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STUDY THE EFFECT OF FLOW WATER/AL_2O_3 NANOFLUID INSIDE MINI-CHANNEL FOR COOLING CONCENTRATED MULTI-JUNCTION SOLAR CELL

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ABSTRACT

In a Fresnel-based Concentrated Photovoltaic system, multi junction solar cells suffer from increased PV temperature, resulting in a decrease its electrical efficiency. This study design to investigate the influence of using Water/Al_2O_3 Nanofluid as cooling fluid on heat transfer enhancement and top surface temperature for multi-junction solar cell in the Fresnel-based Concentrated Photovoltaic thermal CPVt System. The CFD simulation was conducted on mini-channel under the concentrated multi-junction solar cell with using water/Al_2O_3 Nanofluid and pure water as coolant fluids. The Reynolds number is in the range of 15000-30000 were examined. The average Nusselt numbers augmented through increasing Reynolds numbers. The water/Al_2O_3 Nanofluid provides highest heat transfer enhancement of 23% compare with water in Fresnel-based CPVt system. The top surface temperature decreases as Nusselt number increases. The Nu_{avg} improves 21% with using of water/Al_2O_3 Nanofluid at lowest Reynolds number of 15000 and 23% at highest Reynolds number of 30000.The top surface temperature dropped from 337K to 327K at lowest Reynolds number of 15000 with using Water/Al_2O_3 Nanofluid as cooling fluid and from 323K to 315K at highest Reynolds number of 30000.This study has confirmed that the use of water/Al_2O_3 Nanofluid has significant influence on the dissipate the heat from Multi-Junction Solar Cell in Fresnel-based CPVt system which led to improve its electrical efficiency.
Keywords: *Nanofluids, mini-channel, simulation, Aluminum oxide nanoparticles, heat transfer.*

1. INTRODUCTION

Global energy consumption is increasing, and due to the limitations of fossil fuels, renewable sources must be developed and utilized. Renewable energy sources, sometimes known as green energies, have carved out a niche in the global energy consumption cycle (Al-Waeli et al., 2017; Hasan et al., 2017; Hasan, Sopian, & Ameen, 2018). Because of their good stability and unexpected increase in thermal conductivity even at low volume concentrations of nano particles, nanomaterials could have a promise as working fluids. The advantage through using water nanofluid include greater thermal conductivities than currently offered modeling methodologies, increased stability, and less pumping power loss due to pressure drop and tube wall resistance. Mohammed et al., (2013) demonstrated analysis using SolidWorks Flow Simulation, which is capable of thermal simulation. They were discovered that the used of nanofluid increased both thermal and electric efficiencies in photovoltaic thermal system. Thermal and electric efficiencies were determined to be 46.84 percent and 6.60 percent, respectively, at an inlet temperature of 100°C with mass flow rate of 540 liters per hour using nanofluid. In this scenario, the improvements in thermal, electrical, total, and exergy efficiencies were 1.66 percent, 5.17 percent, 2.08 percent, and 3.05 percent, respectively.

Bellos & Tzivanidis (2019) tested experimentally the effect of using cooling by water and nanofluids Al_2O3 in photovoltaic thermal system. The maximum performance of electric and thermal were 13% and 65% for photovoltaic module without cooling, and 11.47% and 56.08% for cooling photovoltaic thermal system with nanofluid at 0.5–0.5 concentration of (wt%). The results also indicated that the total efficiency photovoltaic thermal collector were 48.54% and 63.26%, respectively (Hooshmandzade et al., 2021). The Al_2O_3/water nanofluid was used to simulate the impact of cooling concentrated solar cells. The Fluid Flow and temperature field were simulated for different nanoparticle concentrations 1%-10%, nanoparticles sizes less than 120 nm, and flow rates ranging from 0.17–3.34 Liter per minute. The greatest enhancement ratio is 1.14 for an 8 percent concentration of nanoparticles, a Knudsen number=0.1 (Al_2O_3 with dp= 6 nm), and a Richardson number= 10. This research gives a useful technique for optimizing nanofluid cooling of CPVT solar receivers (Su et al., 2022).The effect of employing a heat sink, phase change material, and nanofluid to remove heat from Concentrated Solar Photovoltaic was simulated. The pack was intended to monitor the temperature of concentrated silicon Photovoltaic at 78°C with a more consistent temperature dispersion. A fluid phase transition material with a proven 97 percent level change provided the greatest thermal energy storage.

Rahmanian et al. (2021) carried out the impact of silicone oil nanofluids for cooling Concentrated Solar Photovoltaics in the CPVT collector was explored. The highest enhancement in thermal was 64% with flow 1% of Si-oil with MXene-nanoparticles at temperature of 150°C. electrical efficiency also improved with used Si-oil with MXene-nanofluids duo to high thermal conductivity. (Aslfattahi et al., 2020) investigated the impact of flow 0.50% graphene/H2O-nanofluid for cooling concentrated photovoltaic thermal collector. The results demonstrate that the improvements in total electrical power generated by

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the CPVT-TE with 0.5 percent graphene/water nanofluid and CPVT-TE compared to CPVT collector are 11.15 percent and 9.77 percent for the summer day(Rejeb et al., 2021). Tested The effect of cooling CPV-T spectral splitting by used nanofluid. The influence of glycol-ZnO nanofluid on thermal and electrical efficiencies was explored. (Huaxu et al., 2020) evaluated The effect of Al_2O_3-nanofluid on heat and power generation for CPV-T system (Deymi-Dashtebayaz et al., 2022).

Do et al. (2010) recommended efficient cooling method comprising heat-sink. The suggested cooling system's thermal performance is examined experimentally. studied the influence of used heat sink an inclined slope on the thermal efficiency. The recommended cooling method meets design limitations for optimum concentration photovoltaic solar performance. A modeling approach encompassing multi-physics disciplines is required to fully examine the performance of optical, thermal, and electrical for concentrated photovoltaic system in order to improve them in the further. A 3D numerical examination was conducted on CPVT system using a coolant fluid to reject the heat and CPC reflector. The thermal efficiency for the system during day time was demonstrated 57.6%. The type of Z-heatsink depresses temperature by reject the heat from solar cells and enhance the power marginally compared to the U shape design (El-Samie et al., 2020). The Solar reflectors reduce the amount of cost photovoltaic materials while keeping the amount of energy from the solar irradiance. The influences of solar system were calculated using this model. The findings indicate variations in solar cell efficiency, power generated, thermal energy produced, monetary value displaced, and global warming potential displaced when the system's residential hot water use was varied. This simulation may be used to identify the best system for a given set of inputs as well as the best working situations for size of system.

Pabon et al. (2020) tested CPV systems by cooling solar cells with high concentrations of solar radiation. Apart from dropping the electrical efficiency from photovoltaic cells with increasing the temperature, the significantly excessive thermal energy created might deteriorate the concentrator photovoltaic cells and cause irreversible damage. The impacts of various design factors on the cooling system's thermal performance, including intake velocity, working fluid characteristics, and cooling block geometry were studied numerically by(Lee et al., 2012).(Feng et al., 2016)Examined the effect of using a cycloidal Fresnel as a solar concentration system on thermal and electrical efficiency with fixing the focal line width. The absorber collected about 80% of the solar radiation. The peak electrical efficiency from photovoltaic solar cells was about 18%, the highest rate of heat reception for cooling water was around 45.0% through daytime with clear sky. The total efficiency for thermal energy and electrical energy was 55.0% at12:00 PM.(Wu et al., 2020)tested under clear sky the effect of using cylindrical Fresnel lens on the efficiency and power for CPVT system , the maximum electric performance was 18.0 percent at 12:00PM, the maximum thermal performance was 45 percent, and the total efficiency CPVT system was 55.0 percent.

Maatallah (2021) showed the electric, thermal and overall efficiencies CPVT collector with used heat sink-pin fins as cooling technique. The pin fins-heat sink had the lowest surface cell temperature at all Re, the thermal performance stayed 9percent better than conventional solar collector system. Due to increasing disturbance in the stream wise direction, pressure drop for the inline heat sink rose dramatically at Reynolds numbers of 726, reaching a value of P=288.20 Pa. (Kerzmann & Schaefer, 2012)used simulation with 2D model to examined the influence of used active cooling technique on the electric efficiency for triple-junction cells. The model was developed by used EES software to evaluated the impact of used active cooling technique on the electric efficiency for CPVT in different weather condition.(Sun & Shi, 2009)used model to studied the effect of cold air on heat transfer enhancement for PVT-CPC. The findings revealed that when solar irradiance increased, the Photovoltaic cells temperature upraised. In the CPVT system, forced and free heat transfer in back of CPV cells give a significant cooling influence. The design and developed useful CPVT collector. On The Analysis Of Actively Cooled Concentrating Photovoltaic Receiver(Tag & Shouman, 1982). (Royne & Dey, 2007a)(Royne & Dey, 2007b)studied the effect of using array of jets as Cooling system to remove the heat from high concentration photovoltaic cells. they presented average and local heat transfer factors and pressure drop. They exhibited the electric efficiency for array CPVT improved with increased coefficients of heat transfer.(Han et al., 2011) investigated numerically the direct-immersion for cooling the CPVT system. They presented 3D simulation the results of used various cooling fluids on thermal performance for array CPV cells. The cooling by direct-immersion was used to decrease the temperature of CPV cells. The performance of CPV cells was influenced by mass flow rate of cooling liquid, as well as Thermophysical properties of the liquid, studied the effect of cooling by heat-pipe on the efficiency of FLCPVT collector. A part of the energy is turned to electricity, while the rest is wasted heat. improved conversion efficiency with low temperature of CPV cells. Efficient cooling technique for CPV cells must use for design efficient Fresnel lens CPVT. A heat-pipe was formed to dissipate passively the heat from the CPV then dissipated heat and rejected to atmosphere. The heat-pipe with heat-sink, with a heat flow of 40 W/cm2, used natural convection to dissipate heat to the atmosphere when ambient-temperature increase to 40°C. Using natural convection from the back plate, however, the temperature of PV cells above 110°C (Anderson, Tamanna, et al., 2008)(Anderson, Dussinger, et al., 2008).

Deng et al. (2009 observed the effect of effective cooling technique with using liquid metallic to remove the heat from PV cells at low melting point. The results indicate that cooling optical focusing photovoltaic solar cell with liquid metal is a highly effective and efficient method of heat dissipation. This thermal management strategy has a lot of potential for future solar power generating systems, since it might encourage the use of concentrating photovoltaic cells on a huge scale.(Cheng et al., 2009) develop 2D mathematical model for Cooling technique in CPV . The results showed use tracking system with cooling were effective methods to provide maximum output power from CPV and maximize the utility of solar energy while lowering the cost, and hot water might be provided with concentrating solar systems. When the concentration ratio increased, the system's electrical efficiency improved, the flow rate of cooling water had an impact on performance.(Mittelman et al., 2007) evaluated the thermal, electric performance and output power for CPVT system. Temperature of CPVT collector reached above 100°C, and the hot water may be used to power operations including refrigeration, desalination, and steam production. CPVT collector with absorption-cooling system was examined in terms of efficiency and cost. The results demonstrated that, under a variety of financial situations, the mix power producing plant with solar cooling and may be equivalent or better than conventional systems, develop densely packed system with direct immersion-liquid cooling technique to dissipated the heat from concentrated triple-junction cells to improve the electrical efficiency. The electrical efficiency of triple junction solar cells increased with increased of liquid layer thickness (Han et al., 2018).

The Experiments test and CFD analysis exhibited the result of cooling technique solar cells on the performance for photovoltaic/thermal system (Dezfouli et al., 2017; Hasan, Sopian, & Fudholi, 2018; Jaaz et al., 2017)(Hasan, Alquziweeni, et al., 2018; K. Sopian et al., 2017; Naje et al., 2016)(K. A. Ameen et al., 2020)(Ameen et al., 2022) . (Hussain et al., 2022) Construction and testing of the humidification-dehumidification desalination system took place in Baghdad, Iraq. The HDH system under investigation comprises of 6 PTSCs with a combined aperture area of 8.772 m2 each. The performance of the system was examined in relation to the flow rate of salty water and the HDH air-water configuration cycles. During the testing period, freshwater production peaked at roughly 6.37 lit/day, whereas salty water productivity peaked at 1.062 lit/hr at a flow rate of l lit/min. Freshwater production suffers when the flow rate of saline water is increased above 1 lit/min. The closed air open water circuit was the ideal setup for the air-water cycle.(Ibrahim et al., 2022) The techno-economic viability of SWHS for swimming pools in vacation destinations and hotels was explored. The trial findings showed that a system with 28 solar absorber collectors and a 1-hp pool pump is the proper size. System cost and COE were $8251.37 and $0.0095 per kWh, respectively. The price to heat one liter of water was $0.387; the payback time was 14 months. Solar water heating was the best option for hotels and resorts for a variety of reasons (Lertnuwat, 2022). The impact of placing winglet vortex generators at various places in rectangular duct-type air heaters was examined numerically. The absorber plate and the insulation plate, which is located across from the absorber plate, were the two places that were examined. Perforated rectangular winglet vortex generators (P-RWVG), rectangular winglet vortex generators (RWVG), perforated trapezoidal winglet vortex generators (P-TWVG), and trapezoidal winglet vortex generators (TWVG) were the four winglet vortex generator forms that were tested. According to the results, in the situations of P-RWVG, RWVG, and P-TWVG, the winglet vortex generators should be installed on the opposite insulating plate to improve heat transfer capabilities.(Faisal et al., 2021) The heat transfer mechanisms that occurred within the Single Slope Solar Still were examined numerically. The 3D mathematical model was created and validated using Comsol Software. Four various tank designs, including sphere, half-sphere, cone, and flat plate, were compared as part of the inquiry. The research found that the maximum production and water temperature were associated with the half-sphere design, which had a capacity that was 2.5 times that of conventional SSSS. Compared to the SSSS's efficiency without preheating, it was increased by 27%.(Ibrahim & Kasem, 2022).

Utilizing CFD ANSYS FLUENT software, a unique thermal analysis of the absorber/receiver circular pipe of the parabolic trough solar collector system was conducted for laminar and turbulent (k-model) fluids flow. The pattern of temperature distribution across the pipe absorber was exhibited, velocity vectors, pressure contours, and temperature contours were investigated, and significant improvements in heat transfer and velocity were found. Discussion is held on the effects of increasing the heat flow toward the pipe wall. While drag and skin friction coefficients fall as Reynolds number rises, the heat transfer coefficient and Nusselt number increase. In laminar flow conditions, the estimated thermal performance factor of PTC was determined to be 74%. By comparing the model's output with output from an analytical model, the model was validated, and the validation verified that the CFD analysis was accurate.(Zhao & Zheng, 2021) The triangular-tube phase change heat accumulator's performance was optimized from three angles. First, compare the three kinds of tubes: the conventional round tube, the square tube, and the elliptical tube. The equilateral triangular tube offers the optimum heat storage and release properties, according to the results.(Kumar et al., 2021) By including different fin shapes on the bottom of the absorber plate in single-pass and double-pass solar thermal collectors, it was shown how to increase thermal performance. the impact of various fin shapes employed by researchers to increase the thermal efficiency of thermal collectors. It has been researched how the Fin's geometry and design affected turbulence and thermal performance.(Li et al., 2020) Three molten salts were used as the phase change materials in a computational test of the charging and discharging operations of a three-stage cascaded latent heat thermal energy storage unit. A vertical shell-and-tube heat exchanger with the PCM and air filled on the shell side made up each stage of the device. During the completely charging and discharging operations, the PCMs' liquid fractions, temperatures, and accumulated thermal energy, as well as the impacts of the HTF intake temperature, were investigated. The findings indicate that lower PCM melting temperatures lead to quicker charging rates and more heat being emitted in cascaded LHTES systems. The choice of PCMs allows the cascaded LHTES systems to have more flexibility than non-cascaded LHTES systems (Sharma et al., 2020). The overall effect of the relative alterations in the thermophysical characteristics of the nanoparticle was used to calculate the increase in exergy efficiency of nanofluid flow via heat exchanger. In comparison to simple conventional fluids, nanofluids moving via heat exchangers have a higher energy efficiency. By disrupting the laminar sublayer close to the heating surface, the energy efficiency of nanofluid flow via heat exchangers may be increased. This can be done effectively by using obstacles as roughness components. This increase, however, came at the price of a reduction in pressure drop. Additionally, it was shown that energy efficiency increased as the volume percentage increased and nanoparticle diameter decreased.

Evans (1981) presented a streamlined process for estimating the monthly average electricity production of solar arrays over the long term. It could only be used with passively cooled, max-power tracked arrays, although it worked with both 2-D tracked concentrators and south-facing fixed flat arrays. The method produces a monthly average array efficiency that, when multiplied by the monthly array insolation, results in the electrical energy output. The procedure combines basic parameters characterizing the array with the local monthly mean temperature and the monthly KT (ratio of the total radiation on the horizontal to the extraterrestrial radiation).This study design to investigate the influence of using Water/Al_2O_3 Nanofluid and pure water as cooling fluids on heat transfer enhancement and top surface temperatures for multi-junction solar cell in the Fresnel-based Concentrated Photovoltaic thermal CPVt System. The CFD simulation was conducted on mini-channel under the concentrated multi-junction solar cell with using water/Al_2O_3 Nanofluid and pure water as coolant fluids. The Reynolds number is in the range of 15000-30000 were examined.

2. THE CFD MODEL

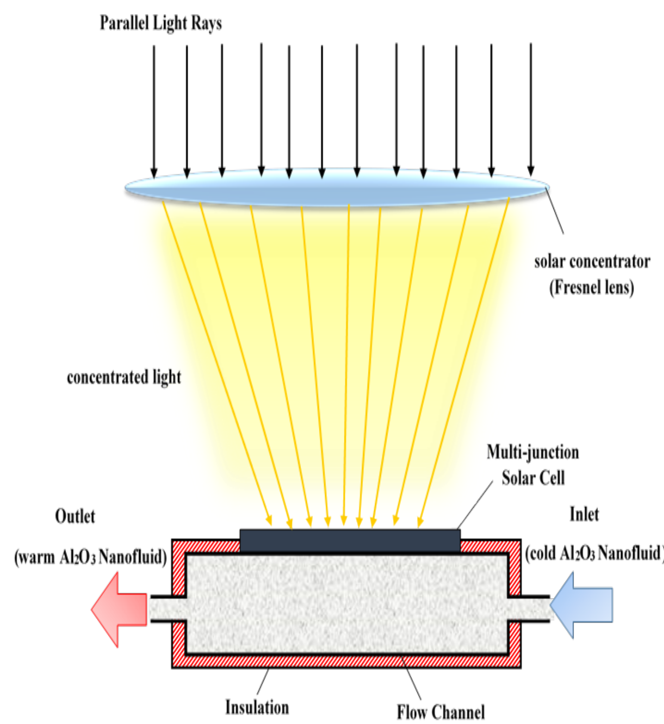

Fig. 1 schematic diagram of Fresnel-based CPVt system

The Physical-Modeling and CFD Evaluation of flow Water/Al_2O_3 Nanofluid and pure water in the mini-channel for dissipate the heat from Fresnel-based CPVt system is presented in Fig. 1. the utilized of Fresnel lens increases the solar radiation intensity but also increase the temperature of Multi-Junction Solar Cell by concentrate the solar energy into a spot. The same diameter of inlet and outlet (5mm) are examined. The mini-channel of water under Fresnel-based CPVt system with dimensions are (l=50mm & w=50mm). The Water/Al_2O_3 Nanofluid and pure water are selected as the cooling fluids. The CFD simulations are used to solve governing equations for Fresnel-based CPVt system. The computational domain's boundary conditions are given for the current problem, as illustrated in Fig. 1. The Physical model show the efficient cooling technique for Fresnel-based CPVt system, uniform heat flux applied direct to the top surface of the channel. At the top wall of the cooling channel, a heat flux of 500W/cm^2 is applied. In current simulation K-epsilon (k-ε) turbulence model with The RNG approach were considered. The FVM was used to solve the For Newtonian fluids, the Navier/Stokes equations numerically define momentum and mass transfer. The SIMPLE pressure-velocity coupling algorithm was chosen to evaluate the pressure field. At the intake, the turbulence intensity was controlled at 1%. The CFD simulation was conducted on mini-channel under the concentrated multi-junction solar cell with using water/Al_2O_3 Nanofluid and pure water as coolant fluids. The Reynolds number is in the range of 15000-30000 were examined.

3. RESULTS AND DISCUSSION

3.1 THE EFFECT OF WATER/AL_2O_3 NANOFLUID ON HEAT TRANSFER ENHANCEMENT

This section analyses the effect of using water/Al_2O_3 Nanofluid and pure water for cooling concentrated multi-junction solar cell. The effect of using Aluminum oxide nanoparticles on the Nusselt number with different mass flow rate inside mini-channel for cooling Fresnel-based CPVt system are investigated. The Variation of average Nusselt numbers with different Reynolds number for flow pure water and Water/Al_2O_3 Nanofluid inside mini-channel in Fresnel-based CPVt system presented in Fig. 2. The results show that the average Nusselt numbers by using Water-Al_2O_3 as coolant fluid higher than pure water under same Reynolds numbers. The Water-Al_2O_3 nanofluid provide maximum Nu_{avg} at different Re. In this point, the thermal conductivity improves with using Al_2O_3-nanoparticles in water-Al_2O_3 nanofluid which led to enhance heat transfer in mini-channel. The Nu_{avg} enhances 21% with using of water/Al_2O_3 Nanofluid at lowest Reynolds number of 15000 and 23% at highest Reynolds number of 30000.It was also noted that the Nu_{avg} rises with the increases Reynolds number for all cooling fluids. The heat transfer coefficients augmentation rises up to 23% when the Reynolds number is raised from 15000 to 30000.

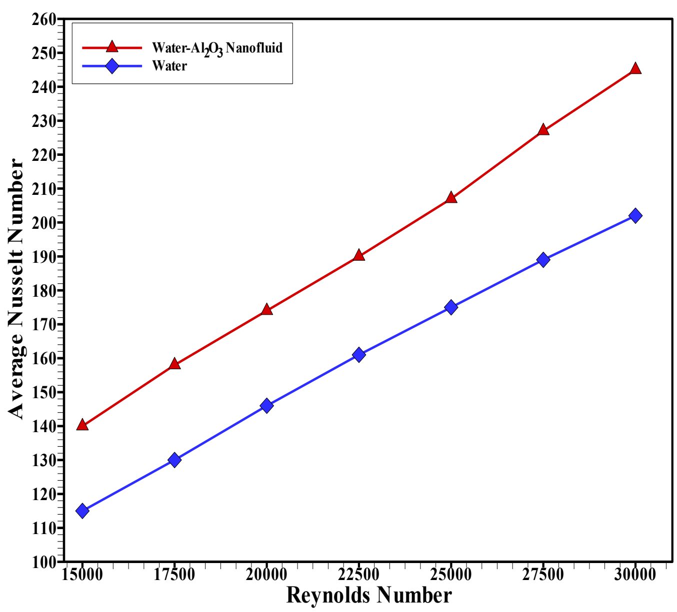

Fig. 2 The average Nusselt numbers with Reynolds number Variation for flow pure water and Water/Al_2O_3 Nanofluid inside mini-channel in Fresnel-based CPVt system.

3.2 THE INFLUENCE OF WATER/AL_2O_3 NANOFLUID ON TOP SURFACE TEMPERATURE OF MINI-CHANNEL

Figure 3 illustrates top surface temperature of mini-channel by using water-Al_2O_3 nanofluid and pure water for cooling Fresnel-based CPVt system. The results show that the top surface temperature of concentrated

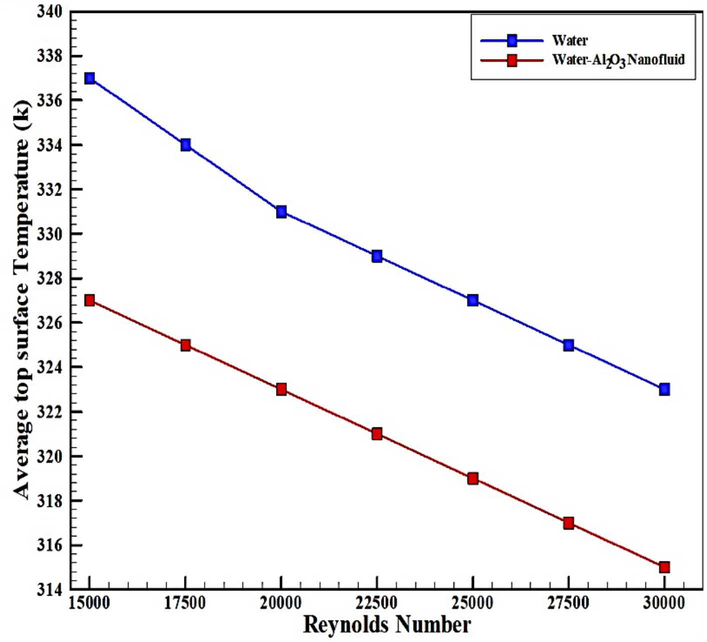

Fig. 3 The top surface temperature with Reynolds number Variation for flow pure water and Water/Al_2O_3 Nanofluid inside mini-channel in Fresnel-based CPVt system.

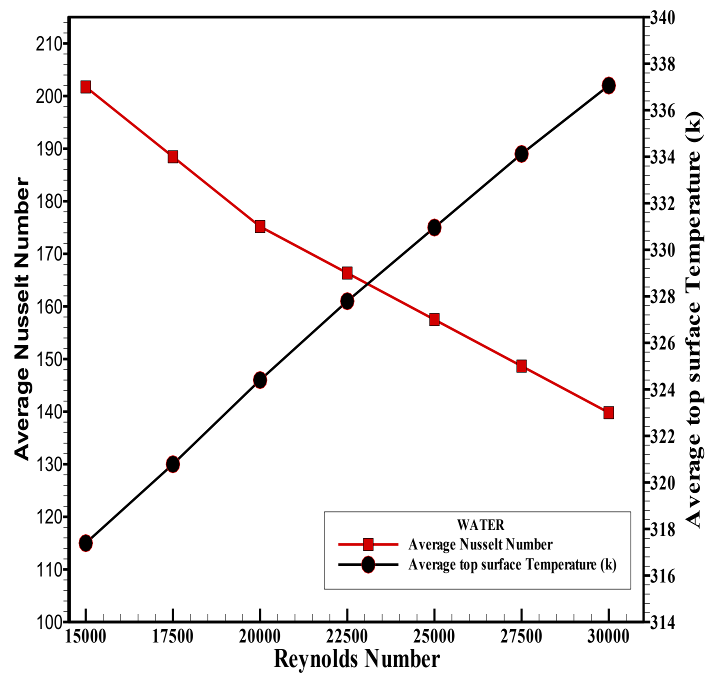

Fig. 4 The average Nusselt numbers, top surface temperature and Reynolds number Variation by using Water as coolant fluid in Fresnel-based CPVt system.

photovoltaics with using water-Al_2O_3 nanofluid has lower than water at same Reynolds number because the Aluminum oxide nanoparticles have a high thermal conductivity. The Top surface temperature dropped from 337K to 327K at lowest Reynolds number of 15000 with using Water/Al_2O_3 Nanofluid as cooling fluid and from 323K to 315K at highest Reynolds number of 30000. Some of the benefits of using nanofluids as cooling fluids are that they have higher thermal conductivities than what is predicted by current macroscopic models. Excellent stability and almost no loss in pumping power due to pressure

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drop and pipe wall wear. The thermal conductivity of nanofluids depends on the size, shape, and material of the nanoparticles that are dispersed in the base fluids. a recent study showed that nanofluids have better thermal properties than the base fluid. For example, their thermal conductivity and convective heat transfer coefficients are both higher (water). The Variation average Nusselt numbers, top surface temperature and Reynolds number by using pure Water and Water/Al_2O_3 Nanofluid as coolant fluids in Fresnel-based CPVt system displayed in Figs. 4-5. From the results, it was clearly noted that the top surface temperature decreases as average Nusselt numbers and Reynolds number increases. The Top surface temperature dropped from 327K to 315K with increasing average Nusselt numbers from 140 to 245 by rise Reynolds number from15000 to 30000 with using Water as cooling fluid. The Top surface temperature dropped from 337K to 323K with increasing average Nusselt numbers from 115 to 203 with increase Reynolds number from15000 to 30000 when using Water/Al_2O_3 as cooling fluid.

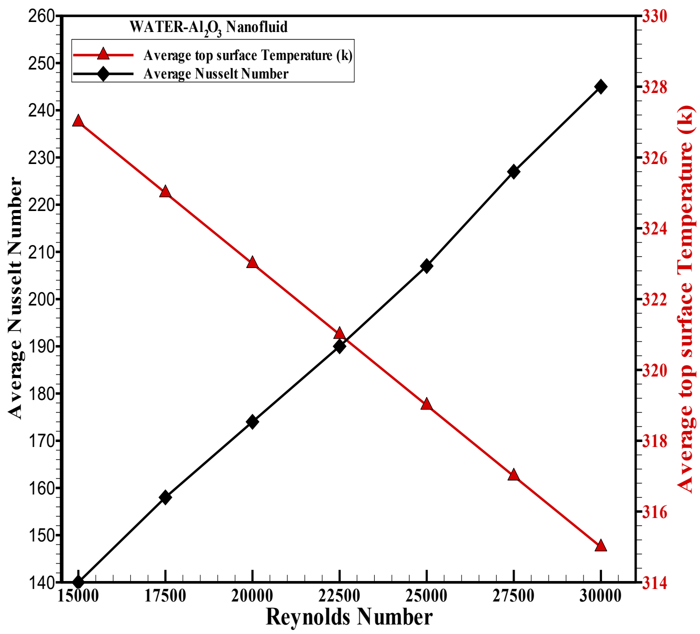

Fig. 5. The average Nusselt numbers, top surface temperature and Reynolds number Variation by using Water/Al_2O_3 Nanofluid as coolant fluid in Fresnel-based CPVt system.

3.3 THE EFFECT OF WATER/AL_2O_3 NANOFLUID AND PURE WATER ON ELECTRICAL EFFICIENCY

This section analyses the effect of using water/Al_2O_3 Nanofluid and pure water on electrical efficiency of photovoltaic solar cell. The electrical efficiency of photovoltaic solar cell can be calculated deponed on the temperature of photovoltaic solar cell(Evans, 1981). After measuring the photovoltaic solar cell, a photovoltaic solar cell efficiency is obtained from Eq. (1)

$$\eta_{pv}=\eta_{ref}\left[1-\beta_{ref}\left(T_C-T_{ref}\right)\right] \quad (1)$$

Where η_{ref} is the reference efficiency of the photovoltaic solar cells , β_{ref} is a temperature coefficient $\beta_{ref}=0.0045°C$, T_C is the cell temperature and T_{ref} is the reference temperature.

The vibration of different Reynolds number and the electrical efficiency for solar cells with using Water/Al_2O_3 Nanofluid as coolant fluid in Fresnel-based CPVt system presented in Fig. 6. From the, it is clearly seen that the electrical efficiency of photovoltaic solar cells increases with the increases Reynolds number for both cooling fluids. the electrical efficiency of photovoltaic solar cells with using Water/Al_2O_3 Nanofluid as coolant fluid in Fresnel-based CPVt system higher than pure water. The electrical efficiency of Fresnel-based CPVt system improves 9% at Re=15000 and 7% at Re=30000. The Variation of the electrical efficiency of solar cells at different temperature of Photovoltaic solar cell with using Water/Al_2O_3 Nanofluid as coolant fluid in Fresnel-based CPVt system are displayed in Fig. 7.The results show that the electrical efficiency of photovoltaic solar cells drops from 19% to 17.89% with rise the temperature of PV module from 309.5 K to 321.5K by using Water-Al_2O_3 as coolant in Fresnel-based CPVt system. It is also noted that the electrical efficiency of photovoltaic solar cells drops from 17.75% to 16.49% with rise the temperature of PV module from 323K to 337K by using pure Water as coolant in Fresnel-based CPVt system. The Water-Al_2O_3 nanofluid provide maximum electrical efficiency at different temperature of PV module. In this point, the thermal conductivity improves with using Al_2O_3-nanoparticles in water-Al_2O_3 nanofluid which led to enhance heat transfer in mini-channel. The Nu_{avg} enhances 21% with using of water/Al_2O_3 Nanofluid at lowest Reynolds number of 15000 and 23% at highest Reynolds number of 30000.It was also noted that the Nu_{avg} rises with the increases Reynolds number for all cooling fluids. The heat transfer coefficients augmentation rises up to 23% when the Reynolds number is raised from 15000 to 30000.

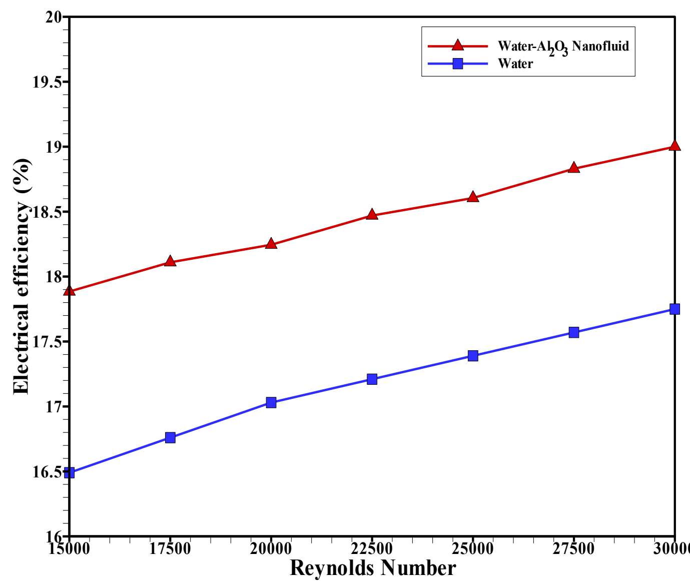

Fig. 6 The vibration between Reynolds number and the electrical efficiency of solar cells with using Water/Al_2O_3 Nanofluid as coolant fluid in Fresnel-based CPVt system.

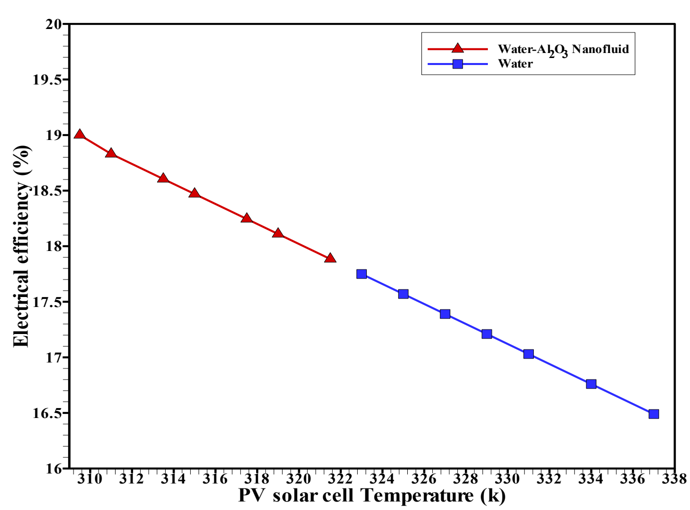

Fig. 7 The Variation of the electrical efficiency of solar cells at different PV solar cell temperature with using Water/Al_2O_3 Nanofluid as coolant fluid in Fresnel-based CPVt system.

4. CONCLUSIONS

The current simulation design to show the influence of dissipate the heat from the concentrated multi-junction solar cell with using water/Al_2O_3 Nanofluid. The 2D simulation used to study the heat transfer augmentation, fluid flow and top surface temperature of concentrated multi-junction solar cell of by using water-Al_2O_3 Nanofluid and pure water. The CFD was used to investigate the continuous heat flux on the top surface wall and turbulent flow of water in the channel with varied Reynolds numbers (15000to30000). The numerical simulation yielded the average Nusselt numbers, as well as the top surface temperature. The following are the findings reached.

The following conclusions were drawn as follows:

1. The Reynolds number increases led to increase Nusselt number for all cases.
2. The water/Al_2O_3 Nanofluid provide higher Nusselt number than pure water.
3. The Nu_{avg} improves 21% with using of water/Al_2O_3 Nanofluid at lowest Reynolds number of 15000 and 23% at highest Reynolds number of 30000.
4. The water/Al_2O_3 Nanofluid use to dissipate more heat and reduce the top surface temperature for multi-junction solar cell higher than pure water.
5. The top surface temperature dropped from 337K to 327K at lowest Reynolds number of 15000 with using Water/Al_2O_3 Nanofluid as cooling fluid and from 323K to 315K at highest Reynolds number of 30000.

This study confirmed that the use of water/Al_2O_3 Nanofluid as coolant fluid are very important for remove the heat from concentrated multi-junction solar cell with high heat transfer coefficient.

NOMENCLATURE

C	heat capacity ($J/m^3 \cdot K$)
c_p	specific heat ($J/kg \cdot K$)
Nu	Nusselt number
k	thermal conductivity ($W/m \cdot K$)
q''	heat flux (W/m^2)
Re	Reynolds number
t	time (s)
T	temperature (K)
u	interfacial velocity (m/s)
x	coordinate (m)

Greek Symbols

β	temperature coefficient
η	efficiency
ρ	density (kg/m^3)
σ	Stefan-Boltzmann constant ($W/m^2 \cdot K^4$)

Subscripts

avg	average
pv	photovoltaic
ele	electrical
ref	reference
c	cell

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