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INVESTIGATION OF AIR INLET HEIGHT ON THE PERFORMANCE OF SOLAR TOWER SYSTEM UTILIZED WITH FLAT PLATE AND POROUS ABSORBER

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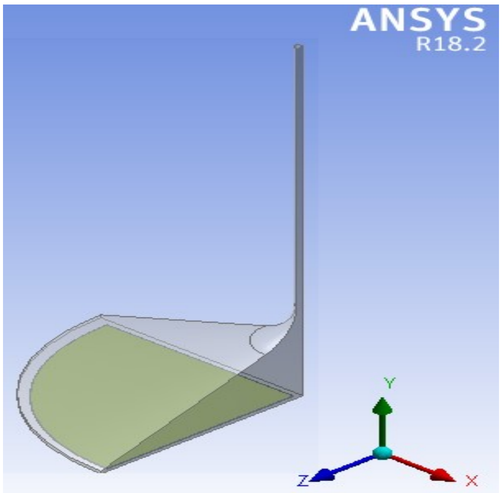
Abstract

The performance of the solar updraft tower system (SUTS) investigates numerically by comparing between two quarters circular thermal solar collectors (with and without porous absorber plate). The porous copper foam 10 PPI and porosity 0.9 is used as an absorber plate. The present work aims to study the effect of variation the heights of the air inlet (3, 5, and 8) cm respectively utilized conventional flat and porous metal foam absorber plate. The physical quantities inside flat and porous absorber plate are simulated. A set of assumptions are adopted such as a steady state condition, three dimensional, Darcy and energy equations. The numerical simulation are approximated k- ϵ turbulent model by a Re-Normalization Group (RNG) and discrete ordinates (DO) radiation model equations. The numerical study is analyzed by using ANSYS FLUENT program (version 18.2) to solve the governing equations. The results showed that variation in the heights of the air inlet with the presence of the porous absorber plate is more effective than the conventional flat plate on the performance of the SUTS. The maximum performance of the system is predicted with the height of the air inlet of 3 cm by using the porous metal foam absorber plate

Keywords: Solar tower, porous metal foam, performance of the solar tower, ANSYS FLUENT, renewable energy.

I. Introduction

Most studies and investigations of the SUTS aim to enhance the thermal performance of the solar air collector that affected on the solar tower to ensure the air circulation for each density gradient and output power to produce the electric energy). One of the most important modern methods inserting the porous metal foam as an absorber plate that used to enhance the thermal efficiency of the solar air collector at which bases on the reducing of the flux density as an increase of the area of the heat transfer between the solar collector and theworking fluid. The basic



working principle of SUTS model is shown in figure1. [XV] Investigated numerically the effect of using a semicircular solar collector (with and without metal foam absorber plate) on the performance of the SUTS. The porous absorber. Results showed absorber. Results showed that the presence of the porous absorber gives a more thermal performance of the SUTS compared with the flat absorber plate. [XI] Applied the finite element method (FEM) to simulate a circular quarter collector using carbon nano tube (CNT) - water nanofluid in the cavity for different inclination angles from $\phi = 0^{\circ}$ to $\phi = 60^{\circ}$ at Rayleigh number (Ra=105–108) with changing the dimensions times. The air flow through a solar chimney power plant by using ANSYS FLUENT was studied by [VII] to simulate the night-time operation of the solar chimney. The model of the porous packed bed was used to simulate the thermal storage layerof the collector floor. Results showed that using the thermal storage layer as a porous material is the best way to model the solar collector with a no-slip, mixed convective and radiative boundary. [XVI] analyzed the indirect model dryeran by assembling the porous absorber plate with the tower tube to investigate the effect of the porosity, material, absorber inclination angle and the dryer height on the thermal performance of the heat transfer and the airflow inside the porous absorber plate. The mass and heat transfer models of the porous medium inside the solar chimney system were presented by [V] to investigate numerically the impact of the porosity, the diameter, the thickness and the velocity of the air inlet on the air temperature distribution. The result was shown that the bigger porosity leaded to a lower surface temperature and higher air temperature as a result of the bigger particle diameter that given the low temperature for the solid surface and increase of the air passage inside the SUTS. [XVII] Compared a composite flat plate with porous absorber inside the solar tower system. The result showed that the presence of the porous absorber surface gaves a more interface area and higher coefficients of the heat transfer . The result indecated that the air flow and the heat flow with porous absorber surface was heated rapidly inside the greenhouse collector. [XII] Investigated numerically the SCPP by studing the behiviour of the air flow inside the SCPP under Iraq weather conditions. A set of parameters was supposed to solve the governing equations by using ANSYS FLUENT software such as the collector diameter and the tower height in different working conditions for diffrent solar intensity (450,600,750 and 900 W/m^2) to get the optimal structure designed. Results showed that the change of the diameter and the chimney height was given a significant impact on the system performance. The current study showed that the weather of Iraq was a suitable to analyze this the system. [I] Investigated experimentally the effect of ground temperature and periphery height on the solar tower system to conclude that the minimum height of the air inlet gives the maximum performance of the solar tower system.

During a review of all the previous literature, it was found that there were a few numerical studies that examine the possibility of enhancing the performance of the SUTS by using porous metal foam as an absorber plate. The main objective of the research is studying the effect of variation the height of the air inlet on the performance of the SUTS with the presence of the metal foam as an absorber plate for a quarter circular thermal solar collectors. This the effect can be seen through studying the porous absorption wall temperature, air temperature, air velocity along the tower, pressure and performance of the SUTS. All the above mentioned is compared with the conventional flat plate under the same Baghdad/Iraq weather conditions.

II. Numerical Simulation:

The numerical analysis is presented for three-dimensional, two circular quarter collectors, steady state and natural convection heat transfer. The working fluid is air that used as an ideal gas. the buoyancy model simulation is carried out by determining the gravity (-g) in the y-direction. 1atm. is selected as a reference of the air pressureas. the numerical simulation is carried out with and without metal foam absorber plate. Copper metal foam 10 PPI and porosity 0.9 are used in this study. The porous copper absorber plate is modeled to choose the best height of the air inlet of (3, 5, and 8) cm respectively, that affected on improvement of the SUTS. And compared with the conventional flat plate modeling at the same changing parameters and weather conditions. The ANSYS FLUENT provides the ability to model, mesh, appropriate boundary conditions and simulating them under Baghdad/Iraq weather conditions.

Governing Equations

Three dimensional fluid equations of the continuity , the momentum and the energy are solved by using ANSYS FLUENT to determine the air flow properties. **[**VII**]**. The conservation of mass (continuity equation) can be illustrated as [XIV];

- **Continuity Equation**

$$\frac{\partial \rho}{\partial t} + \vec{\nabla}.(\rho \vec{v}) = 0 \qquad (1)$$

According to the assumptions, the flow is incompressible fluid, the continuity equation can be simplified to:

$$\left(\overrightarrow{\nabla}.\vec{v}\right) = 0 \quad (2)$$

- **Momentum Equation**

The momentum equation can be written as followes **[VII];**

$$\vec{v}\overrightarrow{\nabla}.\vec{v} = -\frac{1}{\rho_O}\overrightarrow{\nabla}P + \frac{\mu}{\rho_O}\overrightarrow{\nabla}^2\vec{v} + \vec{g}[1 - \beta(T - T_o) \quad (3)$$

Where ***P*** represents the static pressure and the vector $\vec{g}$ is the gravitational acceleration which equal to (0 m/s^2) in the x- and z-directions and equal to (-9.81 m/s^2) in the y-direction.

- **Conservation of Energy** [VII]:

$$\vec{v}.\overrightarrow{\nabla}T = \alpha\overrightarrow{\nabla}^2T \quad (4)$$

Where $\alpha = \frac{k}{\rho C_P}$

The enthalpy of the fluid (***h)*** is expressed as:

$$h = \int_{T_0}^{T} C_p\, dT \quad (5)$$

One of the assumptions that can be accommodated in the governing equations is that of the Boussinesq model of buoyancy in the conservation of momentum equation. The air density is only a function of temperature by assuming the Boussinesq buoyancy model, and can be determined in terms of coefficient of the thermal expansion, β [VII]:

$$\beta = -\frac{1}{\rho}\left(\frac{\partial\rho}{\partial T}\right)_P \quad (6)$$

Equation (6) represents how the density of the fluid varies with the temperature. Since the temperature change within the solar tower system is small, the density of the fluid is expressed by the following equation;

$$(\rho - \rho_o) \approx -\rho_o\beta(T - T_o) \quad (7)$$

Equation (7) is used only in the FLUENT program to calculate the density associated with the buoyancy in the conservation of momentum equation. The density can be expressed in the continuity equation, the energy equation and the left side of the momentum equation as the reference density, $\boldsymbol{\rho_o}$ due to incompressible flow.

Formulation of Porous Copper Foam

The main objective of this research is to use porous copper foam as a heat-absorbing surface of the solar tower system. Therefore, a proper model of the porous surface in ANSYS FlUENT is required to take into account the heat transfer to the flow of the air towards the tower. ANSYS FLUENT program calculates the heat transfer by conduction, convection and radiation in the porous absorber area. The porous absorber model interprets the air that moves between pore particles and reacts with them.

Adding a pore model in simulation adds an additional source, $\vec{S}$, to the conservation of momentum equation;

$$\vec{S} = -(\frac{\mu}{a}\vec{V} + C_F\frac{1}{2}\rho|\vec{V}|\vec{V}) \tag{8}$$

The first term in the equation (8) is the Darcy term and the second term is the Forchheimer (or inertia resistance) term, metal foam resistances to the flow of air where a and C_F are the permeability and the inertial drag factor respectively, of the metal foam. They are calculated by the following [IV];

$$a = 0.00073(1-\varepsilon)^{-0.224}(\frac{d_f}{d_p})^{-1.11}(d_p)^2 \tag{9}$$

$$C_F = 0.00212(1-\varepsilon)^{-0.132}(\frac{d_f}{d_p})^{-0.163} \tag{10}$$

Where ε , d_f and d_p are porosity of the porous copper foam, the ligament diameter and the pore diameter respectively.

The effective thermal conductivity $keff$ is estimated as the volume average of the conductivities of solid and fluid porous material which are denoted by [VIII];

$$k_{eff} = \varepsilon k_f + (1-\varepsilon)k_s \tag{11}$$

Modeling Geometry

i. Geometry Creation

The geometry of the SUTS is created by Solid Works program (2016). the radial directions represent in ANSYS FLUENT by (x and z) coordinates, while the vertical direction by (y) coordinat.. Figures (2 and 3) show the main components and dimensions of the SUTP without and with porous copper foam absorber plate in each a quarter circular thermal solar collector. The SUTS is designed to generate the output power that based on the created geometry, so the present study is carried out on the quarter shape of the SUTS by using the following dimensions; two a circular quarter solar collectors with a radius of 2 m. One of the two collectors contains a flat (Copper) absorber plate (r= 1.75 m and t=1mm) and the other collector a porous (Copper Foam) absorber plate (r= 1.75 m and t=10mm). The height of the air inlet is changed at (3, 5, and 8) cm. The tilt angle of the collector roof at 22.5°, updraft tower height 3.5 m, and the diameter of each tower is 6.5cm.

ii. Mesh Generation

Figure 4 presents the mesh which uses to model the SUTS using ANSYS FLUENT. The mesh of the model geometry is 3-D with a triangular mesh type. The accuracy of the temperature and velocity distribution is increased by using (mesh → insert → inflation) that selected feom the mesh options. To regulate the mesh shape at the edges of the metal foam is chosen (mesh → insert → edge sizing) from the mesh options. In the case of the porous metal foam, the computations are carried out with the various elements depending on the heights of the air inlet section (It starts from 1552150 elements and increase by depending on the above selected descriptions). While in the case of the conventional flat absorber plate are different depending on the case (It starts from 938130 elements and increase with the height of the air inlet section). After reaching a successful mesh, the models were exported to ANSYS FLUENT for setup and analysis process.

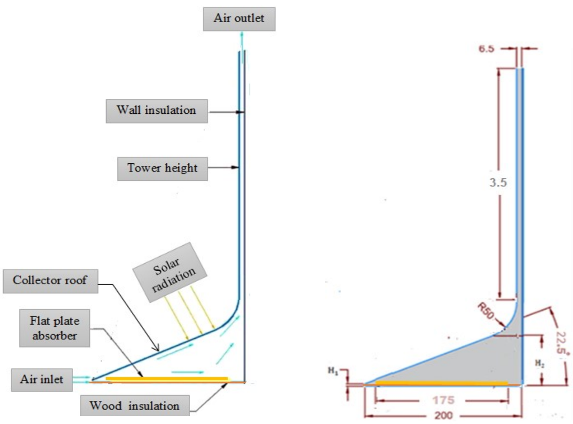
iii. Numerical Setup

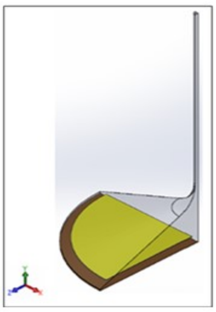
- **Setting Models**

In the present simulation, equation of the energy is activated to set up the ANSYS FLUENT simulation. The effect of the full buoyancy force is determined by selecting k- ϵ turbulent model and choosing Re-Normalization Group (RNG). Two equations are applied to calculate the specific turbulent of the kinetic energy (k) and the rate of turbulent dissipation (ϵ), where:

$$\vec{\nabla}.(\rho k\vec{v}) = \vec{\nabla}.\left[\left(\mu + \frac{\mu_t}{\sigma_k}\right)\vec{k}\right] + G_k + G_{b_t} - \rho\epsilon \qquad (12)$$

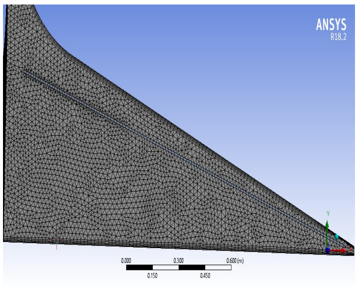
$$\vec{\nabla}.(\rho\epsilon\vec{v}) = \vec{\nabla}.\left[\left(\mu + \frac{\mu_t}{\sigma_\epsilon}\right)\vec{\epsilon}\right] + \rho C_1 S_\epsilon - \rho C_2\frac{\epsilon^2}{k+\sqrt{v\epsilon}} + C_{1\epsilon}\frac{\epsilon}{k}C_{3\epsilon}G_b \qquad (13)$$





Symble	Discrption	Selected specification
H_1	Height of air inlet section	(3,5,8)
H_2	Height of collector exit section	(70,72,75)

Fig. 2: Schematic diagram of the physical domain.



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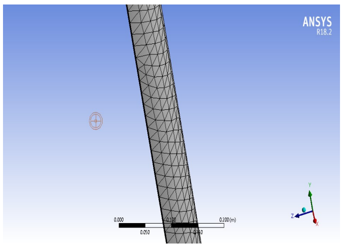

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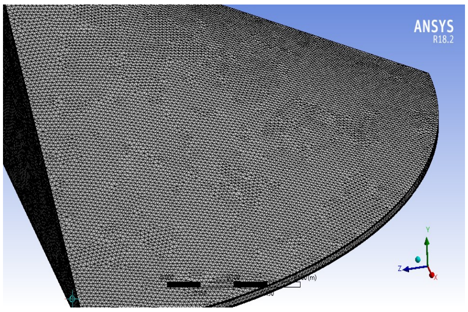


-c-

Fig. :3 (a-c): Mesh Generation of the Used Models.

The radiation heat transfer equation is solved by selecting the model of discrete ordinate (DO). The discrete ordinate is chosen due to the semi-transparent walls design and this the model can be operated well through the full range of the optical thickness.

The radiative transfer equation (RTE) for an emitting, absorbing, and scattering medium at the position r in the direction s is expressed as follows; [III]

$$\frac{dI(\vec{r},\vec{s})}{ds} + (a + \sigma_s) I(\vec{r},\vec{s}) - a n^2 \frac{\sigma T^4}{\pi} + \frac{\sigma_s}{4\pi} \int_0^{4\pi} I(\vec{r},\vec{s}')\Phi(\vec{s},\vec{s}')d\Omega' \tag{14}$$

Where; I(r,s) is the solar radiation intensity that based on the direction and the position, (a) is the coefficient of the absorption, (n) is the refractive index, (σ_s) is the coefficient of the scattering, and (σ) is Stefan - Boltman constant.

- **Setting Materials**

Defining the physical properties of each metal which has been used in this present work necessary to build the CFD model. Due to the properties of materials are not defined in FLUENT, therefore the physical properties are entered manually in the materials task page. Density, thermal conductivity and specific heat must be defined weather the material was fluid or solid metal. Also the radiation properties of the solar collector roof must be defined because it is semi-transparent media [XIII]. The density variation of air has to be set as Boussinesq with a constant value, and the thermal expansion coefficient has to be specified. These are very important when the Boussinesq model is used. [See Table (1)] [IX].

Table 1: Physical properties of materials

Physical property	Glass roof	Tower	Absorber plate	Door	Air
Density kg/m^3	1900	7833	8978	700	Boussinesq
Specific heat J/kg.K	837	465	381	2310	1006.43
Thermal Conductivity W/m.K	0.91	54	387.6	0.173	0.0242
Viscosity kg/m.s	-	-	-	-	1.7894e-05
Refractive index [-]	1.562	1	1	1	1

- **Setting Condition of the Cell Zone**

The cell zone condition is prepared as a result of the presence of the porous metal foam absorber plate. where, the porous zone and the radiation participate are activated.. The porous zone is activated by inserting the required value of porosity, the viscous and inertial resistance values, and heat transfer settings. The viscous and initial resistance values represent the velocity coefficients ($\frac{1}{a}$ and C_F) respectively, in Darcy- Forchheimer terms in equation (8). For heat transfer settings, the equilibrium thermal model is selected and the porous material is chosen. Table (2) presents the measured of the inertial and the permeability coefficientof of the porous metal foam.

Table 2: Measured permeability and inertial coefficient of the porous copper foam

Pores per inch (PPI)	Porosity (ε) (%)	Permeability (K)(m^2)	Inertial Coefficient (C)
10	90.302	7.859×10^{-8}	0.17
40	89.81	1.75×10^{-8}	0.159

- **Boundary Conditions**

Tables (3 and 4) show the main parameters that have been considered in determining the boundary conditions for solving the governing equations for turbulent free convection, as well as the energy equation for the SUTS. While the boundary condition of the porous absorption plate, a several methods exists to define the boundary condition of the porous absorption plate model, but since the thickness of the porous metal foam is small compared with the model radius, the condition the porous jump is the best method can be used to the modeling approximation [II].

Table 3: Thermal Boundary conditions of the physical model [15].

Boundary	Type	Parameter value
Collector inlet	Pressure inlet	T=Ta , P=1 atm.
Tower outlet	Pressure outlet	T= Ta, P=1 atm.
Absorber plate	Wall	Convection + radiation
Glass roof	Wall	Convection + radiation
Tower	Wall	Fixed heat flux
Door	Wall	Fixed heat flux

Table (4): Radiation boundary condition [X].

Part	**Radiation Boundary Condition**
Collector inlet	External black body temperature= Boundary temperature
Tower outlet	External black body temperature= Boundary temperature
Absorbing plate	Opaque
Glass roof	- Semitransparent, $q_{rad.}$ = variable depending on the case - Direct beam radiation (x=0, y=-1, z=0).
Tower	Opaque

- **Solution**

All simulations were performed assuming a steady state condition. The method that selected to simulate the modeling is SIMPLE algorithm system. In order to get the accurate solution, a body forced weighted is selected for pressure, and power law resolution is selected for all other variables. The approximation is run up to (700 - 900) iterations which are needed to obtain a converged result are different depending on the model.

III. Results and Discussion

The numerical result is presented and analyzed to investigate the effects of changing the heights of the air inlet section of (3, 5, 8) cm with the presence of the porous metal foam absorber plate on the performance of the SUTS. This performance is compared with the performance of the SUTP in the case of using the conventional flat absorber plate. The model is simulated the heat transfer and the air flow characteristics by deriving the wall and the air flow temperature distribution, velocity vectors, and the effect of dynamic air pressure in the solar tower that subjected at constant solar intensity (850 W/m^2) when the solar radiation is directly perpendicular to the collector roof.

III.i. Temperature Distribution

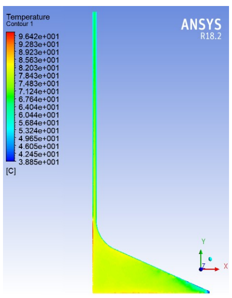
The temperature distribution of the porous absorber plate is increased with decreasing in the height air inlet to reach to the maximum values at height air inlet of

3 cm with a percentage about 15.8 % compared with the conventional flat absorber plate. The working mechanism of the porous copper foam lead to increasing the surface area of the rate of the heat transfer from the porous wall (solid matrix) to the air flow towards a solar tower. Thus, the air bulk temperature is increased while the porous wall temperature is decreased due to increasing in the Darcy number that leaded to increase the heat convection. The wall temperature distribution decrease with the increasing in the height of the air inlet. The temperature distribution for 10 PPI in all heights of the air inlet section are greater than the conventional flat plate because the metal foam consists of the more pores that have been increased from the thermal contact area, which promotes a large heat transfer when the air passes through pores of the metal foam.

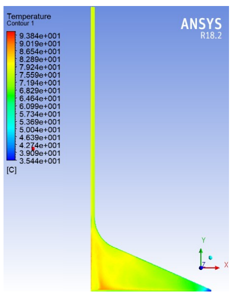
Figure 4 shows the temperature contours (with and without porous copper foam absorber plate) with changing of the heights of the air inlet (3, 5, 8) cm. The figures investigate the effect of changing the height of the air inlet on the performance of the SUTP. The figures appear that the temperature distributions along the porous and flat absorber plate is reduced with the increase in the height air inlet due to the height between the collector roof and the absorber plate is increased and this lead to decrease the thermal boundary layers formed during the heat transfer. The temperature distribution gives better results in case the presence of the porous absorber plate in all heights of the air inlet compared with the flat absorber plate.The air bulk temperature towards the solar tower reduces due to increasing the swirls inside the green house leading to delays the airflow towards the tower and this the reason applies in case presence or absent the porous absorber plate.

III.ii. Air Streamline

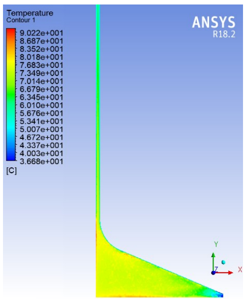
Figure 5 shows the air stream line without and with porous metal foam absorber plat at different heights of the air inlet (3, 5 and 8) cm respectively. A general behaviour can be deduced from the figure. In the case of flat plate absorber plate, the



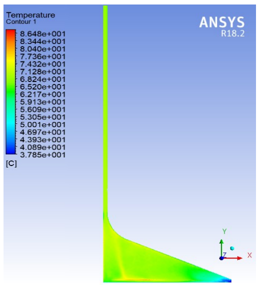
a- Without MFA H_1=3cm



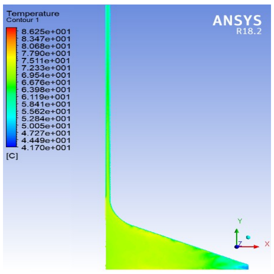
b- With MFA H_1=3cm



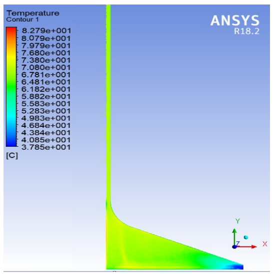
c- Without MFA H_1=5cm



d- With MFA H_1=5cm



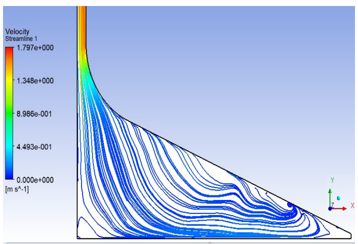
e- Without MFA H_1=8cm



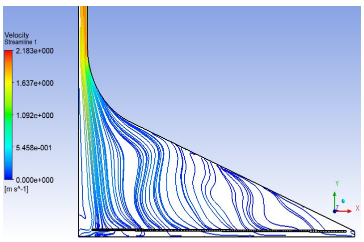
f- With MFA H_1=8cm

Fig. 4: Temperature counters without and with MFA at different heights of the air inlet

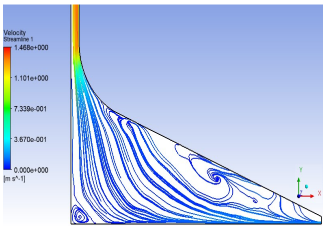
buoyancy effect produced circulated stream lines with a continues returned air in the collector space. This behaviour represents the defect in the flat plate collector setup which caused a considerable losses in the total power production. In the case of metal foam absorber plate, the buoyancy force induced the stream lines to move towards the exit section which indicate an enhancement in the heat transfer performance from that in the case of flat plate absorber. Also it is noted from the figure that the stream lines is more smooth with the reduction the hight of the air inlet.



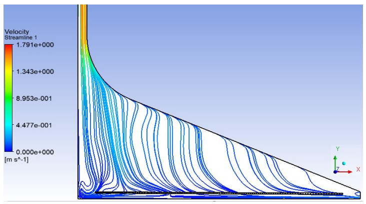
a- Without MFA H_1=3cm



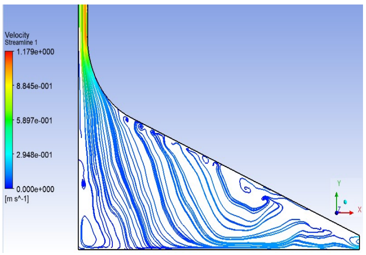
b- With MFA H_1=3cm



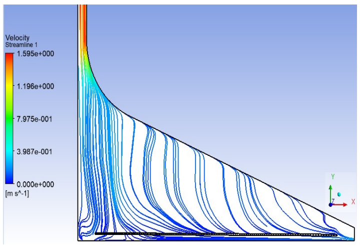
c- Without MFA H_1=5cm



d- With MFA H_1=5cm



e- Without MFA H_1=5cm



f- With MFA H_1=8cm

Fig. 5: Air stream lines with and without MFI at different heights of the air inlet

III.iii. Air Temperature Distribution:

Figure 6 presents the air temperature distribution along the radial direction form the air inlet section towards the tower inlet for each a circular quarter collector (above the flat and porous absorber plate) at a different heights of the air inlet (3,5,8) cm respectively. It is obvious that the air temperature increases along the flow path in each a quarter circular collector region to reach to the maximum value near of the tower base, This because that the increasing of the air temperature in collector region is caused by the greenhouse effect and heat transfer from absorbing hot plate to the air flow and the presence of the metal foam as an absorber becomes more remarkable. The abrupt dip near the tower base is caused by the response of abrupt velocity change due to flow area reduction. The decreasing of air temperature along the tower region is caused by heat transfer from flowing hot air to the tower wall. Better air temperature distribution along the radial direction is found at height air inlet of 3 cm with the presence of pourse absorber plate.

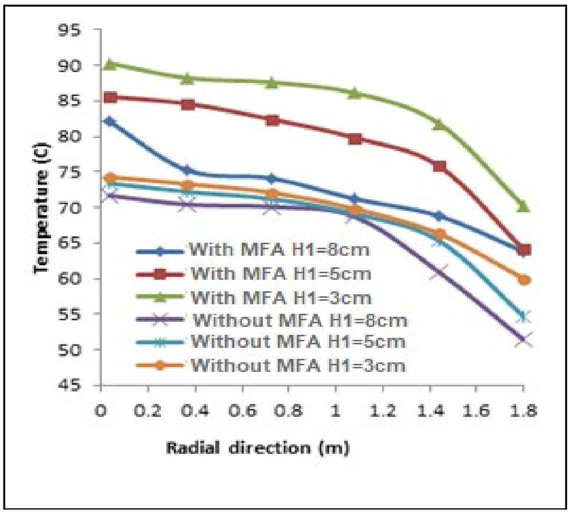


Fig. 6: Air temperature distribution a above wall of flat and porous absorber plate at different heights of the air inlet.

III.iv. Air Velocity at the Tower Inlet

The airflow velocity at the entrance to the tower is one of the important performance criteria as it directly preportional the SUTS output power. And this is associated to the overall performance of the plant. This means that the higher the air velocity the higher is the output power that can be extracted. Figure 7 presents the air velocity at the tower inlet utilized flat and porous absorber plate at different heights of the air inlet. Higher values are recorded by using metal foam absorber plate at height 3 cm and a minimum value is found without using the porous medium at height 8 cm . This is attributed to the fact that the collector flow area will be decreased by reducing the collector cover to absorber height and thus the mass flow rate will be increased, leading to increase the air velocity at tower inlet because the air temperature is increased with presence porous absorber plate compared with the conventional flat plate.

III.v. Static Pressure

Figure 8 shows the static pressure distribution along the SUTS in the vertical direction (with and without using a porous absorber plate) at different heights of the air inlet. From the figure it is seen that the static pressure is increased from the air inlet to reach to a maximum value at the tower inlet and then began reduced with the tower height in all cases. Furthermore, the static pressure decreases with the reduction the height of the air inlet to reach a minimum values with the metal foam absorber plate de to the increase of the buoyancy effect as a result of the heat transfer enhancement between the metal foam surface and movement of the air towards the tower.

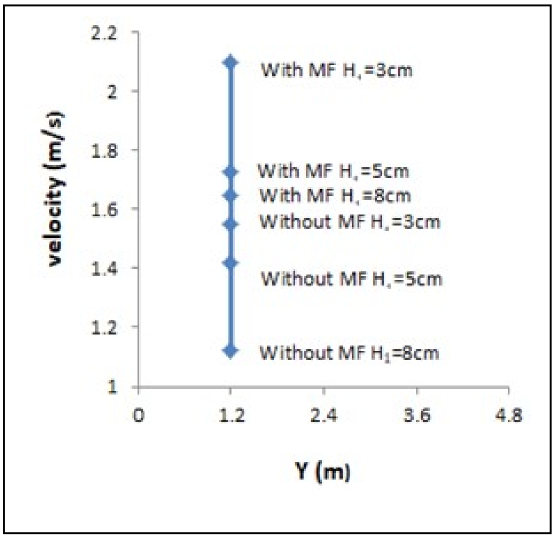


Fig. 7: Air flow velocity at the tower inlet at different heights of the air inlet.

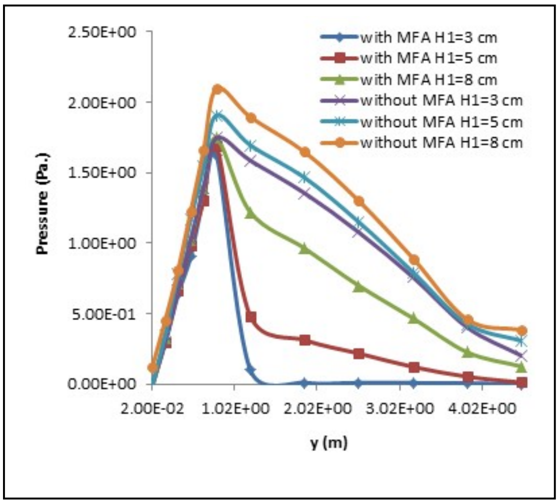


Fig. 8: Static pressure distribution along the SUTS at different heights of the air inlet.

iv. Power Output

Figure 9 presents the effect of changing of the air inlet heights (3, 5 and 8) cm respectively on the power output versus mass flow rate with and without porous metal foam. It is noted the power output increases with decrease of the height of the air inlet due to increase the air velocity flow as an increase of the buoyancy effect. . It is obvious that the power output has larger values with using 10 PPI MF absorber plate compared with flat absorber plate. The maximum power output is decreased about 40.1% with the increase of the air inlet height from (3.2 to 8) cm in the case of using the metal foam absorber plate, while about 34.5% in the case of using the flat absorber plate. And this gives evidence of the important using the metal foam absorber plate in this systems. To calculate the power output can be expressed by the following equation [VI];

$$Power_{out} = \Delta p_{total} * V_{tower} * A_{collector} \quad (15)$$

The pressure difference between the tower base and the ambient can be calculated from the following equation ;

$$\Delta P_{total} = g * (\rho_0 - \rho_1) H_{tower} \quad (16)$$

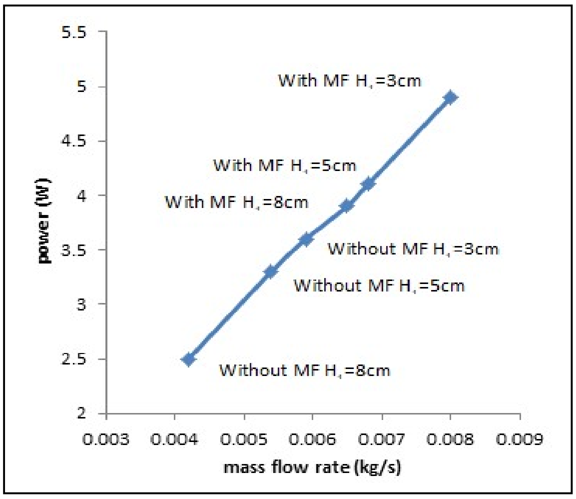


Fig. 9: Power output versus air mass flow rate at different heights of the air inlet.

V. Conclusions

Numerical simulation is conducted to investigate the effect of changing of the air inlet heights (3, 5 and 8) cm on the overall performance of the SUTS which achieves with and without using metal foam as a collector absorber plate. the numerical simulation is applied on the considered that the heat is transferred by natural convection with the inclination angle of the collector roof of 22.5° and the intensity of the solar radiation is 850 W/m2. The remarkable conclusions that obtained from the current work are:

1. The fluid temperature with metal foam absorber is higher than that in the case of without metal foam absorber.
2. The airflow velocity at the tower inlet increases by using metal foam absorber plate about 23.4% from using the flat absorber plate at the same height of the air inlet of 3 cm, and this gives evidence of the importance of using the metal foam as an absorber plate in this application.

3. The effect of the porous metal foam absorber inclination angle shows clearly where the absorber temperature, balk temperature and air flow velocity increase gives a better results compared with the horizontal conventional flat absorber plate.

4. Using 10 PPI porous copper foam absorber plate gives a better enhancement in the performance of the solar tower system with the decreasing in the height air inlet section.

5. The use of the metal foam absorber plate leads to an increase of the air mass flow rate is largely compared to the flat absorber plate in all cases of changing the air inlet height due to the increase in the pressure difference between the negative pressure and the pressure outside the tower.

6. The results showed a clear difference in the power output resulting from the air movement towards the tower between flat and metal foam absorber plate, where the presence of the metal foam leads to enhance the power output about 23.5% at 3 cm, 21.4% at 5cm and 34.3% at 8cm by comparing with conventional flat absorber plate. .

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