Optimization Technique in Solar Heaters Using ANN (Artificial Neural Network) and Genetic Algorithm)

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ABSTRACT

Solar energy is most easily and abundaent sorce of energy available now a day, and the availability of the solar energy in large context the source is used at large extent for day to day life products.The solar energy is absorbed by solar pannels and is then transferred into some other form of energy mainly in solar heaters and as sorce has large energy and the same is to be controlled to protect the over heating and device management. Thermal control systems are devices which control the thermal consuption or energy consumption without need or as per the user comfartability. This paper reviews some of the Thermal control Strategies and also a new thermal control methodology is being discussed entilled as "Optimization Technique in Solar Heaters Using ANN (Artificial Neural Network) and Genetic Algorithm)" which utilizes the concept of Neural Network to find out the factors which can be optimized so as to optimize the over all energy comsuption and meet the user's comfortability and Genetic Algorithm is used to optimize the predicted factors.

Keywords- *ANN, Solar Radiation, Temperature, Thermal Control, Threshold, transmittance, water heater.*

I. INTRODUCTION

Thermal system engineering deals with utilization of energy and its functionality in industry, transportation, and also its application with respect to the day to day life. In industry, thermal systems are found in electric power generating plants, chemical processing plants, and in manufacturing facilities. In our day to day life thermal engineering is everywhere around us in the form of ovens, refrigerators, furnaces, ice rinks, snow making machine, etc. The respiratory and circulatory systems are the part of thermal energy equipments which are the major surgical equipments. Solar water heating (SWH) is the conversion of sunlight into renewable energy for water heating using a solar thermal collector. Solar water heating systems comprise various technologies that are used worldwide increasingly. Some of in the paper and some of them as under "The reference model REF1 [2]", "Linear Model (AR/ARX)" [4], "Stochastic Model (STO)"[3], "External Temperature Prediction Model" [8], "Dynamic Programming Optimal Control Algorithm" [5][6][7], "Thermal Management with Phase Change Material" [10], etc.

The paper is formatted in various sections as section II describes the related work for proposed algorithm or the comparison, section III describes the proposed algorithm "Thermal Power Control System in Solar Water Heaters using ANN (Artificial Neural Network)", section IV describes the results and experiments, section V describes the strength and limitations of the proposed algorithm and section I provides a short conclusion of the paper.

II. RELATED WORK

In this section related work with respect to the proposed methodology "Thermal Power Control System in Solar Water Heaters using ANN (Artificial Neural Network)" is being presented which uses which uses difference learning and thermal control strategies.

The Reference Model [2] incorporates the measurement values of horizontal solar radiations and also same is being considered as the major factor for predicting the values for successive six hours and also in the next version of reference model the atmospheric transmittance is the major factor. During the night, the atmospheric transmittance is not defined and therefore the average value over the last hours of the previous day is considered as predicted value.

The linear adaptive models are classified further into AR and ARX [4] for thermal control in solar heating devices, least square method or the least square process is used to estimate the parameters for the model. The prediction process in the linear model is considered upto six successive hours, hence while the prediction process of six hour ahead the estimated values of the past time steps are being considered as the input parameter for the linear model.

Stochastic Model [3] is the thermal control strategies which incorporates the prediction of solar radiation and outside air as its major factor for thermal control in solar heaters. Solar radiation and the outside air are considered as the relevant parameter and are discretized into 10 different classes, which are thus used as 10 x 10 Markov probability transition matrices. Linear mode and the neural network mode is used to compare the stochastic model with rest of models.

Dynamic Programming Optimal Control Algorithm [5][6][7] works on optimizing the thermal comfort of the user and also look after the energy consumption during the fixed time stamp or interval, the same is being achieved with the help of a cost function. PMV (Predicted Mean Vote) is the thermal discomfort as given by the Fanger's formalism. The correct weighting of the two cost function terms is achieved by using a simple heuristic rule: "The cost of the energy consumption which is needed to compensate a 0.2 variation on the PMV is equal to the cost of the discomfort resulting from that same PMV variation".

A thermal Management with Phase Change Material [10] incorporates a Thermal Control Unit (TCU) which fulfills the cooling needs of the heating devices so as to control the thermal conditions for few successive hours. A specialized thermal material is being used so as to absorb the heat generated by the solar radiations which is used as the major source of energy for further conversion during the complete processing of the device. The releasing of heat absorbed keeps the surface temperature of the device at low level and keeps the comfortable level of user's skin. The boundary conditions and thermal conductivity of the polymer composite substrate have a significant effect on the TCU's performance because they affect the heat path in the system.

III. PROBLEM STATEMENT

ON/OFF strategy of the solar heaters is based on a threshold deciding method using which the starting and stopping of the system is decided. The threshold value of the system is decided at the time of installation of the system hence decision making strategy of the threshold value is major issue for automating the complete system. It should incorporate some of the past data or the practical change to decide the threshold to provide maximum comfort for user and to maximize the energy consumption.

Apart from the fixed system of making the system out of state one from another the time is that the system should acquire some capabilities from outside world so as to perform better and effective. The normal heating architecture of the solar heaters may be extended using the Genetic Algorithm methodology.

Genetic Algorithm [6] is the searching algorithm which has opted the natural selection and natural genetic processing. In the Genetic Algorithm new population is being created on the basis of the old, which is carried out by ranking and interbreeding the strings so as to create new strings. A set of strings are generated in each generation of the Genetic Algorithm, the end result is a search strategy that is tailored for vast, complex, multi-modal search spaces. GA is a form of randomized search, in that the way in which strings are chosen and combined is a stochastic process. Genetic Algorithm is the process of four different steps as: Initialization, Evaluation Crossover and Mutation.

IV. PROPOSED ALGORITHM

In this paper a new thermal power control system using Artificial Neural Network for prediction process and the Genetic Algorithm [6] for the purpose of the optimization of the overall heating process and titled as "Optimization Technique in Solar Heaters Using ANN (Artificial Neural Network) and Genetic Algorithm" is manipulated which predicts the different factors like external temperature, building temperature, solar radiation frequency, energy absorbed by devices, user comfortability, etc which are to be used further for optimizing the overall heating process. ANN works on the basis the past data which is used by the ANN in its learning process to predict the same. ANN(Artificial Neural Network) comprises of three different layers as input, hidden and output layer among which the data transfer process takes place and on the basis of the past data given to the input layer processing is being done in hidden layer and final outcome is through the output layer last in the ANN(Artificial Neural Network) process.

In the complete prediction process of thermal control three steps are being employed, first step is the data gathering step which comprises of collecting the past and present thermal conditions such as indoor ,outdoor temperature, cavity temperature, etc. Data collected in the first step of the prediction model is then used as the input variable to the ANN (Artificial Neural Network). In the second step of the prediction process future temperature is predicted on the basis of data from four different ANN (Artificial Neural Network) models. Four future temperatures are being predicted for the future opening strategies of the solar water heater by the four ANN (Artificial Neural Network) models [9].

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Step1: Initialization

In the process of initialization of genetic algorithm the individual strings are being generated with respect to the different parameters obtained from ANN processing, the strings are considered with in there defined range.

Step 2: Evaluation

In the evaluation of the genetic algorithm the single unique string are copied to the step or for next generation, string fitness values decides the possibility to copy the single string for next generation.

Step 3: Crossover

Two different single string are taken and then decides whether to perform the crossover or not, if Genetic Algorithm goes not to perform crossover then the string considered are directly copied for next generation.

Step 4: Mutation

Mutation is a random modification of a randomly selected string. It guarantees the possibility of exploring the space of solutions for any initial solution space so as to permit a zone of local minimum to be abandoned.

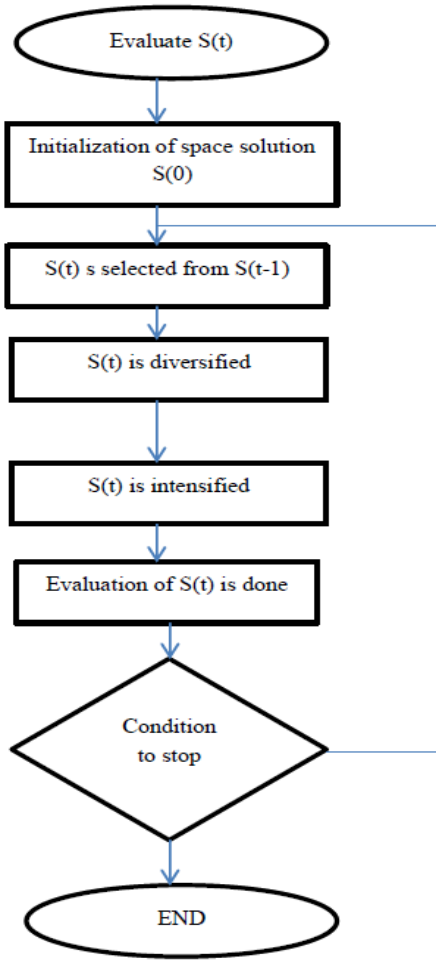

Figure 1: figure shows the basic steps of genetic algorithm.

Figure 2 shows the complete prediction and optimization process using two standard algorithms as ANN (Artificial Neural Network) and Genetic Algorithm for different functions.

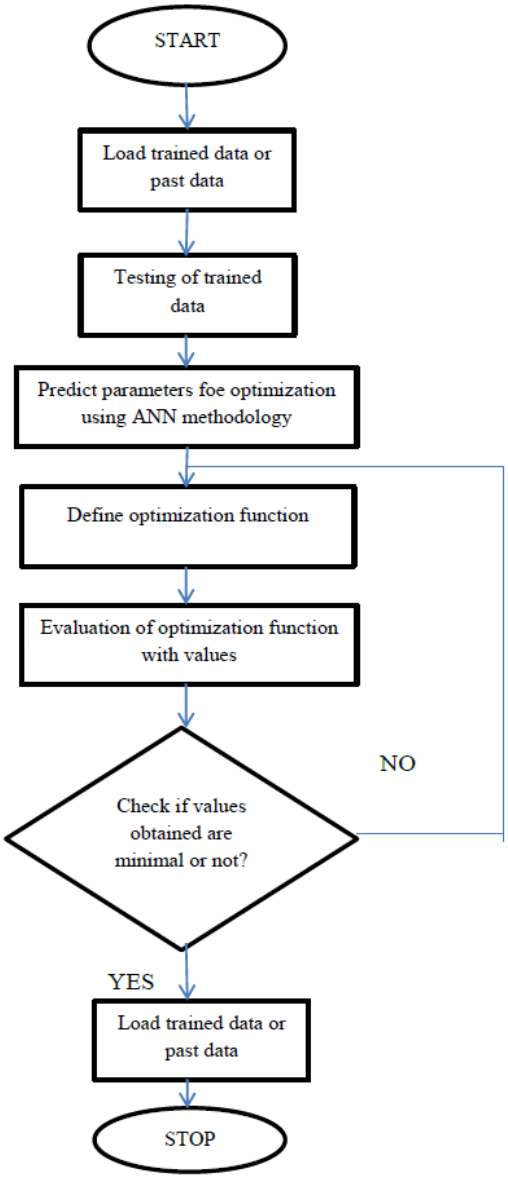

Figure 2: figure shows the complete optimization process.

V. RESULT AND DISCUSSION

The proposed thermal control strategy "Optimization Technique in Solar Heaters Using ANN (Artificial Neural Network) and Genetic Algorithm" shows better results than other discussed thermal control methodologies. The experimental results are being compared for the average heating energy consumed by the models and the comfort level of the user.

The data in table 1 below represents the summary of results for the year 1997(Jan to Apr) and 1998 (Oct to Dec) after eliminating those days which are being used for experimental test performing and also the days when the systemis un-operated on the basis of the standard deviation error.

Table 1: Comparison of proposed model with discussed other.

Algorithms	1 hrs	2 hrs	3 hrs	4 hrs	5 hrs	6 hrs
REF1	66	114	149	168	171	161
REF2	43	68	88	103	109	110
ARX1	46	73	87	93	94	93
ARX2	47	64	77	86	91	93
STO 1	48	48	70	89	111	115
STO 2	43	62	77	89	96	100
ANN	43	58	71	78	83	83
Proposed Algorithm	39	53	65	71	76	78

Table 2: Experimental results of the linear, NEUROBAT and the proposed algorithm.

Variants	**Heat (MJ)**	**Energy (Cost/Day**	**Comfort (Cost/Day)**
(Linear model)	HIGH	HIGH	LOW
NEUROBAT standard	HIGH	HIGH	LOW
NEUROBAT with ideal Mateo prediction	LOW	HIGH	HIGH
Proposed Algorithm	LOW	LOW	HIGH

Data represented in table 2 shows the average energy consumption by the controllers used in various thermal control models and also the comfort level of the user. As per the experimental results the comfort level in case of proposed algorithm "Optimization Technique in Solar Heaters Using ANN (Artificial Neural Network) and Genetic Algorithm" is higher as in the other discussed two and also the energy consumption is being minimized.

V. CONCLUSION

In this paper few thermal control strategies have been discussed and also a proposed algorithm is being discussed "Optimization Technique in Solar Heaters Using ANN (Artificial Neural Network) and Genetic Algorithm", on the basis of artificial neural network and the genetic algorithm. Where the ANN is being opted so as to find the or to guess out the parameters which are to be optimized to optimize the complete heating process. Genetic Algorithm [6] is being opted to optimize the predicted parameters from the ANN process. On the basis of some comparison parameters the proposed algorithm shows better than other discussed algorithm the comparison parameters are relevancy, efficiency and comfortability.

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