ISSN 2321-807X
VOLUME 12 NUMBER13
JOURNAL OF ADVANCES IN CHEMISTRY

GAMMA PROBABILISTIC NEURAL NETWORK MODELS TO TRACK OPTIMAL THERMAL AND ELECTRICAL POWER IN SOLAR PVT SYSTEMS

C.Ramesh[1], Dr. J.Kumar[2] S.C.Prasanna[3]
[1]Associate professor, M.Kumarasamy College of Engineering Karur, Tamilnadu, India
hodmech@mkce.ac.in
[2]Principal, Kalaivani College of Technology, Coimbatore, India – 641 105
[3]Assistant Professor, M.Kumarasamy College of Engineering Karur, Tamilnadu, India
Prasannacareers89@gmail.com

ABSTRACT

Solar PVT systems combine the characteristics of the photovoltaic and thermal solar systems in a single module. Due to the abundant presence of the natural resource from the sun–solar energy, in the past decade several algorithms and related electronic approaches were developed in order to monitor the photovoltaic and thermal panels maximum power generation. Solar PVT Systems possess several control parameters designed to produce better results and in this paper, the task is to track the optimal thermal and electrical power. As such, no appropriate control mechanism has been developed for tracking the maximum power generated from Solar PVT systems. In this paper, a PVT control algorithm based on the proposed neural network architectures are designed to compute the Optimal Power Operational Point (OPOP) by taking into account the model behavior of the Solar PVT system. Ambient temperature and irradiation are considered by the optimal power operational point to compute the optimal mass flow rate of Solar PVT module. Numerical simulation results prove the effectiveness of the proposed neural network models compared with that of the calculated outputs and the solutions derived from the earlier literature studies.

INDEXING TERMS/KEYWORDS

Solar PVT System, Neural Network, Optimal Power Operational Point, Thermal – Electrical Power.

INTRODUCTION

Over the last decade there has been an extravagant growth in the applicability of Solar PVT System modules for various applications like building integration, commercial aspects and so on. The generation of electricity in Solar PVT system is completely different from that of the conventional PV systems since, the influence of temperature variation is based on the quantity of heat that is been eliminated by the absorber of the Solar PVT system and as well as on the Solar systems insulation level. In this paper, the various aspects considered include rapid variation of the radiation of the sun, speed of the wind and ambient temperature. As a result, considering photovoltaic systems Maximum Power Point Tracking (MPPT) is one of the most important factor as it is found to maximize the photovoltaic generated power for the specified meteorological climatic conditions. The work is carried out in this paper to track the optimal thermal and electrical power based on the various energy factor constraints.

The widely used maximum power point tracking techniques for Solar PVT systems includes: perturbation and observation, the short current pulse and the constant voltage, heuristic computational techniques like neural network architecture models, fuzzy linguistic models and other evolutionary strategies. The various works that has been carried out for the computation of thermal – electrical power for the designed Solar PVT systems based on various parameters are discussed in detail in this section.

Chow et al proposed thermal or over all energy and energy analysis of photovoltaic-thermal collector with and without glass cover view point of thermodynamics. From the first law point of view, a glazed PV/T system is always suitable to maximize the quantity of either the thermal or the overall energy output[1]. Mondol et al presented a optimizing economic viability of a grid-connected PV system was analyzed using TRANSYS simulation model. The reduction of PV electricity cost at low and high insulation conditions were described for sizing ratios of 1.6 and 1.2, respectively[2] Dubey Swapnil et al. proposed detailed analysis of energy, exergy and electrical energy by changing the number of collectors and air velocity considering four weather conditions (a, b, c and d type) and five different cities (New Delhi, Bangalore, Mumbai, Srinagar, and Jodhpur) of India [3] Chow analyzed the photovoltaic / thermal Solar solar Technology, collaborations have been underway amongst institutions or countries, assist to sort out the appropriate products and systems with the best marketing potential[4] Aste et al carried out a work to find the optimal value of solar thermal fraction for Solar photovoltaic thermal (PVT) systems, based on energetic and economic point of views, and to calculate a correlation between the percentage of heat demand covered by the PVT system and photovoltaic cells temperature. The solar fraction variation results various average cells operating temperatures and changes in total energy efficiency [5]. Krishna Priya et al presented a design space methodology for effectively sizing a PVT system. A design space is the collection of all feasible design configurations. Design space for a PVT system is governed by the thermal demand, the electrical demand, the temperature requirement for the thermal load, and the boiling point of working fluid [6]. Dubey & Tay proposed photovoltaic thermal (PVT) system for producing electricity10 kW p (kilowatt peak) and hot water in a student hostel in Singapore. Thermal models were designed based on basic energy balance equations and average climatic conditions for Singapore over a year and hot water consumption pattern over a week was used in this design [7] Calise Francesco et al performed analyses the integration of renewable energy sources and water systems, proposed a novel solar system producing simultaneously: electrical energy, thermal energy, cooling energy and domestic water [8]. Pathak et al. (2014) presented an optimizing limited solar roof access by exergy analysis of solar thermal, photovoltaic, and Solar photovoltaic thermal systems. Three locations, Detroit, Denver and Phoenix, were simulated due to their variations in solar flux and average monthly temperature [9]. Dupeyrat et al analyzed thermal and electrical performances of PVT solar hot water system, first, the performance of the experimental flat plate PVT collector are described, then next, the performance of this Solar collector being part of a solar thermal system in a building is determined and compared to that of systems operating with standard solar devices using TRANSYS [10].

MATHEMATICAL MODELING OF SOLAR PVT SYSTEMS

Generally mathematical modeling can be carried out either in the form of a transfer function approach (considering the Laplace transform modeling) or in the state space representation form (considering the derivatives of the physical variables in the system). In this chapter, steps are taken to obtain the state space model of the considered solar PVT system. Before computing the state space model, the parameters of the system are defined as in Table 1.1.

Table: 1 Parameters of solar PVT system

PARAMETERS USED IN STATE SPACE MODELING	DESCRIPTION OF THE PARAMETER	PARAMETERS USED IN STATE SPACE MODELING	DESCRIPTION OF THE PARAMETER
Tg	Glazing temperature	Ts	Solar cell temperature
Tap	Absorber plate temperature	Tw	Water circulation temperature
ws	Speed of the wind	gsh	Solar radiation
Ta	Ambient temperature	$\dot{m}$	Mass flow rate of fluid; acts as the control vector
Pelec	Electrical power output	Ptherm	Thermal power output (profit)
hcg	Heat transfer coefficient between solar cell and glass cover.	hwind	Convective heat transfer coefficient between wind and cell
hrga	Heat transfer coefficient between the glass cover and environment.	hrcg	Heat transfer coefficient between collector plate and the front cover.
hcp	Conductive heat transfer coefficient between solar cell and the absorber plate.	Nun	Nussel Number
ε	Emissivity factor	σ	Stefan Coefficient
kl	Thermal conductivity of plate	Tc	Instantaneous operating temperature of the solar cell module.
I0	Opposite current of saturation	Iph	Photovoltaic current
Ipv	Electric current of PV Module	Vpv	Photovoltaic module voltage

The output differential equations for the PVT panel system of different

modules are given by:

i) Glass Cover sub-model:

$$m_g c_g \frac{dT_g}{dt} = \alpha_g g_{sh} A_g + A_g \left(h_{wind} + h_{rga}\right)\left(T_a - T_g\right) + A_g h_{rcg}\left(T_s - T_g\right) + A_g h_{cg}\left(T_s - T_g\right) \quad 1.1$$

ii) Solar cell sub-model:

$$m_c c_c \frac{dT_s}{dt} = \left(\alpha_c \tau_g A_c \left(1-\eta_r\right)\right) g_h - A_g h_{rcg}\left(T_g - T_s\right) - A_g h_{cg}\left(T_s - T_g\right) - A_c h_{cp}\left(T_s - T_{ap}\right) \quad 1.2$$

iii) Absorber plat sub-model:

$$m_p c_p \frac{dT_{ap}}{dt} = A_c h_{cp}\left(T_s - T_{ap}\right) - A_c h_{pa}\left(T_{ap} - T_a\right) - A_f h_{fa}\left(T_w - T_a\right) - m c_f \Delta T_w \quad 1.3$$

iv) Output fluid temperature sub-model:

$$m_f c_f \frac{dT_w}{dt} = A_f h_{pf}\left(T_{ap} - T_w\right) - c_f \dot{m} \frac{\Delta T_w}{\Delta y} \quad 1.4$$

The above given heat transfer coefficients in the differential equations are given by:

$$h_{wind} = 2.8 + 3w_s \quad 1.5$$

$$h_{rga} = \varepsilon_g \sigma\left(T_g^2 + T_a^2\right)\left(T_g + T_a\right) \quad 1.6$$

$$h_{rcg} = \frac{\sigma\left(T_g^2 + T_a^2\right)\left(T_g + T_a\right)}{\frac{1}{\varepsilon_g} + \frac{1}{\varepsilon_c} - 1} \quad 1.7$$

$$h_{cp} = N_u \frac{k_1}{L} \quad 1.8$$

At this juncture, it is required to compute the electrical output power and thermal output power for the solar PVT system. The electrical output power is noted to depend on the instantaneous operating temperature of the cell and as well on the thermodynamic potential appearing and the photovoltaic module voltage i.e.,

Electrical Power: $$P_{elec} = V_{p\upsilon} \times I_{p\upsilon} \quad 1.9$$

Where, $V_{p\upsilon} = N_S \cdot V_T \ln\left(\frac{I_{SC,STC} - I_{p\upsilon}}{I_0}\right)$ and

$$I_{p\upsilon} = N_p\left\{I_{ph} - I_0\left[\exp\left(\frac{V_{p\upsilon} + R_s \cdot I_{p\upsilon}}{V_T}\right) - 1\right] - \frac{V_{p\upsilon} + R_s \cdot I_{p\upsilon}}{R_{sh}}\right\} \quad 1.10$$

Also, the thermal output power is given by,

Thermal Power: $$P_{therm} = \dot{m} c_f\left(T_{fo} - T_{fi}\right) \quad 1.11$$

Where, Tfo is the outlet fluid temperature, Tfi is the inlet fluid temperature, Cf is the specific heat of the average fluid temperature.

Employing the derived electrical output power and thermal output power, the state space model is to be obtained. Generally, a state space model is a combination of state equation and output equation. In case of state equation, the physical variables based on which the variations are to be observed are considered along with their derivatives and the inputs. The state model comprising of state equation and output equation aregiven as follows:

State equation:

$$\dot{T} = AT + BU + DW$$

$$\begin{pmatrix} \dot{T}_g \\ \dot{T}_s \\ \dot{T}_{ap} \\ \dot{T}_w \end{pmatrix} = \begin{pmatrix} a_{11} & a_{12} & a_{13} & a_{14} \\ a_{21} & a_{22} & a_{23} & a_{24} \\ a_{31} & a_{32} & a_{33} & a_{34} \\ a_{41} & a_{42} & a_{43} & a_{44} \end{pmatrix} \begin{pmatrix} T_g \\ T_s \\ T_{ap} \\ Tw \end{pmatrix} + \begin{pmatrix} b_{11} \\ b_{21} \\ b_{31} \\ b_{41} \end{pmatrix} \dot{m} + \begin{pmatrix} d_{11} & d_{12} \\ d_{21} & d_{22} \\ d_{31} & d_{32} \\ d_{41} & d_{42} \end{pmatrix} \begin{pmatrix} g_{sh} \\ T_a \end{pmatrix} \quad 1.12$$

Output equation:

$$Y = CT + EU$$

$$\begin{pmatrix} P_{elec} \\ P_{therm} \end{pmatrix} = \begin{pmatrix} c_{11} & c_{12} & c_{13} & c_{14} \\ c_{21} & c_{22} & c_{23} & c_{24} \end{pmatrix} \begin{pmatrix} T_g \\ T_s \\ T_{ap} \\ T_w \end{pmatrix} + \begin{pmatrix} e_{11} \\ e_{21} \end{pmatrix} \dot{m} \qquad 1.13$$

In equations (1.12) and (1.13), T refers to the state variable, which is the temperatures of the four nodes of the PVT system and $\dot{T}$ refers to the derivative of the state variables considered. A is the state matrix, B is the input matrix, C is the output matrix, D is the perturbation matrix and E is the transmission matrix. The coefficients of all the matrices A, B, C, D and E are computing by solving the early derived differential equations and aij, bij, cij, dij and eij represent PVT system model coefficients. From equation (1.12) and (1.13), the perturbation vector and output vectors are given by,

$$W = \left[g_{sh} \quad T_a \right]'$$
$$Y = \left[P_{elec} \quad P_{therm} \right]' \qquad (1.14)$$

Thus the output parameter 'Y' plays a major role to track the thermal and electrical power.

SOLAR PVT SYSTEM DESIGN

The performance of the solar PVT collector system is analyzed with the electrical power (P_{elec}) and thermal power (P_{therm}). During the due course, it should be observed that these two required outputs are influenced by the following operating conditions: ambient temperature, solar radiation and the mass flow rate. The variation of each of these parameters results in the influence of the delivered electrical and thermal outputs. The solar cell temperature decreases when the mass flow rate into the system is increased, but this increase in mass flow rate increases the generated electrical power of the system and as well decreases the thermal power output of the system.

Considering the said facts, the optimal power operational point (OPOP) is taken as the optimal flow rate which allows optimal electrical and thermal power generated ie., optimal power operational point should ensure optimal PVT system outputs P_{elec} and P_{therm}. Its aim is to devise a control law that makes the derivative of the mass flow rate optimum. This control law is computed based on the two parameters – solar irradiation (g_{sh}) and ambient temperature of the system (T_a). The derived state space models as represented by equations (1.12) and (1.13) are found to be nonlinear in nature. As the system is non-linear in nature, it is very difficult to analyze the performance of the system employing traditional techniques and to determine and track the optimal power operational point. The non-linearity is found to exist in the PVT system in the following manner – a rapid fast output (P_{elec}) is obtained and the next output is delivered with a time delay. Because of the existence of time delay in the system, traditional techniques are difficult to be applied. Table 1.2 shows the specifications of the considered solar PVT system

Table 1.2 Specifications of considered solar PVT system

S.NO	PVT SYSTEM PARAMETERS	PARAMETER VALUES
1	Area of the collector	2 m^2
2	Rate of flow	50 kg/m^2h
3	Collector efficiency factor	0.94
4	Overall loss coefficient	5.4 W/m^2K
5	Electrical efficiency of the cell	15%
6	Temperature coefficient	0.4%/degree C
7	Packing factor of solar cell	0.8
8	Thermal transmittance	0.5 W/m^2k
9	Absorptivity of solar cell	0.9
10	Specific heat capacity of cell	903 J/kg K
11	Emissivity of cell	0.35
12	Thermal Conductivity	385 W/m K
13	Heat Transfer coefficient h_{pf}	100 W/m^2
14	Heat Transfer coefficient h_{cp}	5.7 W/m^2

CONVENTIONAL APPROACH FOR DETERMINING OPOP

The state space model derived in equation (1.12) and (1.13) are utilized to simulate for various solar radiation, ambient temperature and mass flow rate. The graphical approach is employed based on the variations of mass flow rate for the given solar radiation and ambient temperature to observe the thermal and electrical powers. Table 1.3 shows the variation that is computed for the thermal power and electrical power for different mass flow rates. In this condition, the ambient temperature is set to 15 degree - centigrade and the solar radiation is set as 1000 W/m^2.

From Table 1.3, it is observed that as the mass flow rate increases, the temperature of the water decreases and hence the thermal power decreases. On the other hand, when the mass flow rate increases, the solar cell temperature decreases and hence the electrical power increases. The optimal power operational point at the considered constant ambient temperature and solar radiation is computed based on the generated values of the thermal and electrical power which corresponds to the maximum of the product of the thermal and electrical power (P_{therm} x P_{elec}). Thus from Table 1.3, on computing the respective products of thermal and electrical power, the optimal power operational point is noted for the mass flow rate to be 0.0163 Kg/s and the corresponding powers are given by, P_{therm} to be 1690.8 W and P_{elec} to be 148.72 W.

Table 1.3 Thermal Power and Electrical Power for different mass flow rates (Constant ambient temperature and solar radiation)

MASS FLOW RATE ($\dot{m}$) (KG/S)	AMBIENT TEMPERATURE (TA) = 15°C AND SOLAR RADIATION (G_{SH}) = 1000 W/M^2	
	THERMAL POWER (P_{THERM}) (WATT)	ELECTRICAL POWER (P_{ELEC}) (WATT)
0.0130	2036	145.36
0.0135	1950	145.78
0.0140	1872	141.20
0.0145	1845	141.88
0.0150	1783	147.42
0.0155	1724	148.00
0.0160	1700	148.64
0.0165	1661	148.86
0.0170	1630	149.20
0.0175	1600	149.61
0.0180	1564	150.22
0.0185	1550	150.60
0.0190	1521	150.86
0.0195	1509	151.00
0.0200	1491	151.40
0.0205	1472	151.60
0.0210	1459	151.86
0.0215	1448	152.00
0.0220	1437	152.24

Table 1.4 shows the computed values of the power (P_{therm}xP_{elec}) for different mass flow rates and solar radiation with constant ambient temperature (15°C). Table 1.5 shows the computed values of the power (P_{therm}xP_{elec}) for different mass flow rates and ambient temperature with constant solar radiation (1000 W/m^2).

Table 1.4 Computed PVT power with different mass flow rates and solar radiation

MASS FLOW RATE ($\dot{m}$) (KG/S)	CONSTANT AMBIENT TEMPERATURE (T_A) = 15°C		
	FOR G_{SH} = 700 W/M^2	FOR G_{SH} = 500 W/M^2	FOR G_{SH} = 400 W/M^2
	(P_{THERM}XP_{ELEC}) (KW^2)	(P_{THERM}XP_{ELEC}) (KW^2)	(P_{THERM}XP_{ELEC}) (KW^2)
0.002	0.2434	0.2432	0.2430
0.004	0.2458	0.2454	0.2450
0.006	0.2478	0.2474	0.2465
0.008	0.2492	0.2482	0.2472
0.010	0.2500	0.2486	0.2476
0.012	0.2504	0.2489	0.2475
0.014	0.2506	0.2488	0.2474
0.016	0.2504	0.2484	0.2468
0.018	0.2502	0.2478	0.2462
0.020	0.2496	0.2470	0.2454
0.022	0.2486	0.2462	0.2446
0.024	0.2474	0.2452	0.2439
0.026	0.2462	0.2442	0.2430
0.028	0.2452	0.2436	0.2160
0.030	0.2442	0.2220	0.1980

Table 1.5 Computed PVT powers with different mass flow rates and ambient temperature

MASS FLOW RATE ($\dot{m}$) (KG/S)	CONSTANT SOLAR RADIATION (G_{SH}) = 1000 W/M^2		
	FOR T_A = 35°C	FOR T_A = 30°C	FOR T_A = 25°C
	(P_{THERM}XP_{ELEC}) (KW^2)	(P_{THERM}XP_{ELEC}) (KW^2)	(P_{THERM}XP_{ELEC}) (KW^2)
0.002	0.2470	0.2468	0.2466
0.004	0.2492	0.2488	0.2486
0.006	0.2508	0.2502	0.2496
0.008	0.2520	0.2510	0.2502
0.010	0.2530	0.2518	0.2506
0.012	0.2536	0.2520	0.2505
0.014	0.2537	0.2518	0.2504
0.016	0.2535	0.2514	0.2496
0.018	0.2532	0.2508	0.2492
0.020	0.2524	0.2498	0.2484
0.022	0.2515	0.2492	0.2476
0.024	0.2506	0.2482	0.2470
0.026	0.2494	0.2474	0.2460
0.028	0.2482	0.2465	0.2454
0.030	0.2472	0.2432	0.1986

Considering the power computed for the varied mass flow rate with respect to constant ambient temperature versus different solar radiation and constant solar radiation versus different ambient temperature, the optimal power operational point corresponds to the common operating point provided by the generated powers – thermal (P_{therm}) and electrical (P_{elec}). Table 1.6 provides the optimal power operational point computed with the common operating principle of the generated powers for the assumed specified constraint parameters as noted in Table 1.4 and Table 1.5.

Table 1.6 Computed optimal power operational point for different parameter values

CONSTANT PARAMETER	VARYING PARAMETER	OPTIMAL MASS FLOW RATE ($\dot{m}$) (KG/S)	OPTIMAL POWER ($P_{THERM}XP_{ELEC}$) (KW^2)
Constant ambient temperature T_a=15°C	g_{sh} = 400 W/m^2	0.011	0.2476
	g_{sh} = 500 W/m^2	0.012	0.2489
	g_{sh} = 700 W/m^2	0.014	0.2506
Solar radiation g_{sh} = 1000 W/m^2	T_a=35°C	0.011	0.2506
	T_a=30°C	0.012	0.2520
	T_a=25°C	0.014	0.2537

NUMERICAL EXPERIMENTS

In order to conduct the numerical experimental study to track the optimal mass flow rate and thereby the optimal power of the considered solar PVT system employing the proposed neural network architecture models, the first phase is to generate the training data samples. The experimental tests are to be carried out for different values of solar radiation (gsh) and ambient temperature (Ta). The solar radiations is varied with the initial start up value being 300 W/m2 to maximum radiation upto 1000 W/m2 with constant ambient temperature and tracking the output optimal mass flow rate. Also, the network is trained to compute the optimal mass flow rate by considering different values of ambient temperature with the initial value to be at 5°C and to a maximum of 35°C with constant solar radiations to form the training data base for the proposed two types of artificial neural network models.

The proposed solar PVT system module is designed in SIMULINK environment of MATLAB and proposed neural network algorithms (ELMAN and GPNN) are realized by developing MATLAB coding to find optimal thermal – electrical power with respect to optimal mass flow rate on a Dual-core PC. The performance of the algorithm has been evaluated through simulation. Simulation studies have been carried out on the developed learning data base based on the inputs solar radiation and ambient temperature.

PROPOSED GPNN MODEL TO COMPUTE OPTIMAL MASS FLOW RATE AND THERMAL ELECTRICAL POWER

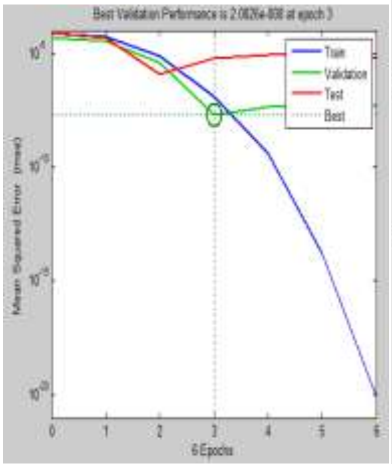
The gamma probabilistic neural network proposed in section 1.5.3 is applied to the solar PVT system to compute the optimal mass flow rate with respect to the optimal power operational point. Table 1.9 presents the range of the training parameters for the employed GPNN model.

Table 1.9 Design parameters of GPNN model

GPNN Model	
Output Neuron	= 1 (mass flow rate)
Input Neurons	= 2 (T_a , g_{sh})
No. of Epochs	= 1200
Smoothing factor	= 1.1 to 7.5
Weight	= random (pattern to simulation layer)

In this case also, the datasets generated is divided into 60% for training, 20% for validating and 20% for testing. Figure 1.7 shows the performance curve obtained during the training process of the solar PVT system to obtain optimal thermal-electrical power and mass flow rate.

The performance value is noted to be 2.0826x10-8 at about 3 epochs of training, which is minimal compared to that of the proposed ELMAN model in previous section. Figure 1.8 shows the various training states during the training process of proposed gamma probabilistic neural network model.



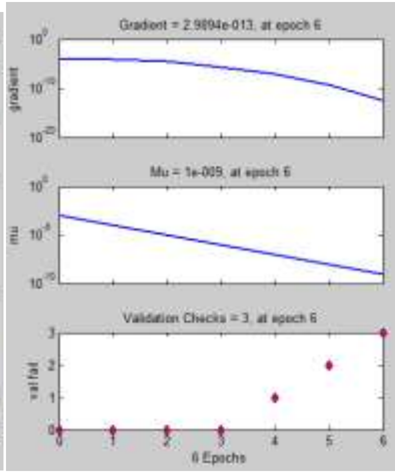


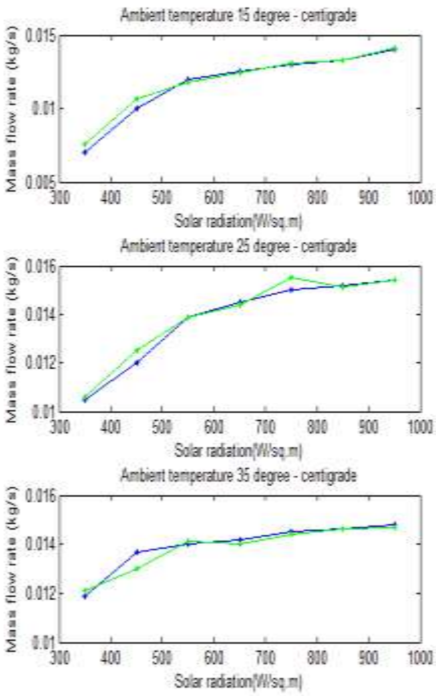
Fig 1.1

Fig 1.2

Figure 1.1 Performance of solar PVT system for 6 epochs – Proposed GPNN model

Figure 1.2 Training states of proposed GPNN model

For validating the proposed approach, a database with values of solar radiation ranging from 350 W/m2 to 950 W/m2 and ambient temperature ranging from 5°C to 35°C is considered as carried out for previous ELMAN model. The computed values for conventional approach and that computed using the proposed GPNN model are plotted in Figure 1.2and Figure 1.3 for different solar radiations and ambient temperatures for the estimated optimal mass flow rates. The proposed GPNN model based mass flow rates estimated which denotes the optimal power operational point are validated with the conventional computed values given in Table 1.3 and Table 1.5. It is clear that the proposed GPNN controller is found to estimate the optimal power operational point (with optimal mass flow rate and thermal – electrical power) for the generated ambient temperature and solar radiation.



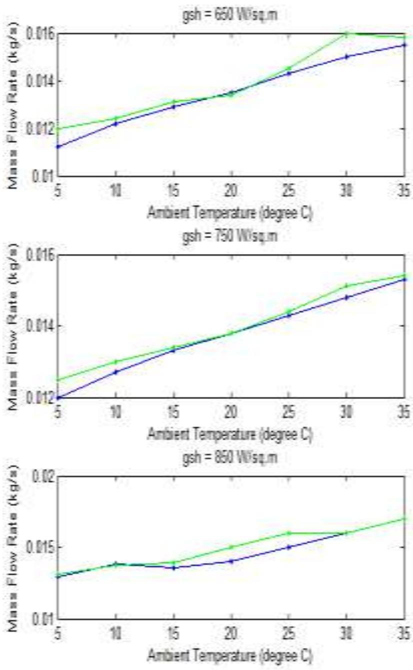


Fig 1.3

Figs 1.4

Figure 1.3 Optimal Power Operational Point computed using GPNN and Conventional methods (constant ambient temperature and different solar radiations)

Figure 1.4 Optimal Power Operational Point computed using GPNN and Conventional methods (constant solar radiations and different ambient temperature)

The mean square error computed for the proposed approach using GPNN model is 3.01% which is found to be very low in comparison with that of the methodology from the available literature 13.05% (Ammar et al. 2013) and that of the previous proposed ELMAN model (4.07%).

DISCUSSION

The proposed neural network models are applied to the considered solar PVT system with the specifications as given in Table 1.2. On carrying out the simulation procedure, it is noted that the specified number of epochs is 100, but the network converged at 9 epochs and 6 epochs for proposed ELMAN and GPNN model respectively. The mean square error computed during the learning trials of the proposed neural network architectures and other parameters considered for comparison are given in Table 1.10.

Table 1.10 Performance comparison of proposed approaches

PARAMETERS	ARTIFICIAL NEURAL NETWORK – MULTI LAYER PERCEPTRON MODEL (AMMAR ET AL. 2013)	PROPOSED ELMAN NEURAL NETWORK MODEL	PROPOSED GPNN MODEL
Mean Square Error	13.05%	4.07%	**3.01%**
No. of Epochs	12	9	**6**

From Table 1.10, it is inferred that the proposed GPNN model performs the best in comparison with that of the proposed ELMAN neural network model and the available multi layer perceptron neural network model as available in the literature (Ammar et al. 2013). Hence the best validity is considered to be the proposed GPNN approach, and now the solar PVT system is synthesized for particular two days to compute the optimal power operational point: one on the cold season day (January 3rd 2014 – New Delhi) and the other on the hot season day (July 3rd 2014 – New Delhi).

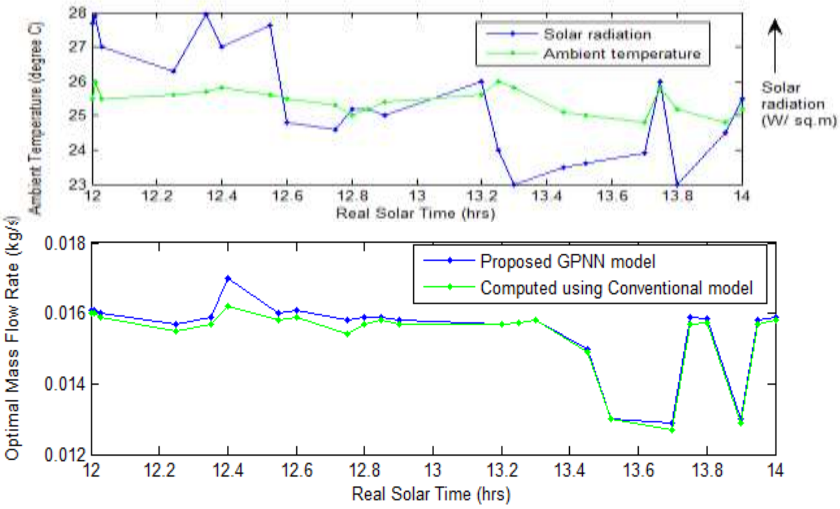
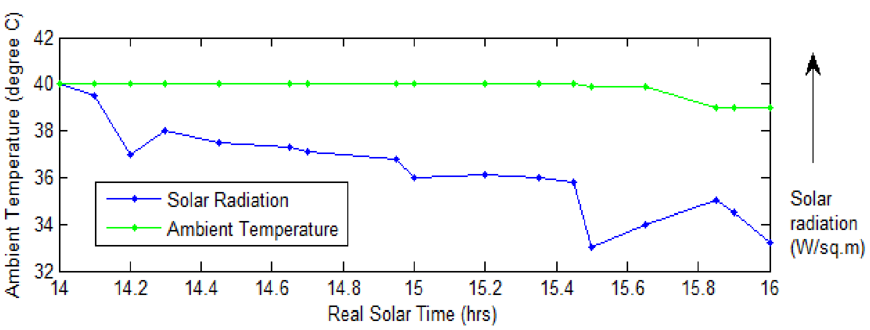


Figure 1.5 Optimal mass flow rate curve for real solar time period – Cold season day



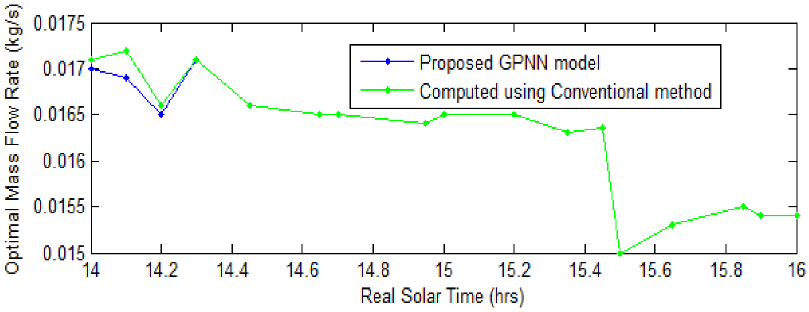


Figure 1.6 Optimal mass flow rate curve for real solar time period – Hot season day

Since the proposed GPNN model possessed minimal mean square error, the climatic conditions for two particular days are analyzed for this case only. From Figure 1.6, it can be observed since the weather is disturbed in cold seasons; the optimal power operational point is found to differ from the calculated one. On the other hand in figure 1.7 for hot season, both the curves are found to be coinciding with each other satisfying that the optimal power operational point for the proposed GPNN as well the computed model since the weather is stable during hot season. Figure 1.6and Figure 1.12 also shows the variation of the solar radiation and ambient temperature for the considered real solar time periods.

CONCLUSION

In the growing variations in meteorological domain, it is required for adjusting the solar energy converters to track and compute the optimal generated power employing various control algorithms. This chapter presented an algorithmic design approach to find the optimal power operational point of the solar PVT system by varying the ambient temperature and solar radiations.

The aim of optimal power operational point in this case is to compute the optimal mass flow rate of the solar PVT system to track the maximum electrical and thermal powers. Also, new neural network architectures, ELMAN neural model and GPNN model are proposed to compute the optimal power operational point and to track optimal mass flow rate thereby the power generated. The neural network architectures are proposed in this chapter, considering the solar PVT system being multivariable and nonlinear in nature. The proposed approaches with the computed results substantiate a fast, reliable and accurate PVT system for mass flow rate control and thermal- electrical power tracking.

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AUTHOR' BIOGRAPHY WITH PHOTO

Mr.C.Ramesh works as Associate professor at M.Kumarasamy College of Engineering, Karur, Tamilnadu, India in the Department of Mechanical Engineering. He holds an undergraduate degree in Mechanical Engineering and a master's degree in Computer aided design. He has submitted his Ph.D. thesis on solar energy. Having 17 years of academic experience.