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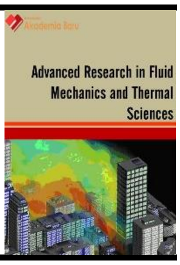

Numerical Investigation for Single Slope Solar Still Performance with Optimal Amount of Nano-PCM

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ABSTRACT

Desalination using solar energy systems is a practical solution for production of potable water and particularly in remote areas, which suffer from lack of drinking water due to poor infrastructure. It is possible for a small distillation system to be a practical and economical solution for current and future demand for potable water with availability water resources and large amounts of solar radiation. Therefore, productivity that could be increased by increasing the model's ability to store the heat energy needed to maintain evaporation was discussed using nanoparticles dispersed in paraffin wax beneath the basin. In this paper, the main objectives of the study are to obtain the optimum parameters of PCM mass, NPCM mass, water mass and solar radiation to give the best productivity of the model inside the atmosphere of Najaf city, a numerical study involving the study of the performance of single-slope solar still using different masses of PCM with and without nanoparticles. Nanoparticles is used to improve thermal conductivity of paraffin wax. The most commonly used paraffin wax (PCM) and Al_2O_3 (nanoparticles) complements its specific thermal properties with fusion temperature where the main active properties are studied. The numerical solution was done using COMSOL 5.3 software and the results were compared with previous studies and showed that a good agreement. Also, the results showed that the use of 1 kg of PCM represent optimal amount of enhancement, and thus using of 3 Vol.% concentration of Al_2O_3 nanoparticles dispersed in 1 kg of paraffin wax gives the possibility of improving the traditional single slope solar still daily productivity by about 20%.

Keywords:
Thermal storage; phase change material; paraffin wax; nanoparticles; solar still; numerical; NPCM; optimal amount

1. Introduction

In recent years, with remarkable scientific development and interest in industries. One of the most commonly used Phase Change material (PCM) because of their ability to store and transfer heat energy. It has been used in many important applications such as heat exchangers, heating systems and solar storage systems [1].

Solar still is a heat storage system that uses heat energy to produce fresh water. Therefore, many studies have focused on using PCMs in solar distiller to increase operating hours and improve

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productivity. The researchers used several methods to improve the thermal properties of PCMs such as adding fins inside them or mixing them with highly absorbent materials, using small metal parts.

In the last period, the focus has been on adding nanoparticles to PCMs to improve thermal conductivity and thus increase the thermal performance of the still and increase its efficiency [2].

El-Sebaii *et al.,* [3] presented a numerical study involving improved single slope solar still production by use PCM under typical summer and winter days of Jeddah in Kingdom of Saudi Arabia. The results show that daylight productivity decreases as mass of PCM increases, but overnight and daily productivity increase significantly with an increase of PCM mass due to increased amount of the heat stored within the PCM. Therefore, on a summer day, the daily productivity has been obtained reaches up to 9.005 (kg/m^2 day) compared to 4.998 (kg/m^2 day) for that one without the PCM. While, the study showed that the use of citric acid (light mass) was very effective during the winter.

Solanki and Patel [4] used paraffin wax in solar still to get increase in daily productivity of pure water by 11.24%.

Rajasekhar and Eswaramoorthy [5] presented an experimental study that included the use of paraffin wax enhanced by nanoparticles (Al_2O_3). The results showed that productivity increased by about 38- 45% compared with Still boosted by only paraffin wax or regular solar still.

An experimental study carried out by Thakkar and Hitesh [6] to use three models of solar stills . The first is a traditional solar still, the second is with PCM and the third boosted by composite PCM-Nanoparticles. The productivity showed an estimated increase of about 92 % and 106% for the second and third models in sequence, when compare with traditional solar still.

An experimental comparison is carried out by Sarada *et al.,* [7]. They used ($MgSO_4.7H_2O$) and ($Na_2S.7H_2O$) as PCM and mixed with TiO_2 as energy storage medium. The results show the maximum efficiency of solar still is enhanced by using ($MgSO_4.7H_2O$ compound TiO_2) and reaches up to 50 % as compare with conventional still.

An experimental comparison between three models of solar still carried out by Elfasakhany [8]. The results show that the addition of pure wax to solar still improve the productivity by 119% while adding CuO powder depressed in paraffin wax improve the productivity by about 125% as compare with classic still. Also, the results show that solar distillation time is increased by about 5 to 6 hours compared with conventional solar distillers.

Kumar *et al.,* [9] studied experimentally input copper tubes filled with Paraffin wax and titanium oxide in basin of solar still. The results appear that solar efficiency enhanced by about 52%.

Amin *et al.,* [10] expedited four different types of (Fe_3O_4, CuO, TiO_2, and ZnO) in them study. These nanoparticles used to increase the conductivity and latent heat of the paraffin wax found in solar still basin and thus obtain the best yield for the same solar still. The results were increase in the latent heat of nano-PCM by 20.67%, 78.89%, 75% and 20.17% receptivity.

Rufuss *et al.,* [11] studied theoretically enhancement of solar still productivity. They used paraffin wax as heat storage material with the incorporation nanoparticles. Three different types of nanoparticles (TiO_2, CuO and Graphene Oxide) with 0.3 weight % are used. The results showed that the best still productivity was when the use of Graphene Oxide with paraffin wax.

Increasing of traditional solar still production tested by Xiao *et al.,* [12]. They used (50 wt.% $NaNO_3$ and 50 wt.% KNO_3) as a phase change material compounded with Nano-graphite. the results showed that productivity increased by about 19.32% as compare with conventional still.

A numerical and experimental study presented by Chaichan and Kazem [13] to improve still productivity using paraffin wax and 1 Vol.% concentration of Al_2O_3. The results show that still productivity increased from 1.91 l/m^2.day to 2.7875 l/m2.day, while the efficiency increased by 25.51 % as compared with conventional still.

Enhancement of distilled water production from solar still is investigated by Rashidi *et al.,* [14] added a mass of paraffin wax with 5 Vol.% concentration of aluminium oxide beneath the basin liner of still. The results show that productivity is improved by 25% as compare with conventional still.

Mohamad *et al.,* [15] They have demonstrated that the used of nanoparticles has the potential to improve the thermal conductivity and storage capacity of phase change materials.

It is clear from literatures that theoretical researches which deals with using PCM and nanoparticles to enhanced solar still performance are few, and a number of experimental works concerned on using different types of nanoparticles enhanced PCM (NPCM) to extending solar still operation and improves still yield. However, there is no literature available states the optimal amount of PCM and NPCM used in solar still application for best daily productivity. Thus, numerical calculation has been carried out in this paper to estimate the optimal amount of PCM and NPCM for productivity enhancement in single slope solar still under the weather conditions of the Najaf city /Iraq.

2. Thermal Analysis of Single Slope Solar Still

Figure 1 shows a pattern of model presented in this study and is enhanced using layer of PCM alone or Nano-PCM, showing the energy and mass equations on it. The basin of still consists of a galvanized iron plate with area of 1 m^2 and thickness of 0.2 cm coated with black thermal paint, directly under it found a gap containing a mass of PCM or NPCM. Pure paraffin wax is used as a phase change material that has the ability to store heat energy and Al_2O_3 Nano powder is used to improve the thermal conductivity of paraffin wax, Table 1 summarizes the characteristics of paraffin wax and Al_2O_3 Nano powder. Bottom and sides of still are completely insulated by a layer of 2.5 cm thick cork and fixed inside a wooden frame with 1.8 cm thickness. Cover of solar still consists of a glass panel with thickness of 4mm, mounted on the wooden frame at a tilt of 32.1° with a horizontal and equal to width line of the Najaf city.

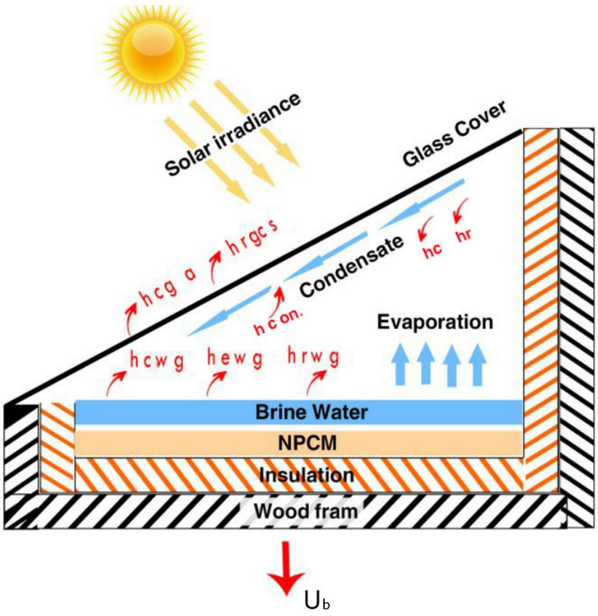

Fig. 1. Heat and mass transfer in single-slope solar still enhanced by NPCM layer

Table 1
Properties of paraffin wax (PW) and Aluminum oxide (Al_2O_3) [16]

Property	Paraffin wax	Al_2O_3
Density (kg/m^3)	ρ_{solid}= 880 ρ_{liquid} = 770	3600
Specific heat (Cp) (J/kgK)	2000	765
Thermal conductivity (W/mK)	k= 0.2	36
Viscosity (μ) (Ns/m^2)	0.001exp(-4.25+1790/T)	-----
Latent heat (L) (J/kg)	160	-----
Melting Temperature (oC)	56	-----

Fresh water is collected by a plastic channel that is fixed at underside of the glass cover. Direct solar radiation passes through the oblique glass cover and water layer to reach basin liner and absorb it, causing an increase in temperature of basin. A part of heat is transferred by convection to salt water layer and the other part of heat is transferred by conduction to PCM layer. When temperature of the basin liner exceed temperature of the PCM, the heat is stored gradually until it is sufficient to melt whole PCM layer. As solar radiation decreases, the heat is transferred from PCM layer to the basin liner to raise the temperature of salt water and continue the process of evaporation until it hardens the PCM layer completely. Heat is transferred from the saline water to inner surface of glass cover by radiation, convection and evaporation. The heat is transferred from glass cover by radiation to the sky and by convection to ambient air.

2.1 Mathematical Analysis of Model

Energy balance equations for single slope solar still parts are resolved after applying the following hypotheses [17-19].

i. The Single slope Solar Still is 2-D.
ii. No leakage for water or vapor outside the still.
iii. Mathematical Analysis was conducted under steady state conditions.
iv. Flow of condensate on inner surface of glass cover be laminar.
v. NPCM layer and water layer have high thermal capacity compared to other parts of the model.
vi. NPCM layer is completely connected to basin plate and temperature of plate shall be transferred to NPCM layer by conduction.
vii. Temperature of NPCM layer is taken as an average temperature for melting and solidification, only in thin layer of NPCM.

2.1.1 Heat balance equations of still parts

This numerical investigation was done by COMSOL 5.3 multiphasic program ,is divide into two parts where the first part is to apply the heat equilibrium equations on the different parts of the model and obtain the temperatures of water basin (T_w)and the temperatures of glass cover (T_g) and the second part is specific to the steam space inside the enclosure, where after inter the results coming from the first part(T_w and T_g) and application the equations of the second part (Mass Conservation Equation, Momentum Conservation Equations, Energy Conservation Equation and Concentration Equations), the productivity is getting.

A- First Part:

After the input of solar radiation values, air velocity and ambient temperature as variables over time. The following energy equations are applied by the COMSOL 5.3 multiphasic numerical program and obtain the values of water temperature (T_w) and glass temperature (T_g) over time.

Glass cover

$$m_g c_{p,g}\left(\frac{dT_g}{dt}\right) = A_g \alpha_g I + A_w h_{wg}\left(T_w - T_g\right) - A_g h_{rgs}\left(T_g - T_s\right) - A_g h_{cga}\left(T_g - T_a\right) \tag{1}$$

where

A_g	is the area of glass cover (m^2)
A_w	is the area of water basin (m^2)
$c_{p,g}$	is specific heat of glass cover (J/kg K)
h_{rgs}	is the radiative heat transfer coefficients between glass cover and sky (w/m^2.k)
h_{cga}	is the convective heat transfer coefficients between glass cover and ambient (w/m^2.k)
I	is the solar radiation (w/m^2)
m_g	is the mass of glass cover(kg)
T_a	is the ambient temperature (k)
T_g	is the glass cover temperature (k)
T_s	is the sky temperature (k)
T_w	is the water basin temperature (k)
α_g	is the absorptivity of glass cover

$$h_{wg} = h_{rwg} + h_{cwg} + h_{ewg} \tag{2}$$

where
h_{wg} is the total heat transfer coefficient between water basin and glass cover, h_{rwg} is the radiative, h_{cwg} is the convective and h_{ewg} is the evaporative heat transfer coefficients.

Basin water

$$m_w c_{p,w}\left(\frac{dT_w}{dt}\right) = A_w\left[I\alpha_w + h_{cbw}(T_b - T_w)\right] - A_w h_{wg}\left(T_w - T_g\right) - A_w U_{ins,w}(T_w - T_a) \tag{3}$$

where

$c_{p,w}$	is the specific heat of water basin (J/kg K)
m_w	is the mass of water basin (kg)
h_{cbw}	is the conductive heat transfer coefficient between the basin liner and water(w/m^2.k)
T_b	is the basin liner temperature (k)
$U_{ins,w}$	is the heat loss coefficient between insulation and ambient (w/m^2.K)
α_w	is the absorptivity of water basin

Basin liner

$$m_b c_{p,b}\left(\frac{dT_b}{dt}\right) = A_w\left[I\alpha_b - h_{cwb}(T_b - T_w) - U_b\left(T_b - T_{npcm}\right)\right] \tag{4}$$

where

$c_{p,b}$	is the specific heat of basin liner (J/kg K)
m_b	is the mass of basin liner (kg)
T_{npcm}	is the temperature of NPCM layer (k)
U_b	is the heat loss coefficient from basin liner to ambient (w/m^2.K)

Nano-Phase change material layer (NPCM)

$$\left(\frac{k_b}{x_b}\right)\left(T_b - T_{npcm}\right) = \left(\frac{(m.cp)_{npcm}}{A_b}\right)\left(\frac{dT_{npcm}}{dt}\right) + U_b\left(T_{npcm} - T_a\right) \tag{5}$$

where

k_b	is the thermal conductivity of basin liner (w/m.k)
x_b	is the basin plate thickness (m)

$$K_{npcm} = \frac{[\,K_{np}+2K_{\mathrm{pcm}} -2(\,K_{pcm}-K_{\mathrm{np}})\,\phi\,]}{[\,K_{np}+2K_{\mathrm{pcm}} + (\,K_{pcm}-K_{\mathrm{np}})\,\phi]}\,K_{\ pcm}+5\times10^4\,\beta_k\zeta\,\phi\,\rho_{pcm}Cp_{\,pcm}\sqrt{\frac{\mathrm{BT}}{\rho_{np}\,\mathrm{d_{np}}}}\,f(\mathrm{T};\phi) \tag{6}$$

where

$Cp_{\,pcm}$	is the specific heat of phase change material (J/kg K)
K_{npcm}	is the thermal conductivity of nanoparticles-phase change material(w/m.k)
K_{np}	is the thermal conductivity of nanoparticles (w/m.k)
K_{pcm}	is the thermal conductivity of phase change material (w/m.k)
ρ_{pcm}	is the density of phase change material (kg/m^3)
ϕ	is the volumetric fraction of nanoparticle
ζ	is the correction factor in the Brownian motion term

$$\rho_{npcm} \ = \phi\rho_{np} + (1-\phi)\rho_{pcm} \tag{7}$$

$$Cp_{npcm} = [\phi(\rho\ Cp)_{np} + (1-\phi)(\rho\ Cp)_{pcm}]\ /\rho_{npcm} \tag{8}$$

$$L_{npcm} = \ (1-\phi)(\rho\ L)_{pcm}/\rho_{npcm} \tag{9}$$

where

B is Boltzmann constant and equal to 1.381×10^{-23} J/K, and

$$B_k = 8.4407(100\phi)^{-1.07304} \tag{10}$$

L_{npcm}	is the latent heat of nanoparticles-phase change material(J/kg)
L_{pcm}	is the latent heat of phase change material(J/kg)
T_{ref}	is the reference temperature =273 K
ρ_{np}	is the density of nanoparticles (kg/m^3)
ρ_{npcm}	is the density of nanoparticles-phase change material (kg/m^3)

$$f\ (T;\phi) = (2.8217\times10^{-2}\phi +\ 3{:}917\times10^{-3})\ \frac{\mathrm{T}}{T_{ref}}+(-3.0669\times10^{-2}\ \phi\ -3.91123\times10^{-3}) \tag{11}$$

From the above hypotheses and Figure 1, energy conservation equations for all parts of the model are written below.

B- Second Part:

After input the temperatures extracted from the first part (T_w and T_g), the equations below are applied to obtain the hourly productivity and the daily productivity of the model

Mass Conservation Equation

$$\frac{\partial \rho}{\partial t}+\frac{\partial u}{\partial x}\rho+u\frac{\partial \rho}{\partial y}\rho+v\frac{\partial \rho}{\partial y}=0 \tag{12}$$

where
u is the flow velocity vector field in x-direction(m/s)
v is the flow velocity vector field in y-direction(m/s)
ρ is the density of steam (kg/m^3)

Momentum Conservation Equations

x – direction momentum equation

$$\frac{\partial u}{\partial t}+u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}=-\frac{1}{\rho}\frac{\partial P}{\partial x}+\mathcal{V}(\frac{\partial^2 u}{\partial x^2}+\frac{\partial^2 u}{\partial y^2}) \tag{13}$$

y – direction momentum equation

$$\frac{\partial v}{\partial t}+u\frac{\partial v}{\partial x}+v\frac{\partial v}{\partial y}=-\frac{1}{\rho}\frac{\partial P}{\partial y}+\mathcal{V}\left(\frac{\partial^2 v}{\partial x^2}+\frac{\partial^2 v}{\partial y^2}\right)+F \tag{14}$$

where
P is the pressure of the steam (N/m^2)
F is the Buoyancy force (N)

Energy Conservation Equation

$$\frac{\partial T}{\partial t}+u\frac{\partial T}{\partial x}+v\frac{\partial T}{\partial y}=\alpha\left(\frac{\partial^2 T}{\partial x^2}+\frac{\partial^2 T}{\partial y^2}\right) \tag{15}$$

where α is the Absorption coefficient.

Concentration Equations

$$\frac{\partial c}{\partial t}+u\frac{\partial c}{\partial x}+v\frac{\partial c}{\partial y}=D_{ab}\left(\frac{\partial^2 c}{\partial x^2}+\frac{\partial^2 c}{\partial y^2}\right) \tag{16}$$

where
c is the vapor concentration of air kg/m^3
D_{ab} is the mass diffusivity of vapor m/s

The hourly productivity (P_h) of pure water can be calculated as

$$P_h=\frac{(-3600\times D_{ab})}{L}\int_0^L \frac{dc}{dy}|_{water}\,dx \tag{17}$$

where L is the length of solar still basin (m) and the daily productivity (P_{d}) can be computed as the following

$$P_{\mathrm{d}} = \sum_{24\ \mathrm{hrs}} P_h \tag{18}$$

3. Effect of Nano-Powder Concentration

Figure 2 illustrates the effect of adding (0, 3 and 5 Vol.%) of (Al_2O_3) nanoparticles on the thermal conductivity of paraffin wax through experimental tests. when add 3 Vol.%, thermal conductivity of paraffin wax increased from (0.2 to 0.235) W/m.°C in the solid state and from (0.12 to 2) W/m.°C in the liquid state. While, for 5 Vol.% the thermal conductivity in liquid state will be reduced to 1.86 W/m.°C when temperature is greater than 88°C, Because it reduces the boiling temperature of wax by about 9°C, as a result of changing physical properties of wax when boiling occurs.

From same test, the melting temperature of pure paraffin wax show that it is about 56°C and after mixing it with nanoparticles with 3 and 5 Vol.% concentration, it was found that the wax melting rate decreased by about 3.6°C and 6.8°C to became 52.4°C and 49.2°C in sequence ,which could dissolve the wax mass in less time and thus increase the water basin temperature leads to an increase in productivity. Taking into account that the boiling grade of paraffin wax used is 105°C.

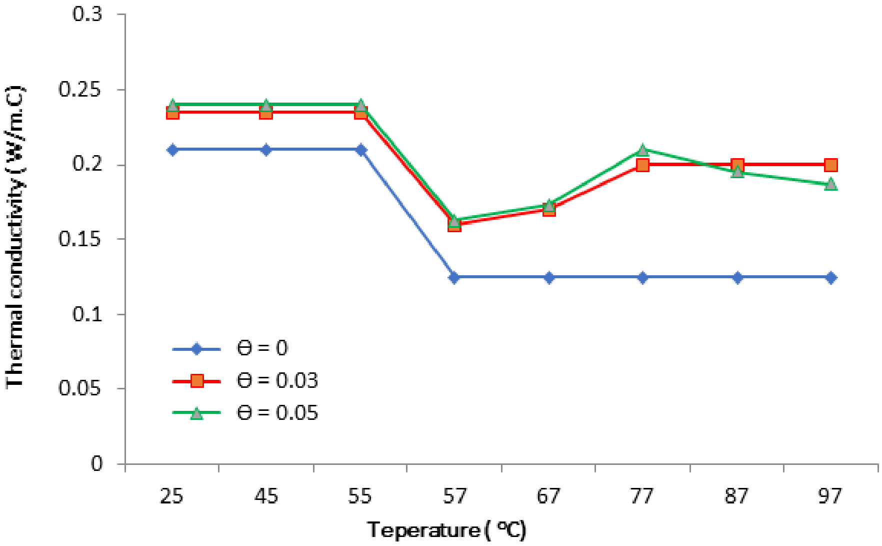

Fig. 2. Variation of thermal conductivity of NPCM with temperature at different nanoparticles concentrations

4. Numerical Simulation

Numerical simulation using computers is an important part of modern engineering, where many specialized programs are used to implement simulation. Many researchers use these programs in numerical analysis to implement advanced geometric methods. The COMSOL 5.3 multiphasic software is very convenient and more efficient to solve the partial differential equations of variable systems over time [20].

Figure 3 and 4 show variation of solar radiation, ambient temperature and wind speed with time for day of (14/3/2019) under conditions of Najaf city in Iraq. COMSOL 5.3 multiphasic software used to create a simulation model to solve the energy equations for with and without PCM and NPCM. Atmospheric variables for solar radiation, air temperature and wind speed on day of (14/3/2019) used as input data for the simulation model, and listed in Table 2 or shown in Figure 5. Through the numerical simulation at the first part, can be calculate the temperatures of glass and water, and from second part can be calculate the hourly productivity value and the total daily productivity.

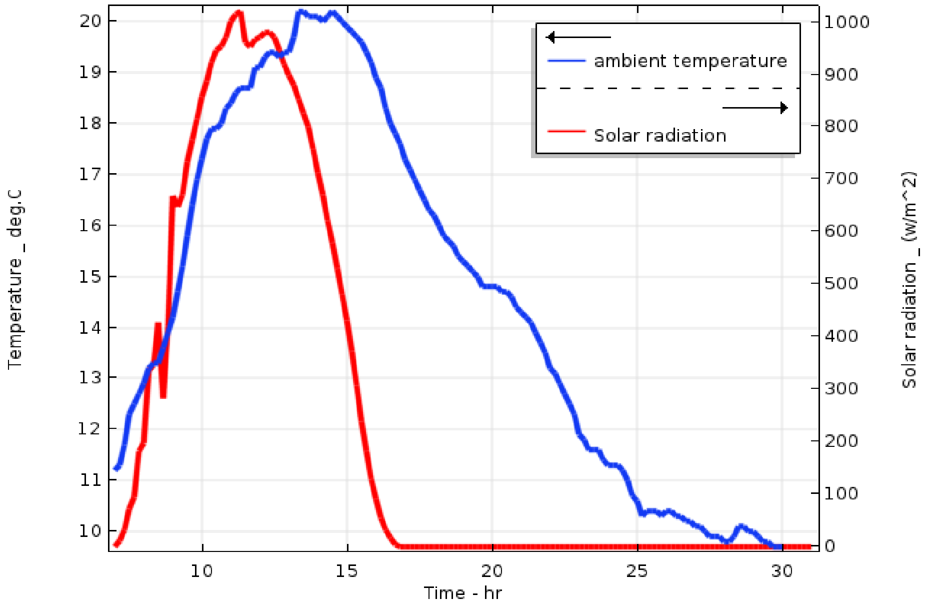

Fig. 3. Solar radiation and the temperature of the air over time for day of (14/3/2019)

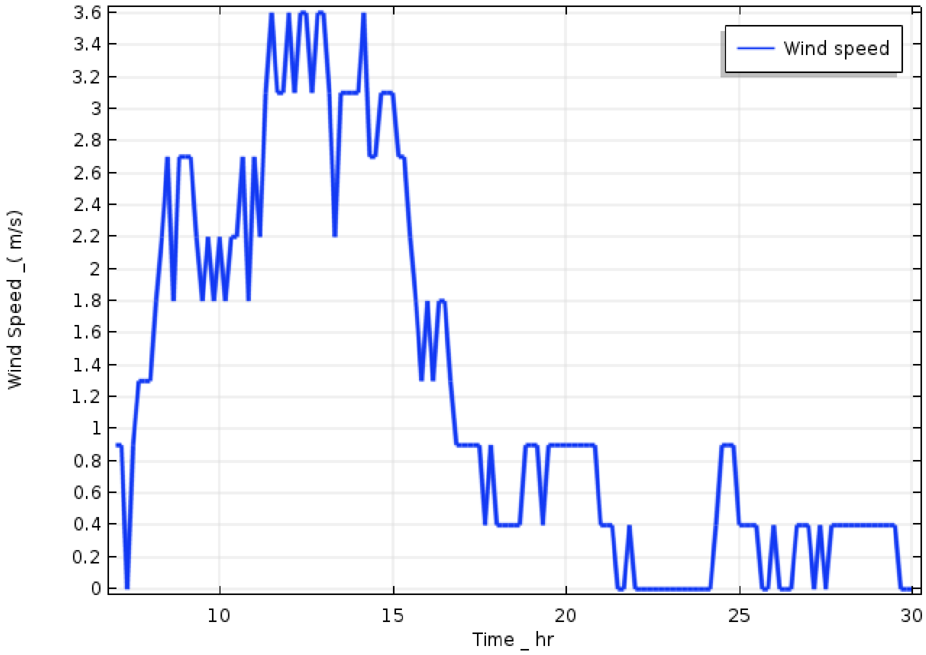

Fig. 4. Wind speed over time for day of (14/3/2019)

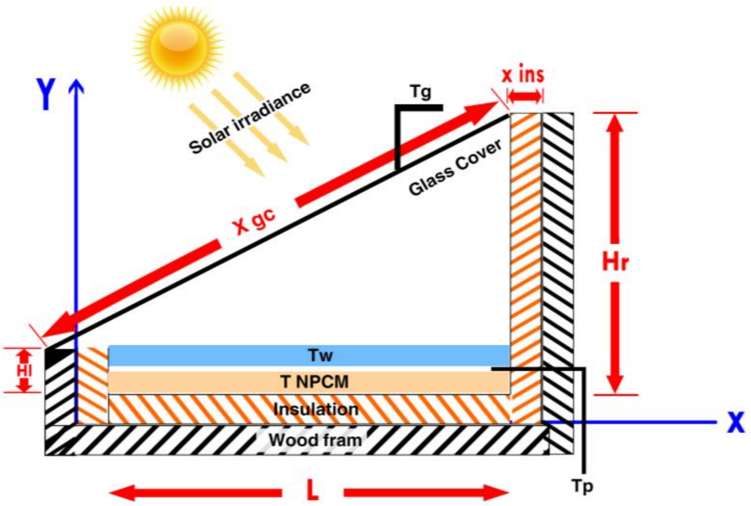

Fig. 5. All dimensions of the model

Table 2
Parameters used in the numerical simulation

Parameter	Value	Parameter	Value	Parameter	Value
$Hl(m)$	0.2	$k_{ins}(w/m.k)$	0.03	$x_b(m)$	0.0015
$Hr(m)$	0.83	x_{ins} (m)	0.025	ρ_b (kg/m^3)	7870
ε_g	0.88	cp_w (J/kg K)	4190	$\sigma(W/m^2\ K^4)$	5.669x10^{-8}
τ_g	0.9	A_w(m^2)	1.0	ε_w	0.96
τ_w	0.95	A_g(m^2)	1.1987	m_w(kg)	10
α_b	0.9	$x_g(m)$	0.004	$\Theta(Degree)$	32.1
α_g	0.05	Cp b (J/kg K)	460	$U_{ins,w}(\frac{w}{m^2k})$	0.5
α_w	0.05	k_b(W/m.K)	73	Xgc (m)	1.1987

5. Present Work Validation

Present numerical simulation output is compared with experimental study presented by Rufuss *et al.,* [21]. The experimental study included the specifications of using two models, one with pure paraffin wax and the other with CuO nanoparticles dispersed in paraffin wax, each model built up from 0.5 square meter for solar still basin and glass cover with tilt angle of 13-degree from horizon. Figure 6 and 7 show that there is good agreement between the present numerical results and the practical results of the researchers.

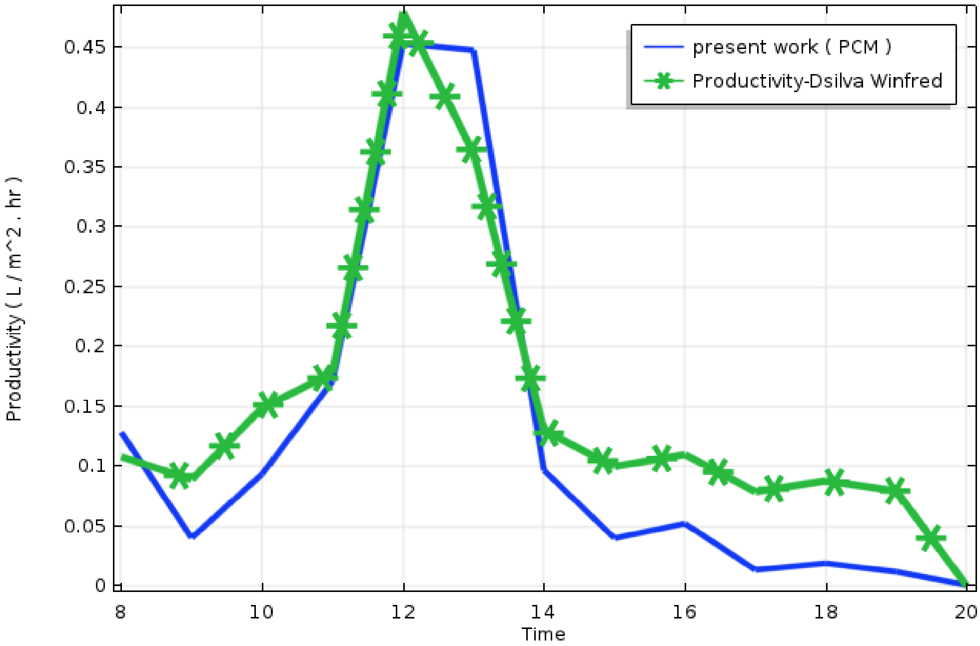

Fig. 6. Productivity comparison between experimental results of Rufuss [21] with theoretical results of the present work with PCM addition

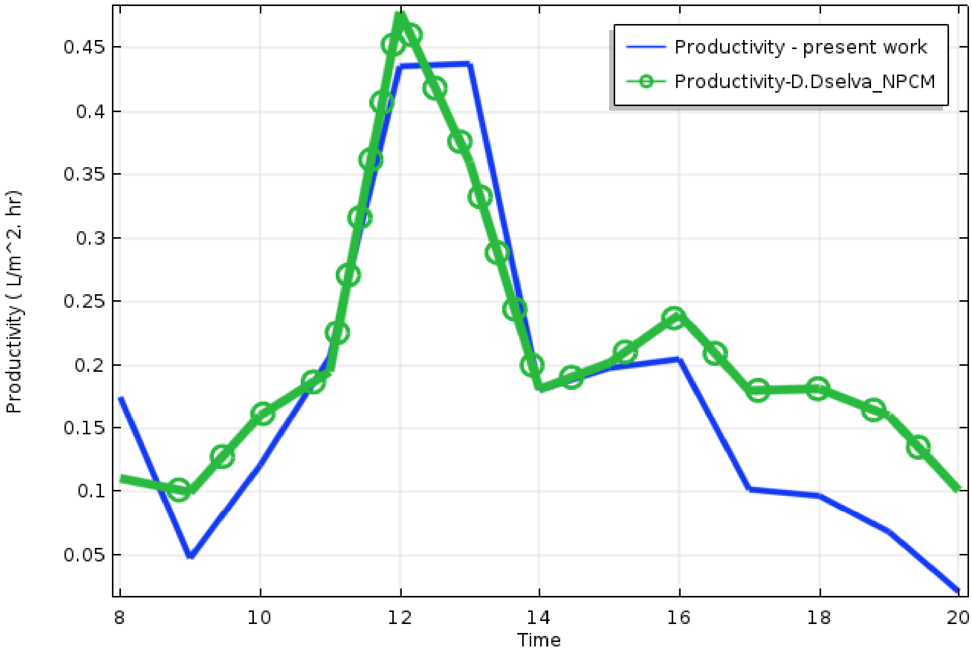

Fig. 7. Productivity comparison between experimental results of Rufuss [21] with theoretical results of the present work with NPCM addition

6. Results and Discussion

A two-stage numerical study was conducted, the first stage for comparing traditional single slope solar still with a model enhanced by different masses of Paraffin wax as PCM and the second is comparing the traditional model with a model enhanced by 3 Vol.% of Al_2O_3 dispersed in different paraffin wax masses nano-PCM, The study was carried out using the COMSOL 5.3 multiphasic simulation program under the influence of weather conditions on (14/3/2019) in Najaf city/Iraq.

For both stages, at time 1 PM, that the productivity and different still temperatures reaches maximum value, when the model is boosted by 1 kg of paraffin wax with and without Al_2O_3 nanoparticles. Figure 8 and 9 show that maximum temperature of basin water reaches up 75.5, 82.1 and 84.8 °C while maximum temperature of glass cover reaches up 46, 48.2 and 50 °C for models of conventional, with PCM and with NPCM, respectively. Daily productivity for different masses of PCM and NPCM shown in Figure 10 and 11. The maximum value reaches up 6 and 5.6 L/m^2 for 1 kg of NPCM and PCM model respectively, while is 5 L/m^2 for conventional model.

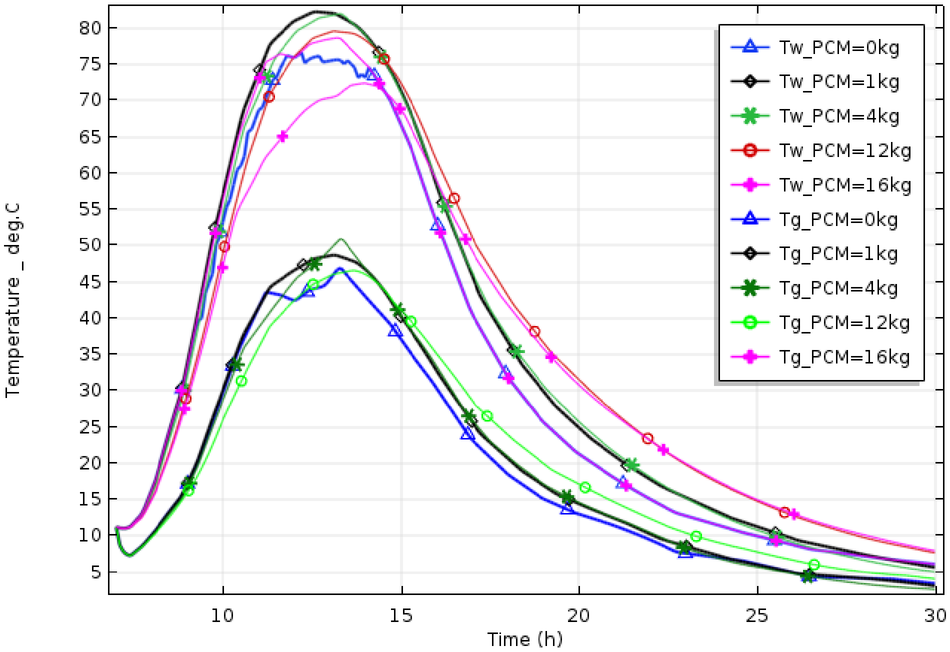

Fig. 8. Variation of basin water temperature (T_w) and the glass cover temperature (T_g) with time at different masses of PCM at day (14/3/2019)

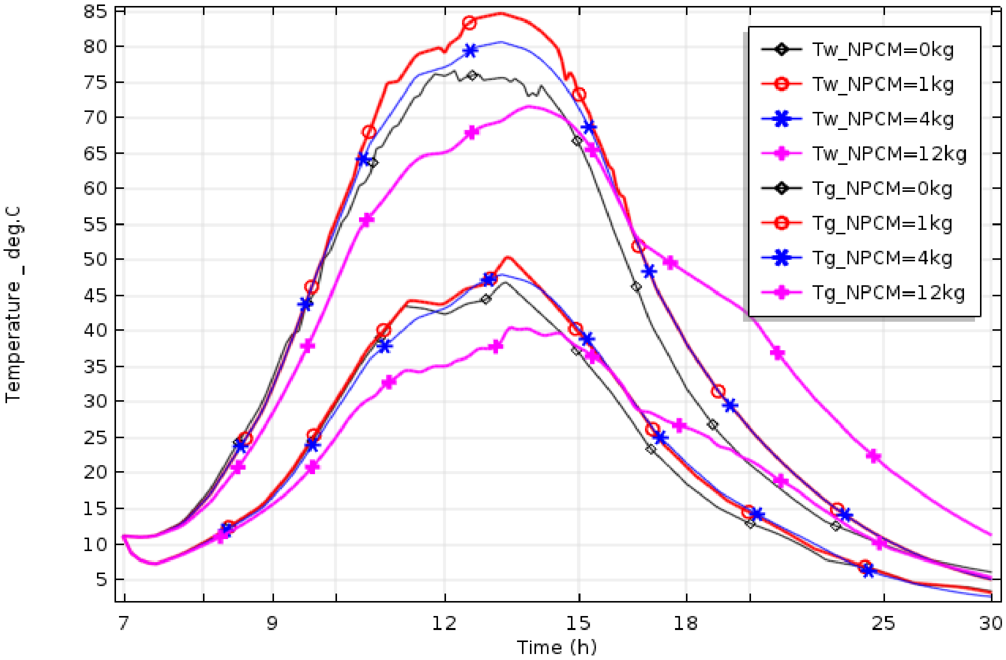

Fig. 9. Variation of basin water temperature (T_w) and glass cover temperature (T_g) with time at different masses of NPCM at day of (14/3/2019)

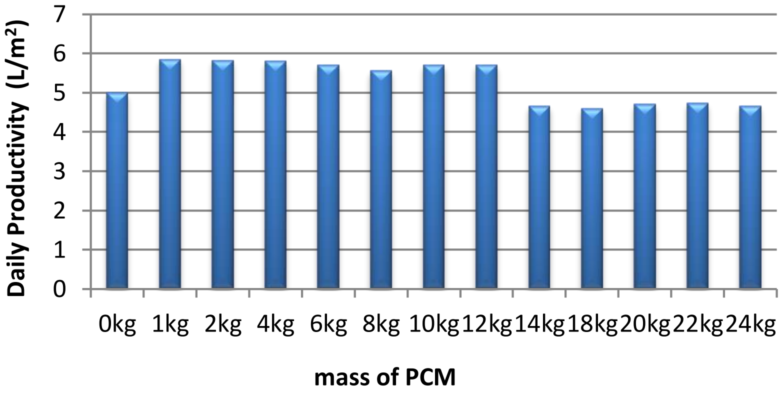

Fig. 10. Daily productivity of model for different masses of PCM at day of (14/3/2019)

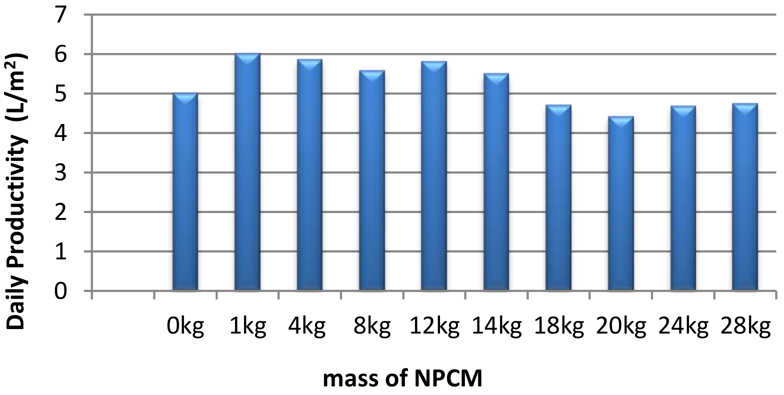

Fig. 11. Daily productivity of model for different masses of NPCM at day of (14/3/2019)

Effect of amount of raw water mass on temperature of basin water and daily productivity are illustrated in Figure 12 and 13 for (1 kg) NPCM model. It is clear from Figure 12 the water temperature increases with time until reaches maximum value, nearly, at 1 PM and then decreases with time progress due to reduce of solar radiation. Also, the figure state that, at the same time, the water temperature decreases with increases of raw water mass due to increasing the heat capacity of water.

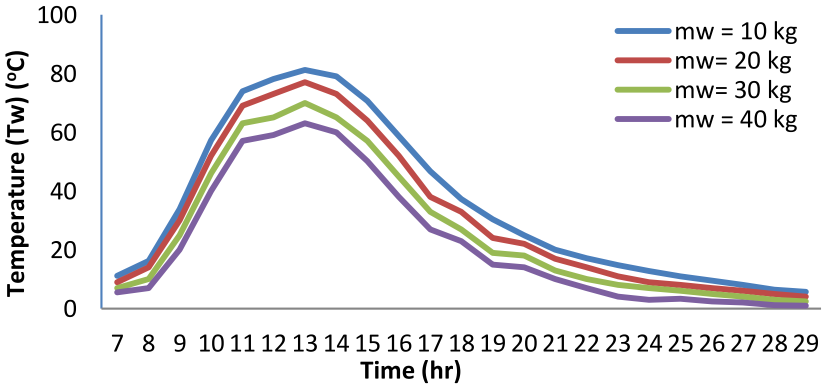

Fig. 12. Variation of basin water temperature (T_w) with time for NPCM model on day of (14/3/2019)

Figure 13 revealed that, for different water masses (10, 20,30 and 40) kg, daily productivity decreases with raw water mass increase and reaches up 6, 5.67, 5.34 and 5 L/m^2 for 10, 20, 30 and 40kg of water, respectively.

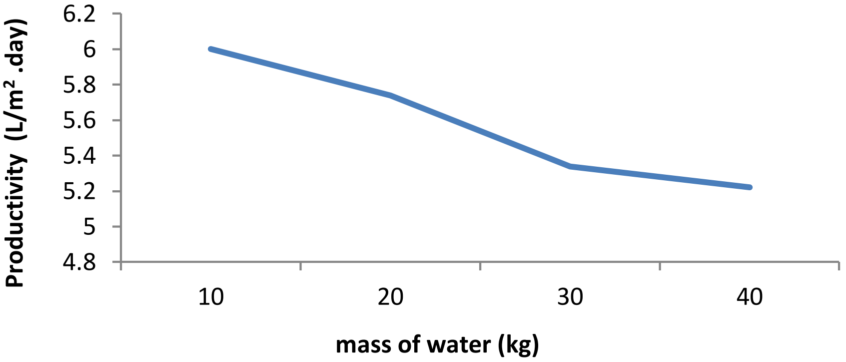

Fig. 13. Variation of daily productivity with basin water mass for NPCM model on day of (14/3/2019)

Figure 14 shows the effect of solar radiation availability on productivity amount. Theoretically, all variables were set and amount of solar radiation was taken for two different days, one was sunny and the other cloudy. where it was found that the productivity of the sunny day is greater than the productivity of cloudy day. In other words, productivity increases with solar radiation increases.

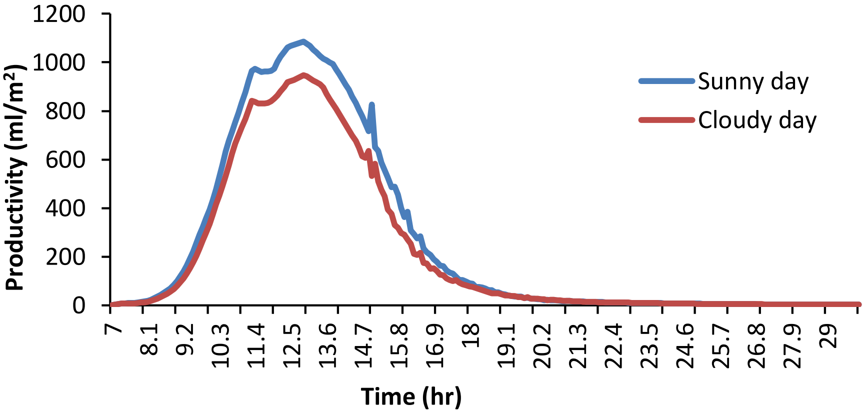

Fig. 14. Variation of water productivity with time for sunny and cloudy days, for NPCM model

7. Conclusions

A computer simulation study of a model was conducted under atmospheric conditions of the city of Najaf/Iraq. A thin layer of paraffin wax with and without Al_2O_3 nanoparticles was used under galvanized iron plate of basin to improve the productivity of the models. The results obtained were compared with the traditional model, and the following conclusions were attained.

i. PCM or NPCM layer works as heat storage after solar radiation decrease and extended the operation time of solar still.
ii. The small masses of PCM and NPCM more effective than large masses, which as solar radiation is able to melt it completely.

iii. The daily productivity of the model enhanced by 1 kg of NPCM and PCM are 6 and 5.6 L/ m^2 respectively, while the daily productivity of the traditional model is 5 L/m^2, i.e. With an increase of 20 and 12% compare to traditional model.
iv. Increase briny water amount in basin lead to decrease amount of daily water productivity.

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