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HEAT TRANSFER EVALUATION FOR AN INTEGRATED SOLAR RECEIVER AND PHOTOVOLTAIC CELL

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ABSTRACT

Due to increase in population, and the fear that the fossil fuel will soon come to an end in the near future as has been reported in various articles. Researchers all over the world are working to see which alternative energy alternative energy that will be easily accessible, stored energy will be easy to access coupled with the less emission as the ozone layer is already messed with carbon dioxide from exhaust of automobiles and industries.

Renewable energy is the choice of consideration when all the factors of clean energy is required. Solar energy and wind energy 4949are different of various forms of renewable energy. Energy with concentration effect has enormous energy to produce the required work.

KEYWORDS: Heat Transfer Evaluation, Ozone Layer is Already Messed with Carbon Dioxide from Exhaust of Automobiles and Industries

INTRODUCTION

Concentrated Solar Power

The Concentrated Solar Power are extremely effective in areas with high sun intensity but the clouds lower their effective energy at evening periods when the thermo-economic value has to be highest for a distribution company.

So this article will try to evaluate the potential of a battery hybridized solar receiver and a photovoltaic model for alleviating the constant pressure on our existing resources which tends to answer the question of global warming and depletion of fossil fuels. Which also inculcate a form of storage to be used to store the energy produced to make it a useful resource during peak period

Concentrated Solar Thermal Powers Systems

Conversion of solar to mechanical and electrical energy has been the objectives of experiments for over a century. In 1872, Mouchot exhibited a steam-powered printing press at the paris exposition, in 1902 the Pasdena Ostrich Farm system was exhibited, and in 1913 a solar-operated irrigation [2,3,4] plant started its brief period of operation in Meadi,Egypt. These and other development utilised concentrating collectors to supply steam to heat engines as shown by Jordan and Ibele (1).

The process of conversion of solar to mechanical and electrical energy are fundamentally similar to other thermal processes [6] and systems form the basis of estimating the performance of solar thermal power systems.

Some transcendent structures which the concentrated vitality seem show up is quickly recorded and the execution information analysis, figure 1.0 of different CSP innovations which make the allegorical trough to be the decision and its ability component has been demostrated and observed to be above different types of concentrated sun powered force gatherers for study, and as a result of its agreeableness concerning its monetary data when contrasted and different structures

Table 1: Performance Data for Various Concentrating Solar Power Options [5]

	Capacity unit MW	Concen-tration	Peak solar efficiency	Annual solar efficiency	Thermal cycle efficiency	Capacity factor (solar)	Land use $m^2\ MWh^{-1}\ y^{-1}$
Trough	10-200	70-80	21% (d)	10-15% (d) 17-18% (p)	30-40% ST	24% (d) 25-70% (p)	6-8
Frensel	10-200	25-100	20% (p)	9-11% (d)	30-40% ST	25-70% (p)	4-6
Power tower	10-150	300-1000	20% (d) 35% (p)	8-10% (d) 15-25% (p)	30-40% ST 45-55% CC	25-70% (p)	8-12
Dish-Stirling	0.01-0.4	1000-3000	29% (d)	16-18% (d) 18-23% (p)	30-40% Stirl. 20-30% GT	25% (p)	8-12

(d) = demonstrated; (p) = projected; ST steam turbine; GT gas turbine; CC combined cycle.

$$\text{Solar efficiency} = \frac{\text{net power generation}}{\text{incident beam radiation}} \qquad \text{Capacity factor} = \frac{\text{solar operating hours per year}}{\text{8760 hours per year}}$$

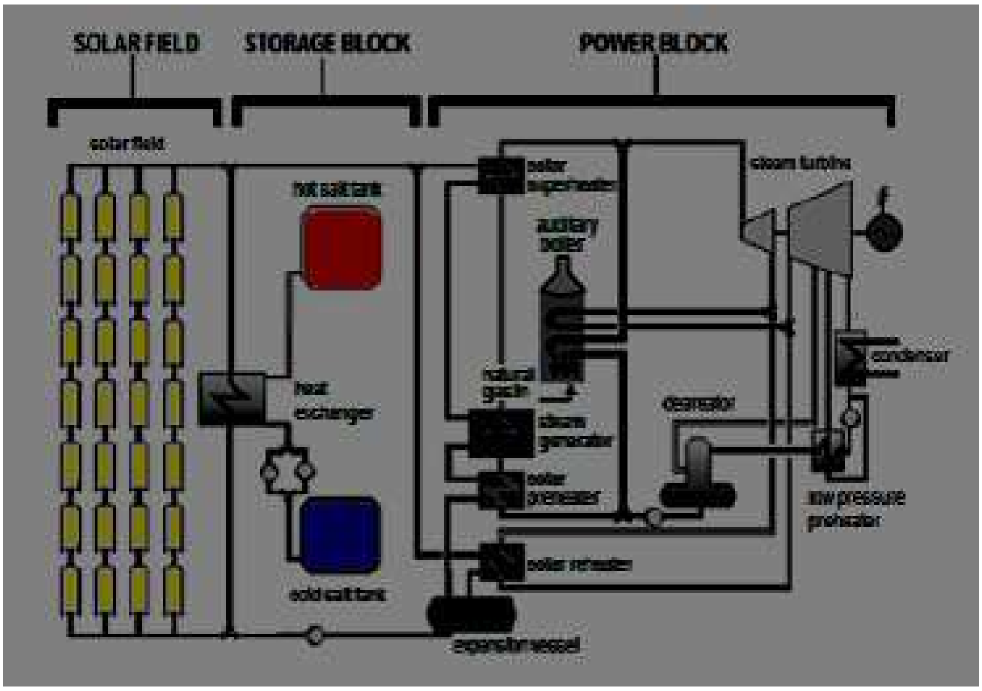

Figure 1: Process Flow Schematic of A Parabolic Trough Solar Power Plant with Tank Storage Capacity [15]

From Figure 1: The diagram shows the schematic diagram of different stages of operation in a parabolic trough operation. The solar field reflects the sun rays to the absorber which converts the rays to heat before been directed to the storage, power block and the thermodynamic conventional turbine coupled with a generator for electricity production for a continuous steam cycle.

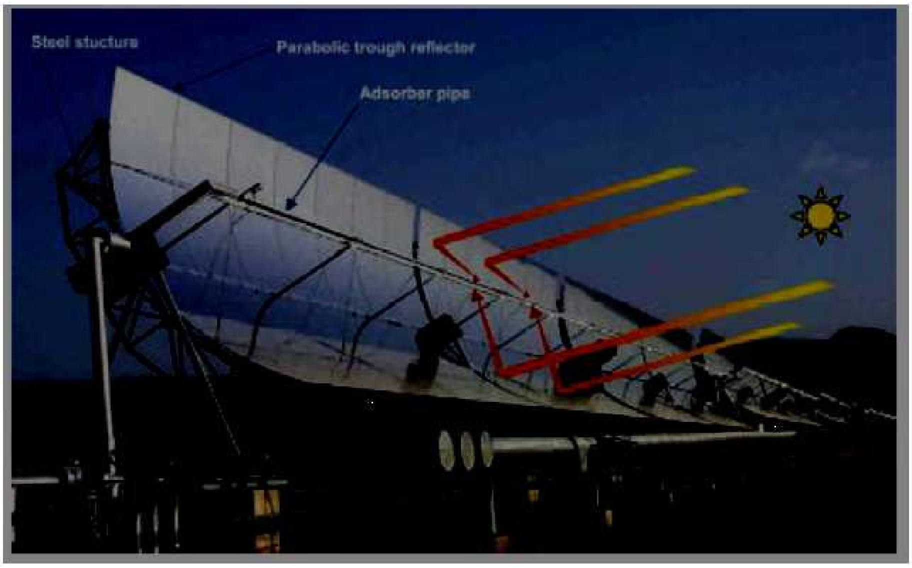

Figure 2: Parabolic Solar Trough Collector Located at a Solar Research Facility in Spain

The figure 3 below shows the receiver, which is a heat collecting element consisting of a glass bellow at both ends and joined by a flange. And an annuli tube integrated into wit which contains the battery cell. The absorber is a stainless steel with a specific coating on the outside surface for optical properties. Duffie,[5] discuss the importance of selective coating on receiver performance. Prince et al,[7] reported the effects of the getter and reflective losses

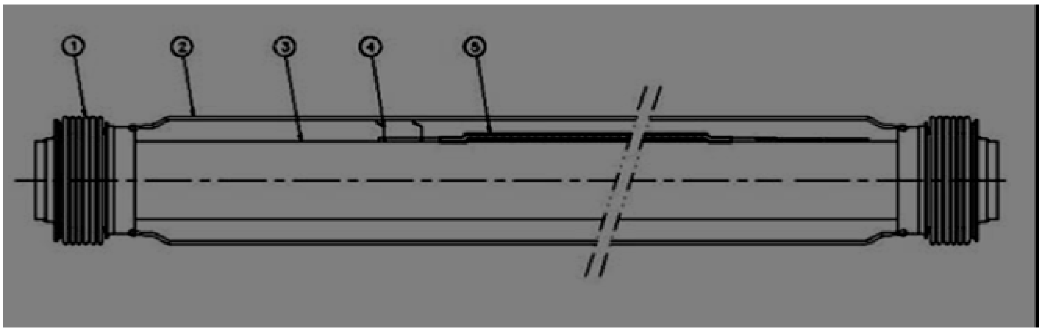

Figure 3: An Absorber Tube, Source Solel Solar System, Isreal

1. Bellow, 2. Glass Casing, 3. Steel Absorber, 4.Getter, 5 Getter bridge

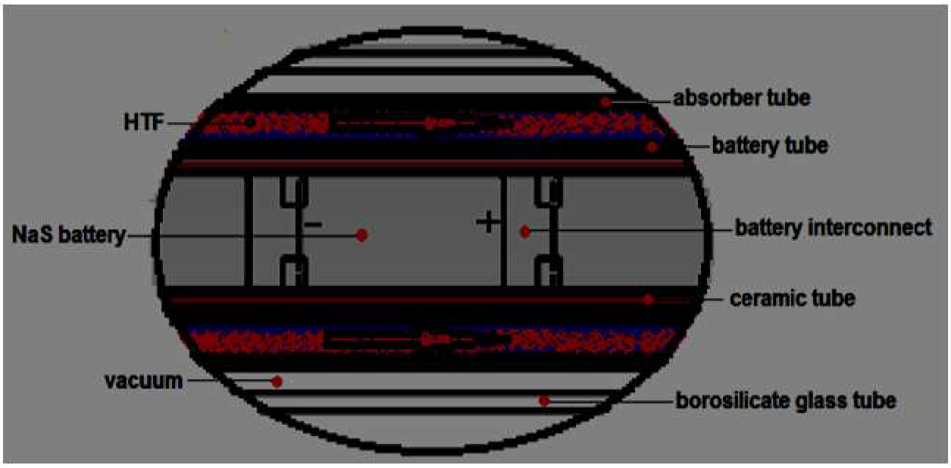

Figure 4: Internals of Absorber Tube with Sodium ion Cell [12]

The figure above shows the internals of an absorber and battery cell casing of sodium inserted, however this study leverage off work previously accomplished by [12] by utilizing sodium ion oxides into an absorber as show in the diagram.

Flow through annulus-- for the above figure the flow which is a double tube heat heat exchanger, fluid flows through the annuli fins while the battery current flows through the tube. It is however noted that the analytical equation for the boundary conditions for Figure 4, So this flux is negative because it passes from the hot fluid into the sodium batteries cell. The hydraulic diameter of the annulus is given in equation 1.0 below

$$D_h = \frac{4A_{flow}}{p} = \frac{(4\lambda(D_0^2 - D_i^2)/4)}{(\lambda(D_o + D_i))} = D_o - D_i \quad 1.0$$

The flow velocity$u_{htf}(m/s)$in the annulus can be defined in terms of mass flow, density and cross sectional area of flow as:

$$u_{htf} = \frac{\acute{M}}{(\rho A_{flow})} = \frac{\acute{M}}{(\rho(\pi(D_i^2 - D_O^2)/4))} = \frac{\acute{M}4}{(\rho\pi(D_i^2 - D_O^2))}. \quad 2.0$$

However [14] this annular concentric force flow is associated with two Nusselt number $N_{ui}$for inner and$N_{uo}$and outer surfaces. The convective coefficient when the Nusselt numbers are known for the inner and outer surfaces is determined with this relationship

$$N_{ui} = \frac{(h_i D_h)}{k} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad 3.0$$

$$N_{uo} = \frac{(h_o D_h)}{k} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad 4.0$$

But Gnielinski [13] modified the above equations recommends the following new correlations when calculating for the turbulent flow $(Re > 10^4)$Nusselt number for concentric flow annuli:

Where the equation constant$c_1$and the annular friction factorf_{ann},the modified Reynold number Re*, and the annular diameter ratio are given as

$$C_1 = 1.07 + \frac{900}{(Re)} - \frac{0.63}{(1+10\text{Pr})} \quad 5.0$$

$$f_{ann} = (1.8 + \log_{10} Re \quad - 1.5)^{-2}$$

$$\text{Re*} = Re\frac{((1+a^2)\ln(a) + (1-a^2))}{((1-a^2)\ln(a))} \quad 6.0$$

$$a = \frac{D_o}{Di} so that, 0 \preccurlyeq a \preccurlyeq 1 \quad 6.1$$

The overall heat transfer coefficient based on outside tube diameter from the surrounding to the fluid is:

$$U_o = \left(\frac{I}{UL} + \frac{D_o}{h_{fi} D_i} + \frac{D_o L_n(Do/Dl)}{2k}\right)^{-1} \quad 7.0$$

are inside and outside tube diameter, $h_{fi}$is the heat transfer coefficient. The reciver temperature $T_r$is expressed in terms of the useful energy gain per unit of the collector length and the absorber solar radiation per unit of the aperture are S, is

Photovoltaic characteristics model

An assessments based on the voltage- current relationship of the cells under various levels of radiation and at various cells temperature. The model provides means of calculating current, voltage and power relationship of cells array over the range of operating condition to be encountered, [2,3,4].

Photovoltaic Converter

The product of the frequency V and the wavelengthλ

$$C = V\lambda. \quad 8.0$$

Energy of the photon is a function of the frequency of the radiation and is given in terms of planks' constant h

$$E = hV \quad 8.1$$

Most energetic photons are those of high frequency and short wavelength. The common photovoltaic cells are made of single crystal silicon.

The known heat transfer mode when considering a photovoltaic panel,conduction mode in the PV cells and surroundings but to the photovoltaic and thermal panel surrounding by both free and forced convection so heat on the other hand is removed by long wave radiation [8] but heat condution is minimal. So the steady state equation for through the photovoltaic panel is

$$\nabla.(k\nabla T) = 0 \quad 8.2$$

So the PV shown bellow converts solar energy into electricity through the PV effect and the rest is transformeed into heat

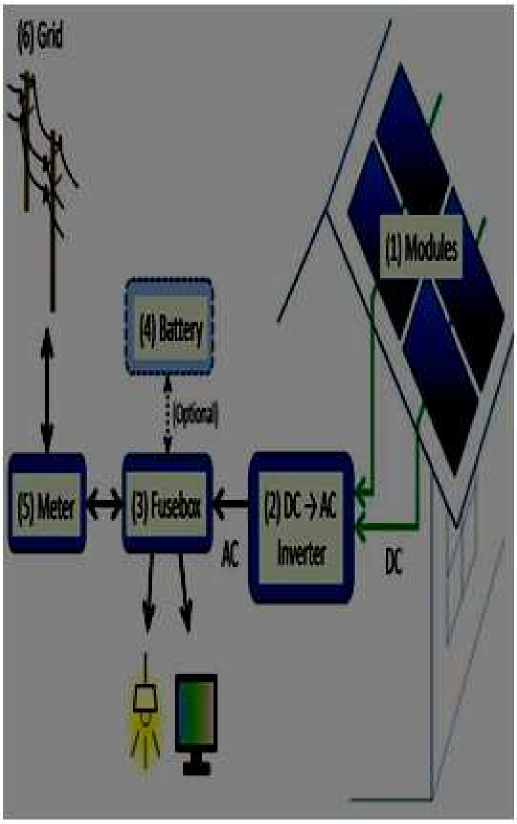

Figure 5: Schematics of Photovoltaic cell, Solar Field and Receiver [15]

The above figure tends to display schematically how the rays of the sun will be reflected in the absorber and part of it directed to the PV panel to charge the battery at same time with the connected accessory

Energy balance for the integrated photovoltaic cell and solar receiver: both can be classified as the primary and secondary absorbers

The PV cell electrical output efficiency can also be expressed as a function of PV cell power output, solar irradiance, and the PV cell surface below [10] from the Enegy Equations the convective heat transfer coefficient between the convective heat transfer coefficients between bopth absorbers and the overall heat loss coefficient indicating the heat enrgy absorbed from the solar radiation as can be see from the sketch below

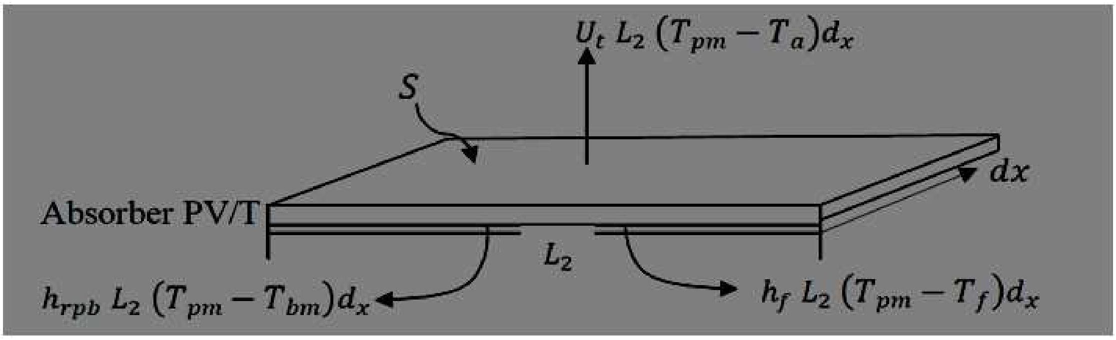

Figure 6: Energy Equation for absorber PV/T model

$$SL_2dx = U_tL_2(T_{pm} - T_a)dx + h_fL_2(T_{pm} - T_f)dx + h_{rpb}L_2(T_{pm} - Tbm)dx \quad 9.0$$

Where

S= Total absorber solar radiation (W/m^2)

h_{rpb}= Radiation heat transfer coefficient between absorber Pv and bottom cover$(W/m^{2.K})$

h_f= Convective heat transfer coefficient between lower surface of the absorber PV/T and fluid

$(W/m^{2.K})$

U_t= Overall top heat loss coefficient between absorber PV/T and ambient$(W/m^{2.K})$

Energy balance for bottom cover: the convective and radiative heat transfer between both absorbers and the bottom cover of the PV can be shown [11]

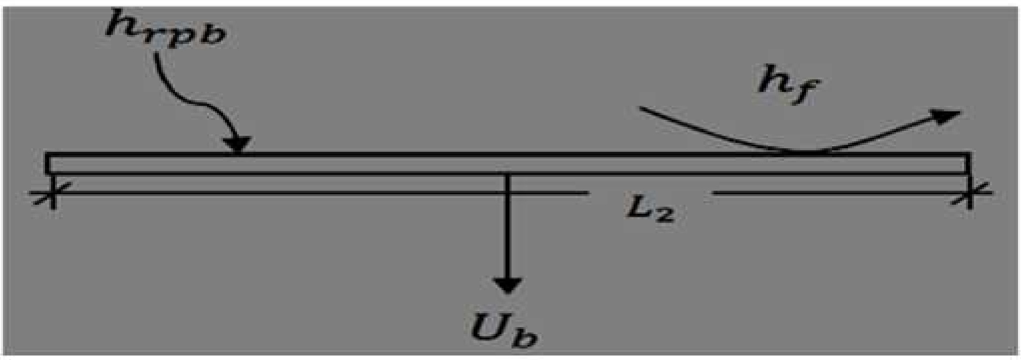

Figure 6b: Energy Equation for absorber PV/T model

Then substitute the above equation in to eliminate T_{pm}

$$U_L = \left(\frac{U_b h_r}{U_b + h_r + h_f}\right) + U_t \qquad 9.1$$

U_L:: Heat transfer coefficient between absorber plate and ambient

$$h_e = h_f + \frac{h_f h_r}{U_b + h_r + h_f} \qquad 9.2$$

h_e:Equivalent heat transfer coefficient between absorber plate,

So

$$S = U_L(T_{pm} - T_a) + h_e(T_{pm} - T_f) \qquad 9.3$$

$$T_{pm} = S + \left(\frac{h_e + U_L T_a}{U_L + h_e}\right). \qquad 9.4$$

$$F = \frac{d_{qu}}{dqu_{max}(T_{pm} = T_{bm} = T_f)} \qquad 9.5$$

***F:* Collector Efficiency Factor**

The above above concentrates on the amount of vitality a sun based safeguard gatherer at consistent operations can be proficient, the conduct of the liquid stream in the convective annular constrained stream. So the warmth exchange scientific examinations were performed for the convective annuli and the photovoltaic and warm model to assess it for diverse stream components of the framework. However exact temperature estimation will give a better result

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