Performance enhancement of stepped basin solar still based on OSELM with traversal tree for higher energy adaptive control

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Abstract

A basin solar still precision design is regularly not reachable. To solve this issue, the basin area is coated with a nanolayer which allows to stimulate and control the multifaceted of the fast evaporations of physiognomies. The use of adaptive neural network-based approaches leads to better design cause permits detecting the conjunction, gigantic period feed, lower performances parameters which can be detrimental to system production. Further, an online Sequential Extreme Learning Machine (OSELM) system can be used to obtain the latest solar still based on adaptive control. Here, the solar still has been created at physical scale activity for haste of energy

absorption. The performance of solar still are defined by the uniform occurrence with time series of dynamics transfer from basin liner to saline water. The feasibility scheme to authenticate were studied by applying calculation to the extensive heat transfer process. The furious SiO₂/TiO₂ nanoparticles used for the stepped basin solar still (SBSS) efficiency shows an increase of performances by 37.69% and 49.21%, respectively using 20% and 30% of SiO₂/TiO₂ coating. It is comparable higher when equated against an SBSS coating either SiO₂ or TiO₂, and/or no nanoparticles coatings. The binary search tree enabled to find the optimal cost for the solar still investigated and obtaining a superior design with higher performances.

Keywords: Stepped basin solar still; Nanomaterials; OSELM; Adaptive tree traversal.

1. Introduction

In an original solar still, heat trapped inside an enclosure where the internal air temperature may reach nearly 120°C that would be sufficient to evaporation or bake basin nanolayer. Industrial process monitoring for real-world applications in financial data was analyzed elements of prediction and buyer performance estimates. Perez *et al.*, [1] studied an online learning algorithm for flexible topologies and implementations of a neural networks system. It is the samples to attain continuity in the method for statistics brook. Qiao *et al.*, [2] developed the non-line self-adaptive modular neural network and time series control ways. They made use of the underlying distribution or a movement with the data vicissitudes concluded time. Lughofer [3] studied an online learning algorithm which was selected the more appropriate assortment done group updated to acquire new knowledge for changing patterns in evolving data stream by Zhang *et al.*, [4] and Zhou *et al.*, [5]. Suresh and Shanmugan [6] have developed basin solar still and was used in flowing water with PCM-nanoparticles. It concluded that the efficiency of the system was FWCW of 70.02%. 24hours yield of solar still has produced of 9.429 kg m⁻² day⁻¹.

Zanganeh *et al.*, [7] were produced an improve solar still and have coated in nano-silicon solution with giving a dip-coating technique. It utilizes that nano-coating caused condensate making of solar still to higher significantly. They are monitored by AFM tests exposed that surface roughness of the glass covers moves to drip. Suresh *et al.*, [8] have considered the thermal performance of a single basin solar still. The sullage water treatment fuzzy logic techniques used to produce clean water from the energy of the sun. It concluded that the 24 hours cycle for yield is 7.624 kg/m²day

and without drip 5.254 kg/m²day. The overall efficiency is 45% for a hybrid nano-black paint increases the temperatures of 66°C. Zanganeh *et al.*, [9] have produced in solar still and have used in the condensation surface for coated by nanomaterials to improve the condensation process. It is improved the productivity of solar still at cover tilt angles of 35° and 45°. Abdullah *et al.*, [10] was studied that an internal reflector on the tray's distiller performance. They are used in nano-coating on the tray's distiller performance and have developed in PCM - paraffin wax + CuO nanoparticle. It found that the efficiency of trays still of 51.5% associated with 35% for conventional solar still. The condensation process prepared by Zanganeh *et al.*, [11] plays a critical role in the efficiency of solar stills. They are coated on the condensation surface in titanium dioxide and silicon nanoparticles and changed the surface of wettability. It the condensing surface increases the productivity of 10–35%. Shanmugan *et al.*, [12] have improved the basin solar still and was used in Al₂O₃ and C₁₈H₃₆O₂ basin area by a drip button to pour saline water drop by drop on absorbing materials in the basin. It concluded that the efficiency of the still of 59.14% (summer) and 27.13% (winter). They are recognized by the FWCW using a basin is on the solar still. Agrawal *et al.*, [13] have expected the theoretical and experimental results obtained for a single sloped basin type solar still. They are discussed for theoretical, and the experiment with daily efficiency of 2cm and 10cm basin water depths is around 52.83% and 41.75% and was 41.49% and 32.42% respectively. Arunkumar *et al.*, [14] have studied in nano-coated CuO absorbers with PVA sponges in the basin of the solar still. They are synthesized by the thermal evaporation method used in CuO nanoparticles coated absorber plates by the system. Absorber plates are coated in CuO nanoparticles with PVA sponges and have improved the yield of 26%.

Saleh *et al.*, [15] were synthesized using Hydrothermal method by using ZnO nanoparticles and verified in solar still. The ZnO non-materials concentration of the solar still resulting in an oxide nanomaterials nano-rod was 100nm lengths, 10–15nm diameters and nano-sphere are 250nm diameters have been studied. It found that nano-rod shape achieves a range of 30% and 38% of productivity increases in solar still. Mahmoud *et al.*, [16] have indicated that the daily productivity of stored energy integrated basin solar still. The solar still acceptable for the product is determined about 11 L/m² by using Glauber's salt with 10% volume fraction of CuO-nanoparticles in CR = 2, h = 0.1M. The basin water temperature is achieved at 70°C to prevent potential scale development.

Wang *et al.*, [17] have analyzed in double metal-dielectric (cermet) solar selective absorber coatings (SSACs) and used in co-sputtering techniques with multiple targets. They suggest in multilayer SSACs exhibit good solar absorptance of 0.93 and were low thermal emittance of 0.06. It concluded that the shows an ideal spectral selectivity of 0.92/0.07. The SSAC was a gifted absorber for stable thermal harvesting in solar vacuum collectors.

Isabel *et al.*, [18] coated gel-dipping with polysaccharides and prepared TiO₂ photocatalytic materials. They used excellent performance for the photocatalytic activity of the final coated tiles was described and conversed. The painted all properties are analyzed for the need to move the photocatalytic action of the coatings. Hualong Liu *et al.*, [19] coated by the use of TiO₂/WO₃ a magnetic nanoparticle and was the absorption of visible light (solar light). Sixteen catalysts quickly mineralized and ten dyes under the focus of sunlight. It found that recycling with a magnet excellent reusability. Sharshir *et al.*, [20] were conducted with an energy and exergy analysis of solar still thermal performance with micro/nanoparticles. MSSs energy efficiency of graphite, CuO was 41.18% and 38.61%, then CSS is 29.17%. The yield of the MSSs has increased energy in graphite, CuO to 41.18% and 32.35%. The exergy efficiency of MSSs is 4.32% and 3.78%, while exergy efficiency for CSS was 2.63%.

Rashidi *et al.* [21] have developed by reviewing the literature on implementing nanofluid technology in active and passive solar distillation systems. The review designates are daily productivities of solar distillation systems enhanced by nanofluid and increasing the volume fraction of nanoparticles. Rashidi *et al.* [22] were proposed the volume of fluid (VOF) model to investigate the potential of Al₂O₃-water nanofluid to improve the productivity of single slope solar still. VOF model was used to simulate the evaporation-condensation phenomena. The efficiency of solar still was increased by 25% using nanofluid by volume fraction of 5%. The maximum entropy generation has happened close to the bottom and top surfaces of the system. Rashidi *et al.* [23] were developed with nanofluid on the productivity of stepped solar still. The sensitivity analysis is determined the hourly productivity of height and length steps. It was conculcated that the optimization analysis of the surface method optimized the geometry of stepped inside the still. The solar still was indicated that of 22% enhancement that yield of nanoparticle ratios from 0% to 5% and 2.1% of the RSM and CFD calculated to best result of 2.1%.

Rashidi et al. [24] performed an experimental analysis of exergy investigated by a reticular porous insert with improvement on single slope solar still. The hourly productivity of the solar still progresses by inserting the reticular porous layer in the basin. The exergy efficiency has improved that system by 7.33%.

Various scientists have documented the use of furious $\text{SiO}_2/\text{TiO}_2$ nanoparticle original familiarizes that of limits production on solar thermal applications. The current study aims of a solar still are enhanced thermal performance of the system. It advances the SBSS has coated with a bar plate that used in doping $\text{SiO}_2/\text{TiO}_2$ nanoparticle at a different ratio of 10 to 50%. The SBSS has studied built on adaptive control through an online Sequential Extreme Learning Machine (OS-ELM). The central part of a binary search trees authorization and originate a limit of the cost optimum by a solar still and developed with previous significance.

2. Experimental materials and methodology

2.1 Analysis of SBSS performance methods

SBSS analysis of a new performance of an experimental method and the schematic diagram shown in Figs. 1(a) & 1(b) as by Feilizadeh *et al.*, [21]. The solar still has an area of 100cm. The length*breadth of the dimensions of the absorption area is 100cm *100cm. The front wall height is 25cm. The height of the back wall is 30cm. It is comprised of a total 16 stepped absorber basin plates fixed inner side with the left side of 8 plates and right sides for 8 plates on the design. It consisted of the absorber basin area in the copper sheet and that the inner stepped basin plate has used in a mild steel sheet with an analysis of preliminary steps. The transmission glass cover thickness of the material is 4mm used in the system. The side walls and bottom of the basin were insulated with the glass wool. The glass wool's thermal insulating material (fiberglass) has used the system increases in moisture content, causing a significant increase in thermal conductivity of 0.040 W/mK.

The SBSS has fabricated in the same dimensions different from the proposal presented by Salarabadi, and Rahimi [22]; Rahbar *et al.* [23], which used nanoparticles of furious SiO_2 , TiO_2 , mixture furious $\text{SiO}_2/\text{TiO}_2$, without nanoparticle (conventional solar still). It was studied, and the results compared to the nanoparticles with the effect of different solar still performances. The

experimental work started at 09.00 am to 17.00 pm and variations of the parameters like temperatures of the stepped basin, saline water, moist internal air and glass cover measured at 30 minutes time interval the experiment conducted under the weather condition of KLEF at Vijayawada, Andhra Pradesh. The solar radiation data was measured using the TENMARS TM-206 solar power meter. The SBSS data were taken in order to a laptop to identify the system. The standard solar power meter measured all the parameters of different cookers are an indicator of 6-channel measure the temperature. It measured the RTD - PT-100 type with sensor absorption of the thermocouple wire in range 0 - 800°C with $\pm 0.1^\circ\text{C}$ correctness of the data separately on the systems.

In the presented study, the integration of nanoparticles aimed to increase the absorbed energy by the SBSS and resulted in output with higher quality. Therefore, to determine the performance of the system. The nanolayer occupied the internal energy presented as follows;

Energy balance equations for the temperature elements of the still have been written and the following assumptions have been considered

- (i) There is no vapour leakage from the SBSS
- (ii) As the thickness of the condensing glass cover is small, there is no temperature gradient throughout the surface
- (iii) Due to small inclination of the condensing glass cover, both evaporating and condensing surfaces are considered to be parallel to each other

2.2 Energy Balance equations

For glass cover:

$$\alpha_g T_{srg} l_g b_g + h_1 (T_w - T_g) A_{eff} = h_2 (T_g - T_a) l_g b_g \quad (1)$$

where

$$h_1 = h_{ewg} + h_{rwg} + h_{cwg}$$

$$h_2 = h_{cga} + h_{rga}$$

$$h_{cwg} = 0.884 \times \left[(T_w - T_g) + \frac{(P_w - P_g)(T_w + 273)}{268.9 \times 10^3 - P_w} \right]^{1/3}$$

$$h_{rwg} = \varepsilon_{eff} \sigma [(T_w + 273)^2 + (T_g + 273)^2]$$

$$h_{ewg} = 0.0163 \times h_{cwg}$$

$$h_{rga} = \varepsilon_g \sigma [(T_g + 273)^4 - (T_a + 261)^4]$$

$$h_{cga} = 5.7 + 3.8v$$

For Stepped basin surface:

$$\alpha_g \tau_g T_{srg} l_g b_g = M_w \frac{dT_w}{dt} A_{eff} + h_1 (T_w - T_g) A_{eff} + h_3 (T_w - T_a) A_{eff} \quad (2)$$

where

$$h_3 = L/k$$

From Eq. 1, T_g can be written as

$$T_g = \frac{\alpha_g T_{srg} l_g b_g + h_1 T_w A_{eff} + h_2 T_a l_g b_g}{h_1 A_{eff} + h_2 l_g b_g} \quad (3)$$

Substituting for T_g in Eq. (2) and can be written as

$$\alpha_w \tau_g T_{srg} l_g b_g = M_w \frac{dT_w}{dt} A_{eff} + h_1 \left(T_w - \left\{ \frac{\alpha_g T_{srg} l_g b_g + h_1 T_w A_{eff} + h_2 T_a l_g b_g}{h_1 A_{eff} + h_2 l_g b_g} \right\} \right) A_{eff} + h_3 (T_w - T_a) A_{eff} \quad (4)$$

After suitable rearrangement, the equation can be written as

$$\frac{\alpha_w \tau_g T_{srg} A_{eff}}{M_w A_{eff}} + \frac{h_1 \alpha_g T_{srg} l_g b_g A_{eff}}{M_w A_{eff} (h_1 A_{eff} + h_2 l_g b_g)} - T_a \left[\frac{h_1 h_2 l_g b_g A_{eff}}{M_w A_{eff} (h_1 A_{eff} + h_2 l_g b_g)} - \frac{h_3 A_{eff}}{M_w A_{eff}} \right] = \frac{dT_w}{dt} + T_w \left[\frac{h_1 A_{eff}}{M_w A_{eff}} - \frac{h_1^2 A_{eff}^2}{M_w A_{eff} (h_2 l_g b_g)} + \frac{h_3 A_{eff}}{M_w A_{eff}} \right] \quad (5)$$

Eq. 5 resembles the form

$$\frac{dT_w}{dt} + P T_w = Q \quad (6)$$

Where,

$$P = \frac{h_1 h_3}{M_w} - \frac{h_1^2 A_{eff}}{M_w A_{eff} (h_2 l_g b_g)}$$

$$Q = \frac{\alpha_w \tau_g T_{srg}}{M_w} + \frac{h_1 \alpha_g T_{srg} l_g b_g}{M_w (h_1 A_{eff} + h_2 l_g b_g)} - T_a \left[\frac{h_1 h_2 l_g b_g}{M_w (h_1 A_{eff} + h_2 l_g b_g)} - h_3 A_{eff} \right]$$

The solution of Eq.6 can be written as

$$T_w \cdot e^{Pt} = \frac{Q}{P} \cdot e^{Pt} + C \quad (7)$$

When $t = 0$, $T_w = T_{w0}$

Therefore $C = T_{w0} - \frac{Q}{P}$

Substituting the value of C in Eq. 7, we get

$$T_w = \frac{Q}{P} + (T_{w0} - \frac{Q}{P})e^{-Pt} \quad (8)$$

Analytical solutions for stepped basin and glass cover temperature have been used to evaluate the instantaneous distillate yield and efficiency.

The amount of distilled water collected for a unit area is given by.

$$m_w = \frac{h_{ewg} \times (T_w - T_g) \times 3600}{L} \text{ kg / m}^2 \text{ hr} \quad (9)$$

The instantaneous efficiency of the still is given by.

$$\eta_{inst}(\%) = \frac{m_w \times L}{3600 \times H_{inst}} \times 100 \quad (10)$$

2.2 SBSS control energy uses an OSELM:

The general approach of extreme learning machine (ELM) anticipated by Liang *et al.* [23] is utilized in several fields. The SBSS used the saline water for weight of the mass and partialities of the covered an initialization ELM. The SBSS developed the least-squares process with the use of parameter values to the considered suitable heaviness of the production coatings. The heat transfer speed is higher than further use in traditional neural networks. This method avoids convergence into local minima Guang *et al.*, [24].

The samples used in S arbitrary separate physical activity for $(X_i, T_i) \in R^n \times R^m$. X_j was the $n \times 1$ vector for involvement and T_i is $m \times 1$ vector for goal. The active function of $g(\cdot)$ and the hidden layer of L used an additive stimulation or Radial Basis Function (RBF) activation or both. The single-hidden layer feedforward neural network (SLFN) approximately given for S working out of the SBSS as zero error with existing for evaporation that are ω_i , m_i , and θ_i ,

$$E = \sum_{i=1}^l \theta_i g(\omega_i, m_i, X_i) \quad (5)$$

where saline water (weights) ω_i, m_i then it is followed in biases of a hidden layer. Output based on purification water (weights) vector is θ . We can write as

$$T = \Phi \theta \quad (6)$$

where Φ, θ expressed for T

$$\theta = \Phi^T T \quad (7)$$

Pseudo-inverse based on back point is Φ

$$\Phi^* = (\Phi^T \Phi)^{-1} \Phi^T \quad (8)$$

$$\Phi^T = (\Phi^T \Phi)^{-1} \Phi^T T \quad (9)$$

Where rank $(\Phi) = L$ for output water result followed in vector θ form eq. (7) we can write as

$$\theta = (\Phi^T \Phi)^{-1} \Phi^T T \quad (10)$$

2.3 Online sequential extreme learning machine (OSELM) approach for SBSS:

The heat transfer with an order of more realistic that of the SBSS values was generated line by line or hunk by a hunk of OSELM is followed as ELM. The recursive least square process estimated with a numerical technique as a result (weight) vector (θ) . The OSELM is a significant part of two like (i) initialization (ii) sequential learning. We have followed a way of that process as consider evaporation process of the design $S = \{(X_i, T_i) \mid X_i \in R^n, T_i \in R^m, i = 1, \dots\}$, then RBF activated function of $g(\cdot)$ these nodes of L hidden layer.

(i) Initialization:

The SBSS values to get initial water temperature as $S_0 = (X_i, T_i)_{i=1}^{S_0}$ and $S_0 \geq L$ were considered from the initial result vector layer as

$$\theta^{(0)} = (\Phi_0^T \Phi_0)^{-1} \Phi_0^T T_0 \text{ where } T = [t_1 \dots \dots \dots, t_{S_0}]^T \quad (11)$$

(ii) Sequential Learning

The SBSS results were generated line by line or hunk by hunk of the heat values of

$S_{k+1} = (X_i, T_i)_{S_{k+1}}^{S_k + S_{k+1}}$ and were created with the outcome of matrix function for a hidden layer of Φ_{k+1} .

The SBSS materials (wights – saline water) of the result are

$$B_{k+1} = B_k - B_k \Phi_{k+1}^T (I + \Phi_{k+1} B_k \Phi_{k+1}^T)^{-1} \Phi_{k+1} B_k \quad (12)$$

$$\theta^{(k+1)} = \theta^{(k)} + A_{k+1}^{-1} \Phi_{k+1}^T (T_{k+1} - \Phi_{k+1} \theta^{(k)}) \quad (13)$$

Finally, that design performance as a $k=k+1$ set of hunk water temperature values is reported sequential learning in development with the conclusion of the SBSS.

2.4 OSELM neural network adaptive controller on SBSS

The algorithm of the SBSS is controlled through DO concentration from heat transfer modes and manipulated variable of the solar still is expressed as

$$Y_{k+1} = f(X_k) + D(X_k)U_k + C_k \quad (14)$$

From Eq. (10) heat is transformed according as

$$Y_{k+1} = \bar{f}[X_k, w^*] + \bar{D}[X_k, v^*]U_k + \Delta_f$$

where the SBSS is used in perturbation C_k and is the sum of Δ_f the showing fault of DO focused that absolute temperature values solar still error and OSELM formed each neural networks as

$$\begin{aligned}\bar{f}[X_k, w^*] &= \sum_{i=1}^L w_i^* g(\alpha_i, m_i X_k) \\ \bar{D}[X_k, v^*] &= \sum_{i=L+1}^{2L} v_i^* g(\alpha_i, m_i X_k)\end{aligned}\quad (15)$$

The SBSS is updated for OSELM principle as followed an online value gotten in a sequential method

$$\begin{cases} B_k = B_{k-1} - \frac{B_{k-1}\Phi_k^T\Phi_k B_{k-1}}{1+\Phi_k B_{k-1}\Phi_k} & \bar{\theta}_{k+1} = \bar{\theta}_k + B_k \Phi_k^T E_{k+1}^* \end{cases}\quad (16)$$

DO concentration of SBSS is controller as

$$U_k = \frac{-\bar{f}[X_k, w^*] + Y_{k+1}^*}{\bar{D}[X_k, v^*]} + Q_{total\ energy + N}(m_w)\quad (17)$$

From control as eq. (17) the energy process of the SBSS uses an OSELM approached in Fig. 2.

2.5 Analysis of SBSS using Binary Search Tree:

The binary search trees analysis of a solar still is given in a sequence for $\sigma_k = (\sigma_1, \sigma_2, \sigma_3 \dots \sigma_n)$ and ordered a set of n distinct elements that energy process. It obtained as following in heat energy process by the binary search tree of $T(\sigma_k)$, and components are $\sigma_1, \sigma_2, \sigma_3 \dots \sigma_n$ an iteratively involves formerly vacant tree of heat energy. The fundamental problems in computer science solved by binary search trees use of data structures by Aho *et al.* [25] and Knuth [26]. The solar still is an important data structure in a place and binary search trees area for a central role investigation as algorithms. The SBSS has higher energy levels of $T(\sigma_k)$ and parameters are considered the heat energy by the level of equal by a Quicksort (σ_k) for compounds for the axis by Cormen *et al.* [27]. Here heat energy developed to reach the solar still by a binary search tree is (n) objective yield of $\sigma_k = (1, 2, \dots n)$ and attained from higher energy levels of parameters to transfer energy on the system. The water temperatures are higher in average values of binary search trees and performed to understand the arrangements of energy levels were not wholly haphazard of the system. Haphazardness is partial of the basin area. Finally, the thermal energy saved higher of binary search trees at that solar still to the small chance that partial arbitrariness.

The binary search trees use of a SBSS is $T(\sigma_k)$ and the thermal energy transfer rule is the left side wall to the right wall with maxima the order of gain $\sigma = (\sigma_1, \sigma_2, \sigma_3 \dots \sigma_n)$. The system of a primarily empty tree the roots of $T(\sigma_k)$ as surveys have a glass cover, stepped basin, water temperature, moist air, product water for σ_1 of σ_k . The design limited σ then all parameters value reduced in σ_1 , we can write as

$$\sigma_k \leq \sigma_k \{ |i| \sigma_i < \sigma_1 \} \quad (18)$$

It is gained for the energy an inductively as of $\sigma < .$

σ is control the parameters increases an analogously σ_1 as

$$\sigma_k \geq \sigma_k \{ |i| \sigma_i > \sigma_1 \} \quad (19)$$

The SBSS is right subtree for σ_1 . $T(\sigma_k)$ has gained for an inductively as of $\sigma_k > .$

The solar still transmission of heat energy as following in Fig. 3(a), it denoted the higher energy level of $T(\sigma_k)$. The SBSS absorbed an energy level of higher (σ_k) and the most extended pathway from the root to a leaf contains several nodes. The internal heat transfer is a maximum level of σ_i , maxima of σ if $\sigma_i > \sigma_j$ for all parameters are $j \in [i-1]$. The energy was saving that settings of the parameters are $(\sigma_k) \leq \text{height}(\sigma_k)$ and amount of heat energy to the maximum value is equivalent to the dimension of the all sidewall pathway in a tree of $T(\sigma_k)$.

2.5.1 Assumption by the SBSS

Binary search tree (BST) is empty or nonempty as the following properties.

- The solar still parameters are BST and must be discrete.
- It is smaller than the root and inserted at the left side of the subtree.
- The setting is larger than the source added at the right side of the subtree.

In a binary search tree, the parameters of the solar still arranged in such a way that for any node the heat energy sources on the left side are smaller than that node and the heat energy source on the right side is more significant than that node. The means that the heat energy in the left subtree is smaller than that key element in the right subtree and is more significant than that essential of the stepped basin solar still. It is easy for searching for key factors. Time taken for searching an element in a tree depends on the higher of the tree.

1. Higher of a binary search tree minimum is $T(\sigma_k)$.
2. Higher of the binary search tree maximum is σ_k .

The solar still performs rotation to convert more gigantic height binary search tree to a smaller height binary search tree.

2.5.2 Algorithm:

1. The solar still value to insert starts comparison from the root node.
2. If the feature name is higher than the root, then the comparison moves towards the right subtree.
3. If the feature name is less than the root, then the feature comparison moved towards the left subtree.
4. Then the current node will become as root and the comparison continue until the desired location to insert is found.

2.5.3 Binary search tree insertion diagram with temperature values by SBSS

In a binary search tree, we take an element as a root element from the given ingredients. If the considered item is higher than the root element, we insert it on the right subtree, if the aspect which we take is less than the root element we enter it on the left subtree as by Roberto De Prisco [28] and Navin Goyal and Manoj Gupta [29].

2.5.4 Experiment:

Intel core i5 8th generation processor is used in the experiment. It has a RAM capacity of 8 Giga Byte and secondary storage capacity of 1 Tera Byte. The temperature measurement in the experiment is performed for duration of one year. The implementation of the experiment is finished with Java Standard Edition version 13. Java Database connectivity is used to access the database. Features and its temperature values are stored in the MySQL version 8.0.4. The reading that take in the experiment is time stamped using a system. A multimeter is a measure of the temperature of different components in the experiment.

2.5.5 Memory Organization:

The experiments are performed for one year. We have used two tables, one for “accountant table” and another for “reference table”. The “accountant” table has three entries in each Row. Entries in the table contain “timestamp”, “feature” and “rtemp”. “Timestamp” contains information related to time at which the reading for the experiment is taken, and it is stored as a long integer with Size 8 bytes. “Material” gives information about item saline water in the stove and it is stored as a character of Size 15 bytes. “rtemp” corresponds to the room temperature in which the various

features reading is taken with a size of 4 bytes. The size of a row in the “reference” table is 27 bytes. In the experiment, when more readings are taken the size of the table increases dynamically. The second table is a mapping table from timestamp to the day of the year. It fixes in length with a capacity of 355 entries. Each entry consists of “day” and “next” field. The “day” field holds a pointer to the day of the year in which the experiment reading is taken. The “next” field points to an address of a linked list. Each entry in the linked list of sizes each entry is 8 bytes, each “day” and “next” field is having a 4 bytes sizes. The overall memory organization of the experimental setup shown in Fig. 3b.

The linked list consists of a collection of nodes. Each node is composed of three fields viz. “timestamp”, “ptr” and “next”. The “timestamp” holds the value of time at which the reads have been taken and it is of type long with 8 bytes. Pointer “ptr” is a pointer to a binary search tree that holds a reading of an experiment for various components in the solar still. The “next” is a pointer to a next node in the linked list. The fields “ptr” and “next” each having a size of 4 bytes. So, the total size of a node is 16 bytes.

2.5.6 Working Principle:

The reading of water treatment is done in the experiment. The various temperature of water treatment needs to be measured using a multimeter. The time of reading is taken as timestamp from the digital clock. This timestamp, material under consideration and room temperature is recorded in the accountant table. For example, the timestamp “1606979426043” contains the following information as day- ‘12’, month- ‘3’, year- ‘2020’, hour- ‘08’, minutes- ‘10’, second- ‘26’ and millisecond- ‘43’. This timestamp is helpful in organizing, storing, retrieving, and finding the information related to the experiments. Time stamp is taken from the table to extract the month and day in which the reading is being taken. Month and day are converted into a number ranging from 0-365 days in a year using a function. Based on this converted value, it is mapped to an address 20568 in the “reference” table. In this table, 71 is the value stored in the “day” field and 2045 is an address points to a linked list collection of Binary Search Tree (BST). To store the reading of an experiment, a node is created in the linked list with a value “1606979426043” for “timestamp”, 1092 for pointer to address of BST and 2074 pointer of the next node in the linked list. This linked list will be a sorted list, consisting of entries of all experiments carried on a

particular day. To insert a value in the linked list, the entire list will be searched and will be inserted in the respective place.

BST is utilized to store the reading of the experiments. It is a continuation of binary tree and provides an efficient way of organizing the elements for storing, retrieving and finding. Accessing an element in BST takes a time complexity of $O(\log_2(n))$ then a linear search with $O(n)$. So, it otherwise calls as logarithmic search. To convert the tree into searchable, the elements in the tree must be comparable and understand the relationship between the elements. To establish this condition, each element must exhibit a Total Order relationship property. When two elements are compared with each other, there exists a property called comparable. This Comparator exhibits the following set of rules:

- 1) Reflexive Relation – If every element in the set map to itself in the set. A relation is reflexive if: $(a, a) \in R \forall a \in A$, where R is the relation, A is the set and a is the element in the set.
- 2) Anti-Symmetric Relation – Relation R of a set A is anti-symmetric if $(a, b) \in R$ and $(b, a) \in R$, then $a=b$.
- 3) Transitive Relation – If $(a, b) \in R$ and $(b, c) \in R$, then (a, c) also belongs to R , where a, b, c is the element in the set and R is the relation.
- 4) Comparable Relation – For any a, b , in the set, either $a \leq b$ (or) $b \leq a$.

BST is a special tree which contains an order way of arranging the nodes in Fig. 3a. The elements on the left side of the parent are lesser and the elements on the right side of the parent are greater. A node is represented by two values as “feature” and “temp” as feature and temperature, with two pointers as “left” and “right” as the left child and right child. Feature and temperature values correspond to feature used in measurement used in the experiment and its temperature respectively, while pointer stores the address of its child’s. The size of the “feature” and “temp” value is 15 bytes of character and 4 bytes of integer respectively. Both the pointers are of 4 bytes of integer. The first node in the binary search tree is identified by a pointer named as root.

Insertion:

Step 1:

When inserting a node “solar radiation” and 779 as temperature in BST is shown in Fig. 3b(i), it checks for the Root pointer. Since the Root pointer is NULL initially. It creates a new node and

changes the Root value to point to the address of the newly created node. Here, the newly created node address value is 9000 and it is stored in the Root pointer.

Step 2:

Inserting of the second node in BST needs to compare the root node with the value to be inserted in Fig. 3b(ii). From the comparison, new value is smaller than the root node value in terms of the alphabet comparison. Again, the comparison must be continued on the left side of the root. Since, the left child of the root node is NULL. A new node is created and it is inserted at the left child of the first node. The left child of the root node is assigned a value of 3120 which is the address of the newly created node.

Step 3:

The node to be inserted in BST takes a value “glass cover” and “44.31” for “feature” and “temp” fields. This “glass cover” is compared with the root node and the right child of root node. It is smaller than root and greater than “ambient” node, so a new node is created and its address is assigned to the right child pointer of it is 9190. Fig. 3b (iii) shows in the below diagram.

Step 4:

The new node is inserted at the right child of “glass cover” with an address value of 9070. Before insertion it is compared with “solar radiation”, “ambient” and “glass cover” node. During comparison it is found that the value is less than “solar radiation”, while it is greater than “ambient” and “glass cover” node. So, it is inserted to right of “glass cover” node in Fig. 3b(iv).

Step 5:

The new node with a value of “basin” as “feature” and “64.3” as “temp” is inserted to the left child of “glass cover” with an address value of 9340. Before insertion it is compared with “solar radiation”, “ambient” and “glass cover” node in Fig. 3b(v). During comparison it is found that the value is smaller than “solar radiation”, while it is greater than “ambient” node. So, it is compared with “glass cover” node and inserted to the left after comparison.

Step 6:

The new node with a value of “water” as “feature” and “61.3” as “temp” is inserted to the right child of “solar radiation” with an address value of 9030 in Fig. 3b(vi).

2.6 Simulation models of solar still results

BST followed an insertion diagram have analyzed the temperature of the values as ways of OSELM control stability for SBSS. The performance of the solar still has evaluated in order of the model estimation and checked to the validity of the control energy operating parameters discussed and evaluations of the system.

The simulation model verified the origin Pro2020 version, and Microsoft Windows service 2010 R² arrived value an atmosphere and occupied in CO concentration. The evaluation of the system has been standard to an analysis of an integral of Absolute Error (IAE), Integral of Square Error (ISE) and maximal Deviation from the setpoint (D^{max}).

$$\begin{aligned} \text{IAE} &= \int_{t_0}^{t_1} |R(t) - Y(t)| . dt \\ \text{ISE} &= \int_{t_0}^{t_1} (R(t) - Y(t))^2 . dt \\ (\text{D}^{\max}) &= \max |R(t) - Y(t)| \end{aligned} \quad (15)$$

where R(t), Y(t) have referred by solar still Input, output and IAE designates the transient response. ISE is suitable damping, (D^{max}) indicates control for solar stability evaporation process as by Hong *et al.*, [31] and Guang *et al.*, [32].

$$\lim_{k \rightarrow \infty} \sigma_k \left[\frac{e_{k+1}^{*2}}{(1 + \sigma_k \Phi_k P_{k-1} \Phi_k^T)^2} - \varepsilon^2 \right] \times Q_{total\ energy + N} m_w = 0 \quad (16)$$

$$\lim_{k \rightarrow \infty} \text{sub} \frac{e_{k+1}^{*2}}{(1 + \sigma_k \Phi_k P_{k-1} \Phi_k^T)^2} \leq \varepsilon^2 \times Q_{total\ energy + N} m_w \quad (17)$$

The comparison of online learning algorithms is investigated in SBSS through the heat transfer to verify all parameters the inherent characteristic of the OSELM such as SVR, Go-GP GOD-LR, respectively. The large-scale data were not considering handle for Go GP and adapted precisely with streaming data. These online learning methods have compared that solar still parameter values, yield of the water data produced by the BSM1 model and controlled through evasion PI organizer. 1450 groups, 1000 groups are the total number of set data and collected by SBSS data for fast productive ways. From table 1 are the solar still parameters of OSRLM and the fastest working process is online SVR. From table 1, the training time of OSELM is the fastest among these plans, especially for Online SVR. OSELM is still the lowest Root Mean Square (RMSE) compared with other methods. As applied in table 1 for the solar still temperature analysis of OSELM is high-speed methods, especially for online SVR. The lower root means square error (RMSE) opposed to the process. Also, R² the online process of GOGP is greater than SRV. The

SBSS concluded that the process of OSELN is a very good performance of machine learning methods and its application of learning methods.

2.3. The analysis of SBSS with uncertainty and error

The error and uncertainty analysis of SBSS occurs with an outcome of the measurement technique. A piece of equipment and the instrument provider collect different quantities was the majority information of the SBSS. The experiments based on outcomes were defected to arising to develop techniques by Taylor (1997). The temperature absorption of the parameters to variations of directly was measured by the SBSS. The freshwater harvest is observed by the natural ways to give in systemic sources of errors. The uncertainty δ of value S has calculated the efficiency of SBSS as the following formula by Taylor, 1997 (32 q); Holman, 2011(33w); Hassan *et al.* 2020a (34b); Rashidi *et al.* (2018 – 34c). The experimental observe values development with conservation environments, calibration, then the error of measurement devices. The experimental values an error with devices have been characterized as

$$\delta_{SBSS} = \sqrt{\left(\frac{\partial S}{\partial X}\right)^2 \delta_X^2 + \left(\frac{\partial S}{\partial Y}\right)^2 \delta_Y^2} \quad (18)$$

where δ_i and δ_{ii} are the uncertainty of measured values X and Y, respectively, and more than two recorded values can be added to this equation. For example, energy efficiency uncertainty is calculated to be 1.9%. The instruments and device's measuring data to use on the SBSS have shown that uncertainty values estimate Table 2. The energy efficiency of the SBSS has been used in uncertainty as followed by the equation (18) and (10), which was measured by the values of solar intensity and harvested with freshwater by the system. At that period of the SBSS was studied to calibrate all measurement sensors (thermocouples, flasks, etc.) and instruments (voltmeter, ohmmeter, etc.). It is also showed that the properties of the calibration consequences designated in this investigation were observed.

3. Results and discussion

The weather conditions analysis of the SBSS has fixed in KLEF at solar energy laboratory in latitude - 16.5062° N, longitude - 80.6480° E. The parameters performance is used in variety volume fractions (10%,20%,30%,40%,50%) by the SBSS, which measured an effect of temperature like ambient, glass, moist air, stepped basin, saline water, and solar radiation. It was experimentally verified for every 30 mints as shown in Fig. 4 (a to e). The parallel an

experimentally of the systems have analyzed solar radiation, then ambient temperature. It calculated solar intensity and ambient temperature. The maximum during the peak was higher up to 3.00 pm and abridged through the nightfall reduced the system. The SBSS have verified exploitation of 20% and 30% furious $\text{SiO}_2/\text{TiO}_2$ nanolayer enhanced an average the temperature increases of 21.9% and 29.7% in Figs. 5. Which has compared to that of the systems with nanolayer coated by the stepped basin of energy absorption for single furious SiO_2 , TiO_2 , and without $\text{SiO}_2/\text{TiO}_2$. The temperature achieved by the SBSS were various ratio of 10%,20%,30%,40%,50% nanofluids that used a basin absorption is 58.4,63.4, 64.7, 63.2,63.0 $\pm 0.1^\circ\text{C}$, and stepped basin area have 58.4,62.6, 64.5, 61.5,62.2 $^\circ\text{C}$ by Abdullah *et al.*, [33] respectively. The fuming $\text{SiO}_2/\text{TiO}_2$ nanolayer is coated by the internal heat transfer modes to contact the basin, stepped basin, moist air, water temperature that concurrently improved for heat energy functions. 20%, 30% for furious on $\text{SiO}_2/\text{TiO}_2$ nanolayer used in SBSS has achieved a temperature of 63.4, 64.7 $\pm 0.1^\circ\text{C}$ and compared to higher than as 40%, 50% respectively, Rashidi *et al.* [34].

Since, the glass, water temperature using 40%, 50% are higher, it is 9.14, 13.14% and 8.14, 11.46% respectively, which are higher than solar still with single elements, without nanolayer. Fig. 4 (a to e) focused on hourly variations in the characteristic of the SBSS with mechanisms of the temperature range in glass, basin, steeped basin, moist air, water, and ambient temperature. An experimental conducted to different a ratio used for furious $\text{SiO}_2/\text{TiO}_2$ nanolayer have observed that the typical ambient temperature to analysis in parallel systems. The different rate of 10%,20%,30%,40%,50% of the furious $\text{SiO}_2/\text{TiO}_2$ nanolayer occupied average basin temperature of the system. It concluded that of as 58.3, 61.6, 64.5, 59.9 and 59.1 $\pm 0.1^\circ\text{C}$ individually. Therefore, the thermal conductivity focusses on the furious $\text{SiO}_2/\text{TiO}_2$ nanolayer increased with a ratio of 20%, 30%, and reduced by the rate of 40%, 50% in basin temperature. It is used the mixed nanolayer with temperature in basin area gain with heat energy of the SBSS is increased by 10.34%, 15.17%, and the ratio of 20%, 30%. The performance of the SBSS has enhanced for evaporation to an essential role of absorption with the saline water. The average temperature produced in the basin temperature an increase of 9.42% and 14.23% respectively. A stepped basin temperature, as achieved by the SBSS has been raised by virtually 71 $^\circ\text{C}$ period for working hours by Shanmugan *et al.*, [34] and Essa *et al.*, [35] as followed by Fig.4(c).

Fig. 5 is shown in hourly variations to improve the average temperature for the SBSS have produced by the hourly variations with a maximum temperature of enhanced single elements, without nanoparticles 0.73, $0.77 \pm 0.01 \text{ kg/m}^2$, which coated of SBSS with 10,20,30,40,50% the furious $\text{SiO}_2/\text{TiO}_2$ nanolayer have achieved of 0.74, 0.76, 0.78, 0.77 then $0.76 \pm 0.01 \text{ kg/m}^2$ respectively and achieved with highest solar radiation at 11.00 to 15.00 by Rashidi *et al.* (36 and 37).

The production of the SBSS has been attained through the daylight 60 minutes since 8.00 am to 06:00 pm. Fig. 6 is the amount of distillate yield of the proposed still in typical days in June 2019 to June 2020. The SSBC be used in 12kg water in a method of the temperature virtually 30min. $\text{SiO}_2/\text{TiO}_2$, single SiO_2 , TiO_2 , without nanoparticles has been produced yield increases in the forenoon as reached in the maximum distillate of 0.467, 0.430, 0.379, 0.221 mL respectively since 11.30 to 15.00. Simulation model SBSS was shown Fig.6 as a nanocoating on the stepped basin surface, which is improved in the yield of fresh water throughout the days. It has been observed that in total daily distillate yield over the 24-hour cycle is deemed to be 8.11, 6.19, 5.89, 3.73L/day, respectively. 20%, 30% ratio used in SBSS has increased the average heat energy daily performance of 21.5%, 24.6% as higher and compared to single elements, without nanolayer. Similarly, SBSS coated in a stepped basin with higher temperature achieved for use by 40%, 50% and without nanolayer concluded stepped basin in peak time a sunlight period.

The Fig. 7(a) as followed with a performance of the SBSS with a ratio of 10%,20%,30%,40%,50% $\text{SiO}_2/\text{TiO}_2$ nanolayer have achieved by a system of 31.77%, 37.69%, 49.21%, 36.99% and 34.66%. To compare the single elements, without nanolayer coated, harvests the stepped basin responses. The SBSS has achieved in a simulation that the course of the ambient, glass cover, basin saline water, solar radiation and distillate production throughout the year. It is achieved that nanoparticles of with, Single, without nanolayer have coated by a stepped basin area improvement of yield production by SBSS as showed in Fig.7(b). It found that to be overall efficiency of 61.14% as a $\text{SiO}_2/\text{TiO}_2$ nanolayer (30%) is achieved by Shanmugan *et al.*, [34] and Essa *et al.*, [35].

3.1 The SBSS Strategies with evaluation for Energy control

SBSS has included as BSM influent load data for the temperature analysis of the initialization condition of the system. The analysis of the solar still was important one-year simulation data of

0.0001. The SBSS control simulation model is selected as an initialization data use of OSELM founded adaptive controller on the BSM model. Performance of the SBSS controlled weather conditions, as showing in Figs. 8a & 8b. It controlled for weather condition for the variable an algorithm as good performance of the SBSS. The error analysis of the solar still controlled flexible set point range of ± 0.05 mg/day frequently.

A comparison of the SBSS with further controller approaches in weather conditions as followed in Table 3. SBSS is supervised by the IAE, ISE and $D^{\max}$, which have calculated for 0.0564, 0.0057, 0.0472 and better values of the system. The regular performance of the SBSS was evaluated to compare an establishes a fast-moving transient with a response to appropriates of damping. It used the heat transfers excessive permanency of the SBSS individually.

Conclusion

SBSS was used as a nonlinear composite design based on a neural network with a controller in an approach that has been analyzed of heat transfer usually. Though nearly scarcities with a traditional neural network affect a consultation innovative control responsibilities also huge period feasting. The SBSS has been achieved a good control effect of research for OSELM based adaptive control with the recursive least square method was introduced for thermal application one of the solar still design. The neural network-based to control approach the evaporation process and solar design for biases of hidden nodes running methods. The $\text{SiO}_2/\text{TiO}_2$ nanolayer coated at stepped basin with the effect of different ratio used a solar still have been enhanced high temperature, which is increased an evaporation process. SBSS is the foremost important to handle influence the stepped basin and enhanced to that of heat transfer modes. The $\text{SiO}_2/\text{TiO}_2$ nanoparticles average temperature were the glass, water, stepped basin, moist air, which enhanced of 12.5%, 16.4%, 16.5%, 16.3% individually through about 30%. The SBSS stepped basin increases the absorption ratio mixture nanoparticle by the 30%, stepped basin temperature, which is no signification for nanoparticle development of the parameters. From furious $\text{SiO}_2/\text{TiO}_2$ nanoparticles of the SBSS efficiency were increased by 37.69% and 49.21% using 20% and 30%. The overall efficiency 30% in the SBSS is 61.14%. It is higher as per equated to that of SBSS with analysis of SiO_2 , TiO_2 , without nanoparticles for the systems. The BSTs have studied algorithms to improve a higher bound by a price with a product and the central part of BST authorizations originate a limit of the

cost optimum of the solar still and developed with previous significances. Time-stamped storage and retrieval of temperature in the memory gives an authenticated way of accessing the correct data in our experiment.

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NOMENCLATURE

A_{eff}	-	Effective area of the stepped basin surface (m^2)
A_c	-	stepped basin surface of the SBSS (m^2)
C_w	–	Capacity of heat transfer to water (L)
E_{o-N}	-	nanolayer occupied the internal energy (kJ)
l_g	-	Length of the glass cover (m^2)
b_g	-	Breadth of the glass cover (m^2)
h_{cwg}	-	Convective heat transfer coefficient from stepped basin to glass cover (W/m^2K)
h_{ewg}	-	Evaporative heat transfer coefficient from stepped basin to glass cover (W/m^2K)
h_{rwg}	-	Radiative heat transfer coefficient from stepped basin to glass cover (W/m^2K)
h_L	–	Convection heat transfer coefficient loss of the SBSS (W/m^2K)
P_w	-	Saturated vapor pressure at water temperature (Nm^{-2})
P_g	-	Saturated vapor pressure at glass temperature (Nm^{-2})
$Q_{total\ energy + N}$	-	amount of total energy (W/m^2)
$\dot{Q}_{ep}$	-	Total heat transfer an evaporation power (W/m^2)
T_w	-	Temperature of the water surface (K)
T_{wo}	-	Initial temperature of the stepped basin water surface (K)

T_g	-	Temperature of the glass cover (K)
T_a	-	Ambient temperature (K)
$T_{f-output}$	-	SBSS of the output temperature (°C)
$T_{f-input}$	-	SBSS of the Input temperature (°C)
t	-	Time (S)
T	-	Temperature(°C)
$T(\sigma_k)$	-	The binary search trees use of a SBSS (°C)
H_s	-	Solar Radiation (W/m ²)
h_{rga}	-	Radiative heat transfer coefficient from glass to ambient (W/m ² K)
h_{cga}	-	Convective heat transfer coefficient from glass cover to ambient (W/m ² K)
h_1	-	Total heat transfer coefficient from stepped basin area to the glass cover (W/m ² K)
h_2	-	Total heat transfer coefficient from glass cover to ambient (W/m ² K)
h_3	-	Total heat transfer coefficient from bottom and side walls to ambient (W/m ² K)
M_w	-	Mass of the distillate yield (Kg/m ² h)
m	-	Mass of the distillate yield (Kg/m ² h) (Dunkle's expression)
k	-	Thermal conductivity of glass wool insulation (W/mK)
L	-	Thickness of the glass cover (0.004 m)
L	-	Length of the SBSS (m ²)
T_{srg}	-	Solar radiation on the glass cover (W/m ²)
dt	-	Time interval (s)
L_b	-	length of the still (m)
v	-	Wind velocity (m/s)
V	-	Volume (m ³)
u	-	Convection heat transfer coefficient (W/m ²)
U_k	-	Control for the SBSS performance (W/m ²)
W	-	Width of the still (1m)

IAE	-	standard to an analysis of an integral of Absolute Error (°C)
ISE	-	Integral of Square Error (°C)
$D^{\max}$	-	maximal Deviation from the setpoint (°C)
R(t), Y(t)	-	referred by SBSS Input, output (°C)
S	-	The calculated the efficiency of SBSS
SBSS	-	Stepped Basin Solar Still

Greek symbols

ε	-	Emissivity of the water surface.
σ	-	Stefen-Boltzman constant. (W/m ² K ⁴)
σ_1 of σ_k	-	glass cover, stepped basin, moist air, water temperature, distillate output (°C)
η	-	Instantaneous Thermal efficiency of the still
$\eta_{total\ energy + N}$	-	Overall thermal efficiency by the SBSS (%)
τ_g	-	Transmissivity of glass cover
α_g	-	Absorptivity of the glass cover
α_w	-	Absorptivity of the stepped basin surface
δ	-	The uncertainty values of SBSS
Φ	-	Pseudo-inverse based on back point (°C)
$\omega_i, m_i,$ and θ_i	-	SBSS as zero error with existing for evaporation (°C)

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