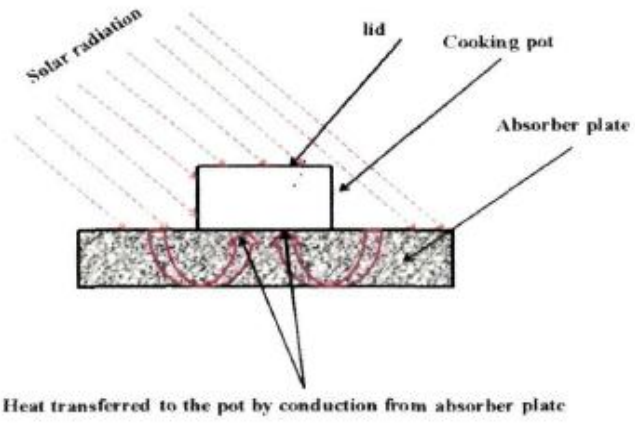

Fig. 1.4. Heat transfer to cooking pot from absorber plate by conduction mode.

Type-II: As shown in Fig. 1.5 in direct heating type or concentrating type cooker, most of the heat from concentrator to cooking pot/surface is transferred by radiation. So this type of cooker can be named as radiative heating or *radiation type cooker.*

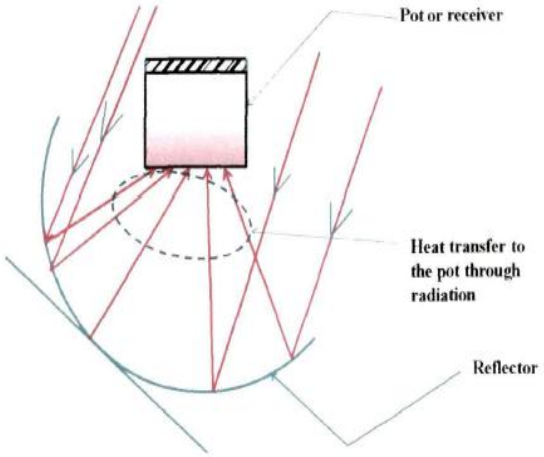

Fig 1.5. Schematic diagram of radiative mode of heat transfer

Type-III: In advanced type cooker the heat transfer is taking place to cooking pot/surface from collector fluid is by convection as shown in Fig. 1.6. So this type of cooker can be named as convective heating type or *convection type cooker.* Here Scheffler cooker is an exception and may be put under the radiative type .

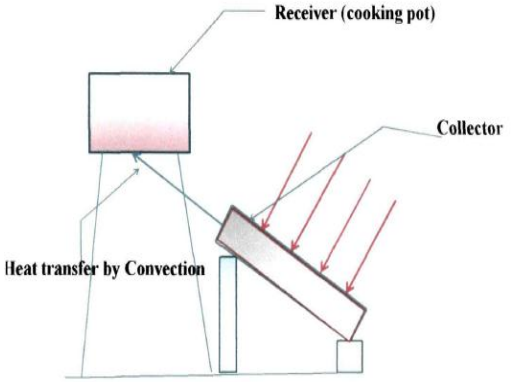

Fig. 1.6 Schematic diagram showing heat transfer to cooking pot by convective mode.

2. LITERATURE SURVEY

Nahar, N.M. [3] designed and fabricated another hot box type solar cooker (BC) with double reflector and transparent insulation material (TIM). TIM was placed between two glazings. Here efficiency was considered as one of the TPP and it was observed that efficiency was more for cooker having TIM than the one without TIM.
Amer, E.H. [4] designed developed a box type solar cooker (BC) which was exposed from both bottom and top side. Solar radiation was allowed to fall with the help of reflector from bottom and top side. The maximum plate stagnation temperature which was considered as one of the TPP was measured and compared with conventional box type cooker with one reflector. Their design showed better performance. Another TPP considered was cooking time. The cooking time was also compared with conventional cooker and found that the design proposed by them took less time to boil water than the conventional one.

Kalbande et al. [5] proposed a test procedure for parabolic concentrator cooker. The heating and cooling tests were performed to measure optical efficiency factor and heat loss factor. From this they estimated thermal efficiency of the cooker and also evaluated approximate time required for cooking. They considered thermal efficiency as the performance parameter.

Sardesh Pande et al. [6] gave procedure to evaluate the thermal performance of steam generating point focus solar concentrator. Thermodynamics of phase change of water was utilized to measure performance of the cooker. Water was allowed to convert steam at constant pressure and temperature and by measuring quantity of water converted to, steam the heat gain by the system was measured. Thus thermal efficiency which is a performance parameter of the system considered here was measured It is reported that thermal efficiency of any point focus concentrator above 100°C can be measured by this method and may be used as a TPP.
Schwarzer et al. [7] presented TPPs and TPs for common cookers based on their basic characteristics for comparing cookers of the same type, efficiency was considered as one of the performance parameter. For comparing different types of cooker, both power and efficiencies were considered to be performance parameter. It was perceived that two different types of cooker essentially differ in terms of power delivered which becomes unique if represented with efficiency.
Pandey et al. [8] reported exergy efficiency as the performance parameter for both box type and parboiled cooker and proposed a testing method for their determination both cookers were tested by boiling water and cooking rice under identical condition exergy efficiency of both cookers was computed and comparison was made. The comparison reveals that parabolic cooker bad better exergy efficiency.

Sharma et al. [9] designed, developed and evaluated the performance of a latent heat storage unit for a solar cooker separately. The TPPs hitherto developed, have not been developed to

reflect this aspect of improvement in the design features. The results of comparative analysis cannot be duplicated and/or repeated. Also the performance parameter of a separately developed and tested heat storage unit do not ensure a proportionate predictable change in the performance of an integrated system. TPP(s) must have absolute value which is dependent only on design parameters and independent of operational and climatic variables. It must also provide a value which is inclusive/holistic i.e. which reflect performance of the integrated system.

Amer, E.H.,[10] proposed a double exposure solar cooker and carried out theoretical and experimental assessment of its performance in terms of absorber plate temperature and cooking time taking conventional box type cooker as the bench mark. Thus he followed a comparative test procedure.
Grupp *et al.* [11] has worked on a new design of box-type solar cooker to enhance the cooker's thermal performance by improving design to increase heat transfer rate from absorber to the pot.
Tiwari et al. [12] designed solar cooker to minimize the heat loss during opening of the cooker cover. The performance of a box type cooker having externally fitted fin on cooking vessel to improve heat transfer rate to the food from cooker interior was investigated by Harmim *et al.* [13].
Buddhi et al. [14] developed a BC with latent heat storage system. In the absence of any TPP and test procedure for such designs the thermal performance of latent heat storage system was evaluated through comparative analysis with an identical cooker without any storage system as the bench mark.

3. CONCLUSION

In the present research work generalized thermal performance parameters (GTPPs) with corresponding generalized test procedure (GTP) has been proposed for testing cookers of different types, designs and their improvised variants. The research emphasis also the different types of solar cooker, categorised on the basis of heat transfer mode and design. The presented study will help to design out the proposed work for improving the performance of solar cooker.

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