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# Modeling Of Flat Plate Collector by Using Hybrid Technique

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***Abstract:*** *(SWH) are becoming increasingly attractive in sustainable development. Hence the Efforts continuously made here is to reduce their costs to make them more affordable. Solar energy has experienced a remarkable development in recent years because of cost reduction due to technological development as well as renewable energy scheme supported by the government. The process of using sun's energy to heat water is not a new technology. (SWH) technology has improved a lot during the past century. The primary method of energy transport in solar energy from sun is electromagnetic radiation .This type of radiation coming from the Sun also depends on temperature. The Sun generates electromagnetic radiation in extensive span of wavelengths. However, most of the radiation is being sent out in the observable range due to its surface temperature. The amount of solar energy received in a particular region depends on the time of the day, the season of the year, the sky's cloudiness, and how closeness of Earth's equator. For modeling we utilized Genetic algorithm and for prediction we employed hybrid ABC and PSO techniques. Genetic algorithm is utilized in order to optimize the modeling technique by using the dataset collected.*
***Kay words****: (SWH) Solar Water Heating.*

## I. INTRODUCTIN

The fact is that the Sun is the source of life and energy to all living creatures on the earth for millions of years. Energy is a vital need in all aspects and due to the increasing demand for energy coupled with its inefficient consumption, the environment has been polluted either directly or indirectly. To prevent this from becoming a global disaster, it is inevitable to strengthen efforts of energy generation and utilization using sustainable means and progressively substituting the fossil fuels for renewable sources of energy. Conventional fossil fuel reserve may last for few more centuries. The power generation technology based on fossil fuel, has serious implication on global warming. Currently the soaring price of fossil fuel does allow to countries to invest in non-polluting and inexhaustible solar technology. Moreover, the solar energy is also driving force behind other renewable such as biomass, wind, and hydropower.

Solar energy has experienced a remarkable development in recent years because of cost reduction due to technological development as well as renewable energy scheme supported by the government. The primary method of energy transport in solar energy from sun is electromagnetic radiation .This type of radiation coming from the Sun also depends on temperature. Renewable energy technologies, such as wind and solar power, are being widely studied by researchers today as many countries are trying to reduce their dependence on nonrenewable energy sources (i.e. fossil fuels). Massive use of conventional, non-renewable resources produces greenhouse gases which contribute significantly to climate change. Renewable energy sources, such as solar and wind energy, on the other hand, do not produce greenhouse gases. They are sustainable and free of cost. The Sun generates electromagnetic radiation in extensive span of wavelengths. However, most of the radiation is being sent out in the observable range due to its surface temperature. The amount of solar energy received in a particular region depends on the time of the day, the season of the year, the sky's cloudiness, and how closeness of Earth's equator. Reducing costs and increasing reliability of solar water heaters (SWH) includes the pumps, controller, sensors, and electrical power needed for active systems, and, having insulated storage, perform better than integral-collector-storage during winter in cold climates. .

## II. LITERATURE REVIEW: RESEARCH ON FLAT PLATE COLLECTOR

In the solar-energy industry great emphasis has been placed on the development of "passive" solar energy systems, which involve the integration of several subsystems: Flat Plate collectors, heat-storage containers, fluid transport and distribution systems, and control systems. The major component unique to passive systems is the Flat plate collector. This device absorbs the incoming solar radiation, converting it into heat at the absorbing surface, and transfers this heat to a fluid (water) flowing through the Flat plate collector. The warmed fluid carries the heat either directly to the hot water or to a storage subsystem from which can be drawn for use at night and on cloudy days. The results show that the system could reach satisfactory levels of efficiency. Furthermore it proved to be inexpensive and easier to manufacture which makes it a potential technological solution to the domestic water heating problems in rural India.

Fawaz S. Abdullah et al. have developed to determine the performance of the solar collectors to develop thermal energy conversion system. This research was to develop a tool for predicting the performance of a flat-plate solar collector from knowledge the absorbed solar radiation quantity. Also, the factors that effects on absorbed solar radiation value have been considered. These factors represented with collector tilt angle, the season changes that represented with month of year that the global solar radiation on horizontal surface has been measured, the location from the world represented with the latitude, time interval represented with hours of daylight from sunrise to sunset. Another optical factors effect on intensity of absorbed solar radiation had been considered. These factors correlated with absorptivity and transmissivity of the transparent glass cover which represented. The result of each factor was analyzed for different collector tilt angle, latitude of place, and solar hour angle.

Amir Hematian et al. have proposed a flat plate solar air collector. The absorber of solar collector made by steel plate with an area of 2×1m2 and thickness of 0.5mm in the form of window shade has been developed for increasing the air contact area. The surface of absorbent plate was covered by black paint. To insulate the collector, the glass wool with the thickness of 5cm was used. The experiments on the efficiency were conducted for a week during which the atmospheric conditions were almost uniform and data was collected from the collector. The results of the collector efficiency in the natural and forced convection were evaluated and their graphs were plotted. The results showed that the collector efficiency in forced convection was lower, but the low temperature difference between inlet and outlet of the collector decreased its heat loss. In addition, the average air speed in forced convection was about 21% higher than the natural convection.

Akachukwu Ben Eke et al. have presented a flat plate surface solar collector of dimension 0.5 m2, hinged on a horizontal support for quick adjustment of inclination from 0 to 90° Measurement of the solar radiation, varying degrees of inclination were taken between 12:00 noon and 2:30 pm for 4 days at clear sky hours, within the week of n th day of the year. The measurements were made for each month of the year in Zaria, Kaduna State, Nigeria. At each degree of inclination, the solar radiation intensity was replicated three times and the average value was taken. The flat plate was set truly facing south with an engineering prismatic compass. The result showed that the optimum angle of inclination of a flat plate for maximum collection of solar radiation intensities are 26.5, 24.5, 10.0, 19.5, 26.0, 30.0, 24.0, 21.0, 11.5, 19.5, 27.0 and 30.0 o, in the months of January to December, respectively. This proposed work revealed that the average angle of inclination at which a flat surface solar collector mounted at fixed position in Zaria is 22.5°. The analysis indicated that when a flat surface was located at the predicted optimum angle of inclination for each month of the year, an average annual increment of 4.23 % solar radiation intensity was achieved, when compared with the yearly average solar radiation intensity harnessed by the same flat plate collector on horizontal position, and under the same condition. This percentage increase amounted to annual average solar energy gain of 370,670 MJ/m2, at no extra-cost, other than positioning the solar collector at the identified optimum angle of inclination. Comparison of the measured and calculated optimum values of angle of inclination of a flat plate surface for trapping maximum solar radiation intensity for each month of the year indicated a high correlation with R2 of 0.97.

Adnan Ibrahim et al. have proposed Flat plate photovoltaic/thermal (PV/T) solar collector produces both thermal energy and electricity simultaneously. This proposed method, the state-of-the-art on flat plate PV/T collector classification, design and performance evaluation of water, air and combination of water and/or air based. This review also covers the future development of flat plate PV/T solar collector on building integrated photovoltaic (BIPV) and building integrated photovoltaic/thermal (BIPVT) applications. Different designs feature and performance of flat plate PV/T solar collectors have been compared and discussed. Future research and development (R&D) works have been elaborated. The tube and sheet design is the simplest and easiest to be manufactured, even though, the efficiency was 2% lower compared to other types of collectors such as, channel, free flow and two-absorber. It is clear from the review that for both air and water based PV/T solar collectors, the important key factors that influenced the efficiency of the system were the area where the collector covered, the number of passes and the gap between the absorber collector and solar cells. From the literature review, it was obvious that the flat plate PV/T solar collector was an alternative promising system for low-energy applications in residential, industrial and commercial buildings. Other possible areas for the future works of BIPVT ware also mentioned.

S. Farahat et al, an exergetic optimization of flat plate solar collectors is developed to determine the optimal performance and design parameters of these solar to thermal energy conversion systems. A detailed energy and energy analysis is carried out for evaluating the thermal and optical performance, energy flows and losses as well as energetic efficiency for a typical flat plate solar collector under given operating conditions. In this analysis, the following geometric and operating parameters are considered as variables: the absorber plate area, dimensions of solar collector, pipes' diameter, mass flow rate, fluid inlet, outlet temperature, the overall loss coefficient, etc. A simulation program was developed for the thermal and energetic calculations. The results of this computational program ware in agreement with the experimental measurements noted in the previous literature. Finally, the exergetic optimization has been carried out under given design and operating conditions and the optimum values of the mass flow rate, the absorber plate area and the maximum exergy efficiency have been found. Thus, more accurate results and beneficial applications of the exergy method in the design of solar collectors have been obtained.

M. Pradhapraj et al. have flat plat collectors are the best heat transferring devices. But the effectiveness of these collectors is very low because of lack of technology. Solar assisted heated air is successfully used for drying applications and space heating under controlled conditions. From the solar flat plate air heater the hot air was transferred to a conventional dryer or to the combined heater and drying chamber directly. Hence, solar assisted air heaters were cheaper and reliable. The air heater efficiency dependson the design of the system as well as the construction materials and the assembly. The solar air heating systems has acceptable life span of 15 to 20 years. The addition of side mirror enclosures was to increase the amount of solar radiation absorption at the collector plate so that the collector increases the yield and operate in a higher temperature range. Therefore with the addition of side mirrors one could able to maximize the output of fixed flat plate collectors. A flat plate air collector will be more efficient if it was made up of porous medium when comparing it with the non-porous collectors according to the study. In this proposed method, the performances of porous and non-porous absorber plates were discussed.

Balaram Kundu et al. have presented an analytical analysis of both Fourier and non-Fourier heat conduction in the absorber plates of a flat-plate solar collector. Separation of variables was employed to develop the model. For the analysis, a repetitive heat transfer module was used for the solution of parabolic and hyperbolic equations. From the practical point of view, two types of boundary conditions were separately chosen. A numerical technique based on the finite difference method was employed to determine the temperature for validation purposes. A comparative investigation was carried out to understand the requirements for use of the non-Fourier heat conduction model easily. A significant difference in the temperatures obtained from the Fourier and non-Fourier models was observed for lower values of the Fourier number and higher values of the Vernotte number. Finally, the effect of the boundary conditions on the Fourier and non-Fourier heat transfer was demonstrated.

N. Ehrmann and R. Reineke-Koch have increased the efficiency of solar-thermal flat-plate collectors at temperatures above 100 °C or with low solar irradiation, they implemented a double glazing with a low-emitting (low-e) coating on the inner pane to improve the insulation of the transparent cover. Since commercially available low-e glazing provides only insufficient solar transmittance for the application in thermal flat-plate collectors they were developing a sputter-deposited low e-coating system based on transparent conductive oxides which provides a high solar transmittance of 85% due to additional antireflective coatings and the use of low-iron glass substrates. Durability tests of the developed coating system show that our low e-coating system was well suitable even at high temperatures, humidity and condensation.

Khaled Zelzouli et al. the modeling of a solar collective heating system in order to predict the system performances. Two systems were proposed: 1) the first, Solar Direct Hot Water, which was composed of flat plate collectors and thermal storage tank, 2) the second, a Solar Indirect Hot Water in which we added an external heat exchanger of constant effectiveness to the first system. The mass flow rate by a collector is fixed to 0.04 Kgs–1 and the total number of collectors was adjusted to 60. For the first system, the maximum average water temperature within the tank in a typical day in summer and annual performances were calculated by varying the number of collectors connected in series. For the second, this proposed method, shows the detailed analysis of water temperature within the storage and annual performances by varying the mass flow rate on the cold side of the heat exchanger and the number of collectors in series on the hot side. It was shown that the stratification within the storage is strongly influenced by mass flow rate and the connections between collectors. It was also demonstrated that the number of collectors that could be connected in series was limited. The optimization of the mass flow rate on cold side of the heat exchanger was seen to be an important factor for the energy saving.

## III. ADVANTAGES AND RESTRICTIONS OF SOLR ENERGY

- There are some advantages of solar energy. First of all, it is free. We do not pay for this energy. Secondly, it is clean. It does not create pollution. It does not produce harmful waste products to the environment. Third, it is renewable. The sun will keep making energy for millions of years.
- As the prices of energy sources rise and become more volatile, renewable sources become more attractive. Solar thermal water heating technology is becoming cheaper and is currently heavily incentivized in many states in the U.S. and by the federal government. Water heating consumes one third of the energy used by the lodging industry in the U.S. Solar thermal water heating systems can be used to supply 60% or more of the required heat to hotels. However, in order to maximize a system's performance, the hot water draw profile for that particular hotel must be known.
- Simplicity and low cost.
- Better performance and quality of the product.

## IV. MOTIVATION OF THE PAPER

To further improve the efficient modeling of Analysis and running cost estimation of (SWH) systems. The weather parameters such as air temperature, atmospheric pressure, direct radiation, global radiation, net radiation, relative humidity, sunshine duration, wind speed and solar water heater parameters such as inlet water temperature, glass wool temperature, copper plate temperature, storage water temperature are used as input dataset. These data's were collected from Weather Monitoring Stations.

## V. OPTIMIZATION MODEL FUNDAMENTALS

The process of creating summary or theoretical model and the use of objects in the creation of a predictive model and the system is said to be modeling. Here genetic algorithm is used for optimization model in solar water heater.

Genetic Algorithms (GAs) are a technique that employs some properties of meta-heuristic. GAs are also a part of evolutionary computing by taking inspiration of evolutional theory that was expanded from Darwin's evolution thought to algorithm solution approach by Holland (1975) . Genetic algorithm is a kind of bionic algorithm that simulates natural process of biological evolution developed problem-solving strategies and approaches. A population of individuals is maintained within search space for a GA, each representing a possible solution to a given problem. It has a variety of coding techniques to represent the complex structure, and through a set of codes that a simple genetic operation and survival of the fittest in natural selection to guide the study and determine the search direction. It is starting from an initial population, constantly repeat the selection, crossover and mutation process, so that more and more closer to a target population evolution.

The general procedure of genetic algorithm as follows

- Selection: a proportion of the current generation is selected for the new generation, usually on the basis of fitness value.
- Crossover: the remainder of the new generation is made up by probabilistically selecting pairs of hypothesis and producing a new pair of hypothesis by applying the crossover operator.
- Mutation: a small percentage of the new population is then changed by applying the mutation operator.

## VI. PROCEDUR AND RESULTS

The modeling of weather analysis using genetic algorithm procedure is shown below. The data set is formed on basis of features such as weather, humidity, temperature, global Solar Radiation, Air Temperature, Relative humidity and wind speed from different weather forecasting stations. Therefore by using the genetic algorithm procedure the modeling process will be carried out and the below equation is used to find the weight

$$f_m = \frac{2}{\sum_{i=0}^{N_R-1} \alpha_i \left[ \left( \frac{1}{1-\exp^2\left(1-\sum_{j=0}^{N-1}\beta_{jk}\right)} \right) - \left( \frac{\exp\left(1-\sum_{j=0}^{N-1}\beta_{jk}\right)}{1-\exp^2\left(1-\sum_{j=0}^{N-1}\beta_{jk}\right)} \right) \right]} \quad (1)$$

Where,

$\alpha_i$ , $\beta_{jk}$ - the initial weights to be optimized

The blind regression model is optimized by selecting the $\alpha_i^{best}$ and $\beta_0^{best}, \beta_1^{best}, \dots, \beta_{N-1}^{best}$ values to make it fit to the historical data. Genetic Algorithm is used to perform the optimization process in our modeling system

The steps below show the optimization model procedure of genetic algorithm. Hence the system first generates population size and then follows with fitness function, crossover and mutation operation as follows,

Step1:

Initially, generate a population of size

$X_m \; ; \; m = 0,1,\cdots,N_q - 1$

Where,

$N_q$ - The population size, in which each chromosome is of length $N+1$.

The chromosome length $N+1$ indicates the number of genes i.e. number of weights to be optimized are $N+1$, $\alpha_i$ and $\beta_0, \beta_1, \dots, \beta_{N-1}$. Each gene value of every chromosome is an arbitrary number to be generated within the interval $[0,1]$

Step 2:
Evaluate the fitness of the population size using the below mentioned formula

$$f_m = \frac{2}{\sum_{i=0}^{N_R-1} (\varpi)^2} \tag{2}$$

Where,

$f_m$ - Maximum fitness value

After the substitution of equation 1 in equation 2 we will get the following maximum fitness formula, hence $f_m$ is given by

$$\varpi = \alpha_i \left[ \left( \frac{1}{1-\exp^2\left(1-\sum_{j=0}^{N-1} \beta_{jk}\right)} \right) - \left( \frac{\exp\left(1-\sum_{j=0}^{N-1} \beta_{jk}\right)}{1-\exp^2\left(1-\sum_{j=0}^{N-1} \beta_{jk}\right)} \right) \right]^{N.C_q} \tag{3}$$

Step 3:
After finding the fitness value, $N_q/2$ Select chromosomes from the population size, which have maximum fitness value and select that maximum fitness value?

Step 4:
Crossover and mutation are important genetic operators of the genetic algorithm. Among the different types of crossover, the two-point crossover is employed here at a cross over rate. Two-point crossover operator randomly selects two crossover points within a chromosome then interchanges the two parent chromosomes between these points to produce two new off spring.
In the two-point crossover, two points are selected on the parent chromosomes. The genes in between the two points are then interchanged between the parent chromosomes to obtain children chromosomes. Here it is $N_p/2$ performed with single point crossover operation with crossover probability. The crossover operation exchanges genes $C_q$ between two parent chromosomes and produce

$N_q/2$ Children chromosomes $X_p^{off};\ p = 0,1,\cdots,N_q/2-1$

Step 5:
After the completion of crossover mutation takes place. Mutation is a genetic operator used to maintain genetic diversity from one generation of a population of chromosome to the next. Perform mutation operation with a mutation probability. In the mutation technique, a uniform random integer is generated and replaced in random positions of $X_p^{off}$ and $X_p^{new}$ is produced. $M_p$
Step 6: $N.M_p$

- After the process is completed $iter_{\max}$ number of times, the best chromosome is selected from the obtained chromosomes. Here the best chromosome is the one that has the greatest mean value.
- Then, the best chromosome's genes are sorted in the descending order and the gene that has the highest values is selected as the best gene.
- The resultant $X_p^{new}$ and the selected population size of chromosomes are placed in the population and the process is repeated.
- In our case, the termination criterion is set as reaching a maximum number of repetitions of process. Once the maximum number of process repetition is happened, the process is terminated and the chromosome (can be represented as $\alpha_i^{best}$ and $\beta_0^{best}, \beta_1^{best}, \ldots, \beta_{N-1}^{best}$), which has maximum fitness, in the population size is extracted.

- The obtained best weights are substituted in Eq. (1) to derive the final model as follows


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