Review of thermal performance enhancement of Solar Air Heater using baffles on absorber plate

Visarion-Cătălin Ifrim
Department of Electrical Engineering
Faculty of Electrical Engineering and Computer Science
University "Ştefan cel Mare" of Suceava
Suceava, Romania
ifrimpv@gmail.com

Oana Vasilica Grosu
Department of Electrical Engineering
Faculty of Electrical Engineering and Computer Science
University "Ştefan cel Mare" of Suceava
Suceava, Romania
vasilica.grosu@usm.ro

***Abstract*—Of all renewable energies, solar energy is abundantly available and can meet current energy requirements if captured and used wisely. Solar hot air heaters are used to capture suns thermal energy and release it to a fluid present in the system. Most often this fluid is air, which after the heat transfer made between it and the absorption surface, it's used either to heat spaces or to dry various farming products. For high efficiency the absorber plate of the system must capture solar energy in as much as possible and retain energy in the presence of sunlight and release it in the absence thereof. The indoor environment to achieve a greenhouse effect without energy loss and a complete heat transfer through the absorption surface and the fluid are desirable to achieve better performances. Improving heat transfer is achievable by using obstacles on the absorber surface that break the present laminar flow and creates vortexes or eddy currents that take over a greater amount of thermal energy from the absorption surface. This work presents various investigations carried out on solar air heaters with deflectors on the absorber plate. The results obtained are summarized and referred in the paper.**

***Keywords*— Baffles; Solar air heater; Efficiency; Absorber plate; Heat Transfer**

I. INTRODUCTION

Solar hot air heaters are equipment that captures solar energy with the help of absorbent materials and transfers it to a natural or forced air flow passing through them. The model of such equipment is shown in Fig. 1.

This way of heating the air represents a technology based on the greenhouse effect, a free, renewable, clean energy and cheap compared to energy from conventional sources with different uses [1].

Usually, a solar air heater has three main components: a material that absorbs solar energy, a transparent material, glass, which allows the flow of air between it and the material that absorbs the sun's rays and a layer of insulation on the back of the panel that reduces heat loss. When heating the inhabited spaces, it is mounted on the south-facing exterior wall (South) or on the roof of the dwelling [2].

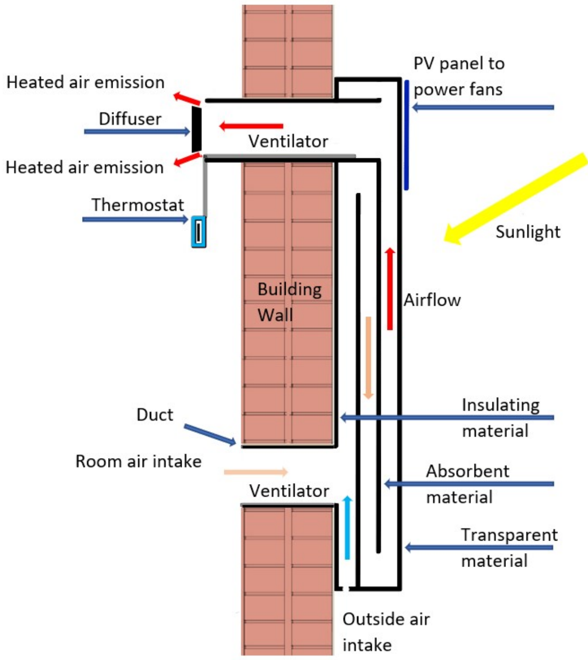

Fig. 1. Model and components of a SAH mounted on the wall of a dwelling

Solar air heating systems are used to heat habitable spaces, to dry fruits and vegetables or for humidification - dehumidification purposes because they have no problems with rust, fluid (air) losses are insignificant and do not affect their functioning, also do not require frost prevention systems [3]. With all these advantages this type of equipment has shortcomings such as: the small thermal capacity of the air requires a higher air circulation, which determines a higher energy intake due to the fans used; the available thermal energy is directly affected by climatic conditions, without the sun systems of this type become useless [4]. To achieve consistent and longer available heat, different storage media are used incorporated into this equipment. Pebbles and rocks have been tested as storage media, but they require large systems to be as efficient as possible due to their low volumetric energy density [3]. For smaller solar air heaters, layers of black graphene paint have proven to be more effective [5].

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II. ANALYSIS METHODS

Researchers have tried, in the past years, to improve the performance of SAHs through different techniques. The most commonly used methods of analysis in this area are listed as followed in Fig. 2.

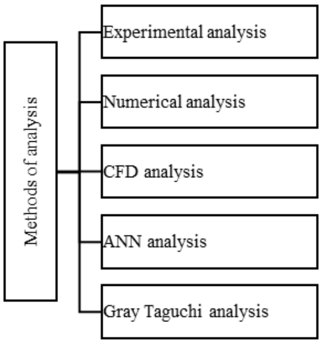


Fig. 2. Analysis methods used to study the solar air heaters performances

Experimental analyses conducted by researchers are often done in accordance with the guidelines of the global ASHRAE society. This organization together with its members focuses on construction systems, energy efficiency, indoor air quality, refrigeration systems and sustainability in the industry, achieving standards and continuous education through research. Among the materials of solar air heater systems used to dry various fruits and vegetables we mention glass, OSB plates and fans to speed up the drying process. More modern systems, used to heat living spaces are constructed of aluminum, polycarbonate with natural air flow or with air intake and emission fans. These models take the air from the room, perform a heat exchange amongst the permissible air and the absorber material inside the SAH, then introduce the heated air back into the room. The tests can be performed externally directly with the sun's rays or in a laboratory environment where the solar radiation is simulated by means of special lamps. Sensors, thermocouples shall be used to measure inlet and outlet temperatures or at specially chosen points to carry out tests and experiments. Experimental methods are easy to realize, easy to modify if they do not work within operational parameters, but require materials that involve costs. Costs rise as equipment improvement is achieved.

Numerical analyses are performed using differential equations operating in the field of fluid physics and temperature flux. Differential equations are solved using classical mathematical formulas.

The CFD (Computational Fluid Dynamic) analysis uses the finite element method to achieve modeling and simulation in the area of solar air heaters. With the help of a computer program, you can build models, perform quickly and efficiently calculations for the existing air flow and heat transfer under certain imposed conditions. These analysis programs offer the possibility of visualizing data with the help of vectors, graphs and contours.

The ANN (Artificial Neural Network) analysis method simulates the processes of the human brain by combining numerical and CFD analysis. The method uses neural networks to approximate and predict the state of some variables. Examples of studies using the ANN analysis method are: predicting thermal capacity for a solar air collector system containing perforated circular discs [6]; predicting thermohydraulic performance for a SAH with circular perforated absorbent material [7]; foretell the approximate thermal performance of solar heater build with porous bed air [8]; predicting heat transfer for a SAH with roughness on the absorber plate [9].

Grey analysis defines circumstances with perfect data as white and those without data as black. This information represents extremities and is ideal but is not encountered in real problems. The situations between these two extremes contain partial information and are defined as gray, unclear, and confusing. For the system without information the analysis does not define any solution, for the system with perfect information the method will define a single solution and in the middle the gray-defined systems will offer a variety of available solutions. Grey analysis does not find the best solution but provides techniques to determine the appropriate solution to the analyzed problem. Among the problems in the domain of solar air heaters analyzed with grey method we mention: determination of the optimal experimental sequence necessary for maximum heat transfer [10]; determining the optimal configuration to achieve optimal performance [11]; obtaining the best configuration for the applicable Reynolds number range [12]; identification of optimal parameters affecting energy and exergy [13].

Recently conducted studies use combinations of experimental, numerical and computational analyses. We recall: experimental and numerical research of the effect of solar irradiation on the yield of a solar dryer [14]; comparative analysis of the thermohydraulic performances resulted experimentally and computationally for a SIX-type SAH with fins on the absorber material [15].

Researchers, Abushka and Kayapunar, experimentally and computationally studied the heat transfer by forced convection for a SAH for which the absorbent material contained staggered arrangements of conical obstacles. The study was carried out at different air flows and under suitable ambient conditions to increase thermal efficiency and create adequate flow for thermal energy storage in conical obstacles aiming to enhance the effectiveness of the system. The study denotes that the heat transfer is higher in front of the conical elements and lower behind them. The experimental data were compared with the data obtained by modelling and simulation. The results of the modelling were in line with the experimental results [16]. To study the exergy, effective and thermal performances of a solar dual-flow air heater, researcher Kumar Saket conducted experimental investigations. The thermal energy storage system was made of a full packet-bed and the upper pipe had a wire mesh as a porous material. Experimental data were collected for various operating parameters such as bed height, air flow and solar radiation intensity in order to estimate the temperature growth factor, exergy efficiency, effective efficiency, thermal efficiency and entropy. The paper also presents different comparisons between the solar heater with double flux air and full bed and the conventional type system with simple absorbent plate [17].

III. PERFORMANCE IMPROVEMENT WITH DIFFERENT BAFFLES ON ABSORBER PLATE

To analyze the solar radiation absorber plate embedded with baffles applied in the field of solar air heaters (SAHs), all articles published in the period 2017-2021 have been taken into account. The information needed to carry out the study was collected from 1355 articles representing the total of publications in the field of SAHs, in which the words "solar air heater" were encountered at least once. The data used were extracted on February 13-28, 2022, from the "Web of Science" database for the considered period. After filtering and analyzing the 1355 publications individually, the most recent articles were selected to be part of present study. The rest of the articles dealt with the same topics or could not be part of the study conducted although they are part of the field of solar air heater systems.

The baffles used on absorber plate in solar air heaters, taking into account the publications of the 2017-2021 period, are shown in Fig. 3. and detailed in Table 1.

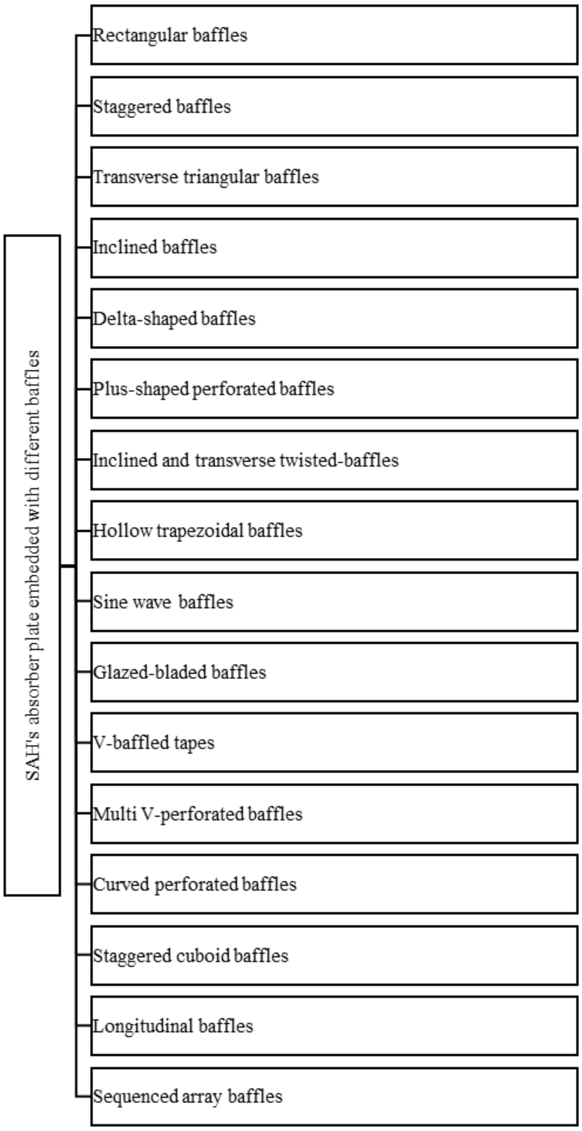


Fig. 3. Absorber plates with baffles used in solar air heaters

The solar air heater with absorption surface with rectangular baffles was numerically investigated in sixteen configurations under the following boundary conditions: Reynolds number range from 4000 to 18,000, heat flow equal to 1000 W/m^2, four baffle locking ratios (B_R) with values 0.7, 0.82, 0.92 and 0.98, and four distance ratios between deflectors (P_R) with values 2, 4, 6, 8. The optimal configuration is as follows: "B_R" equal to 0.7 and "P_R" equal to 2 to a Reynolds number with the value of 5000. The highest recorded thermohydraulic performance factor was 0.857 with a friction factor of 2.16% [18].

For the analysis of a SAH with an absorption surface with staggered baffles [19] the deflectors were placed as follows: on the entire absorber surface, only on the middle of the surface, only on the half corresponding to the output of the air flow and only on the half corresponding to the air input. The optimum thermohydraulic performance factor of 0.75 is achieved in the case of SAH with baffles arranged on the half of the absorption surface corresponding to the airflow input for the Reynolds number equal to 2370. The minimum friction factor obtained had a value of 0.05. The thermal efficiency was maximum 92.5%, recorded with baffles on the entire absorption surface.

Analysis of the solar air heater system with absorber plate embedded with triangular baffles was performed to investigate the characteristics of airflow friction and heat transfer. The height of the block, the Reynolds number, the step and the length were chosen as design parameters. From gained data, it was found that the existence of a triangular transverse block on the absorption surface leads to a Nusselt number greater than that of a smooth surface with values between 1.19 and 3.37, depending on the geometrical investigated conditions. However, the use of the triangular transverse block returns significantly greater friction losses. The maximum value of thermohydraulic performance was 1.001 for the length of 120 mm, the height of 20 mm and a step of 150 mm, for the value of 8000 attributed to the Reynolds number [20].

For the study of a solar air heater system with absorbing surface with inclined baffles, the following values of the dimensionless parameters were considered: the angle of the baffles (a) in interval 30-120°, the locking ratio of the deflector (Br) from 0.375 to 0.75, the Reynolds number between 5000 and 20,000, the spacing ratio of the deflectors (Pr) between 2 and 8. To design the experiment, Taguchi method was used, generating an orthogonal matrix consisting of four elements each at four levels. The results acquired from the Taguchi method and the CFD analysis indicated that the optimal geometry of the parameters "a" equal to 90°, "Pr" equal to 6 and "Br" equals the value of 0.375 brought the maximum value for the thermohydraulic parameter, of 1.01 [21].

The study of a solar system with absorption surface with Delta baffles covered the relative longitudinal length of the deflectors on the absorption surface (P_l/e) valued between 3 and 5, the Reynolds number range from 2500 to 12,000, the single angle of attack (α) equal to 45°, the relative transverse length of the deflectors on the absorbent plate (Pt/b) in interval 0.6-1 and the relative height of roughness (e/H) equal to 0,8. The maximum result of the thermal improvement factor was 2,26 for "P_l/e" and "P_t/b" equal to 3 and 0,6 respectively [22].

The solar air heater with perforated plush baffles placed on the absorbing surface was analyzed numerically and experimentally [23]. The maximum thermal efficiency of 75.11% was reached by the SAH with an absorption surface with twice the number baffles placed on top of each other.

The investigations of SAH with absorber plate embedded with inclined and transverse baffles were carried out taking into account: the Reynolds number with the values 4000, 8000, 12,000, 16,000 and 20,000, the roughness ratios of the step (p/w) equal to 4.0, 6.0, 8.0, 10.0 and 12.0 and the twisting ratios of the baffles (y/w) with values 2.0, 3.0, 4.0, and 5.0 associated to the loop numbers with twisted deflector (n) equal to 5, 7, 8 and 9. The SAH with absorbing surface with inclined deflectors has the maximum thermal performance index of 1.98 corresponding to values of "p/w" equal to 6.0 and "y/w" equal to 5.0 [24].

The purpose of the study of a solar air heater system with baffles type empty trapezoid-shaped integrated on the absorbing plate is to optimize the design parameters using the Taguchi experimental design method [25]. Modeled parameters are: corner angle (α), angle of inclination (β), height of the deflector (H), length of the deflector (L), width of the deflector (S) and Reynolds number. The maximum value of heat transfer was achieved at Re equal to 17,000, height of 36 mm, length equal to 45 mm, width of 26 mm, corner angle at 0° and inclination angle of 0°. Minimum friction factor was 0.0337.

The study conducted by Sharma Sachin includes a comparison of solar air heaters containing absorber surfaces with: transverse, transverse inclined, deepened, inclined, arched recesses and sine waveform baffles using computational fluid dynamics analysis (CFD). The outcomes were gained by varying the Reynolds number (Re) from 3000 to 18,000, while the relative roughness step (P/e) and the height of relative roughness (e/Dh) were maintained fixed at the values 10 and 0,271 respectively [15]. The maximum of 2.05 for the thermohydraulic performance parameter was recorded with sinusoidal wave-shaped baffles on the absorption surface at Re equal to 15,000. The sinus wave deflector form was considered the best of the deflectors studied for the considered interval of geometric and operating indexes.

The research conducted for the solar air heater system with glazed blade type baffles on the absorbing surface was aimed at investigating the effect of attaching a different number of baffles (n equal to 800, 410 and 170) on system's performance [26]. The maximum thermal efficiency of 77.83% was recorded for the solar air heater built with an absorbent surface with a total number of 800 baffles.

The study of a SAH with absorber plate containing V-shaped baffles comprise the range of the Reynolds number between 4120 and 25,800, the angle of attack was fixed (α) with the value of 30° [27]. Two types of arrangements were analyzed: with the V peak pointing downstream and with the V peak pointing upstream (called "V-down" and "V-up"). The tests performed on the two types of arrangements had three baffles height ratios (R_B) equal to 0.10, 0.15 and 0.20 and (R_P) step ratios equal to 0.5, 1.0 and 1.5. The maximum thermal performance improvement factor of the V-down arrangement was around 2.07 at "R_B" equal to 0.15 and "R_P" equal to 1.0. On average, the V-down arrangement is about 1.4% higher than the V-up arrangement with the value of 2.04.

The experiment on a SAH containing perforated V-shaped baffles on the absorbing surface was conducted by varying the relative width (W_D/W_B) of the deflector from 1.0 to 6.0 and by keeping the fixed values for the relative height of the deflector (H_B/H_D) by the value 0.5, the relative step of the deflector (P_B/H_B) of 10.0, the relative position of the hole (O_B/H_B) had a value of 0.44 and the ratio of the open area (β_O) was 12%. The thermohydraulic parameter performance of the analyzed system was 3,41 for "W_D/W_B" equal to 5 [28].

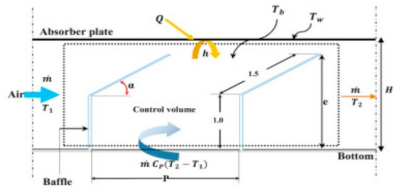
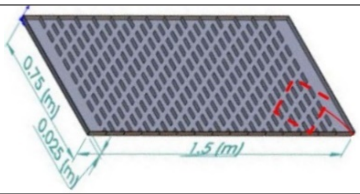
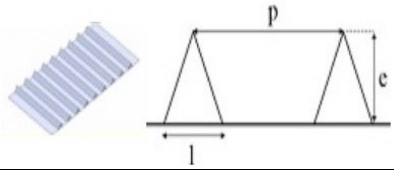
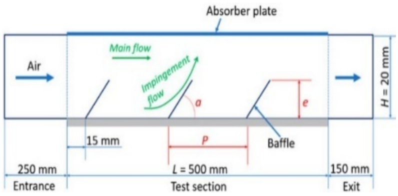
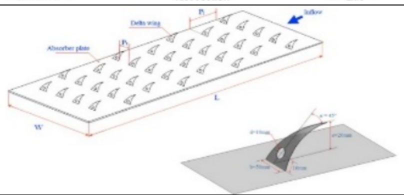
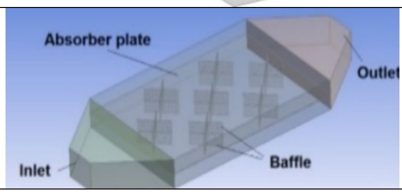
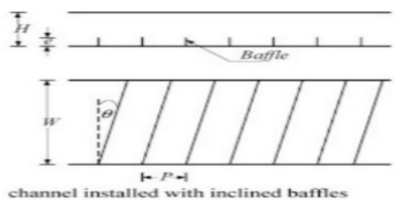
The solar air heater with absorbing surface with curved and perforated baffles was analyzed in the light of the following factors: the diameter of the hole, the tilt angle of the baffle and the mass flow rate of the fluid flow. The impact of these factors on thermal efficiency of the system and the difference in temperature and pressure at the input and output were analyzed. For the considered cases, the results obtained indicate an approximate maximum thermal efficiency of the analyzed SAH equal to 77% at the mass flow of 0,03 kg/s, the hole diameter valued to 3 mm and the angle of the deflector equal to 7°. However, the pressure drop of the section of work analyzed for this solar system varies between 15.05 and 1.7 N/m2 for the fluid mass flow rate equal to 0.07 kg/s, the hole diameter equal to 1 mm and the angle of the deflector with a value of 27°, respectively for the mass flow rate equal to 0.03 kg/s, the diameter of the hole equal to 3 mm and the angle of the deflector having the value of 7° [29].

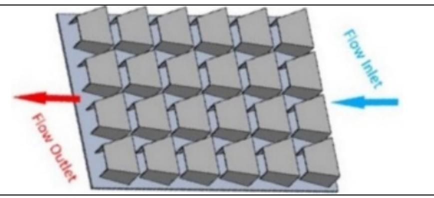
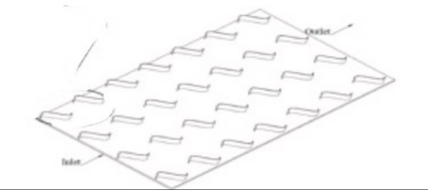
Improving the thermal performance of SAHs is essential for the efficient use of energy. The solar air heater system with baffles type staggered cube on the absorber plate is examined by numerical analysis to obtain the most efficient characteristic of convective heat transfer. The numerical outcome disclose that the proposed optimal design has better performances than the existing ones. The study indicates that the relative height of the deflector (c/H) and the relative pitch of the deflector (s/H) are the parameters influencing the most the efficiency and the thermohydraulic performance factor. Also, the optimum thermohydraulic performance factor of the analyzed solar air heater is 3.43, 2.80 and 2.38 for the Reynolds numbers 5080, 7620 and 10,160. Conditioned on the Number of Reynolds, the thermohydraulic performance factor of the proposed baffle is up to 17.5% better compared to the performance of the best SAH existing in the published literature [30].

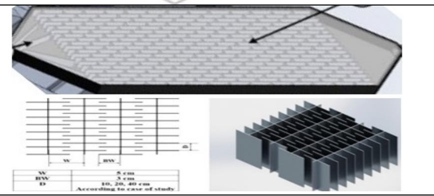
The experiment of an absorbing surface with longitudinal baffles of a solar air heater was carried out aiming to analyze the effect of longitudinal deflectors on the particularities of airflow and heat transfer [31]. The maximum effective efficiency assigned to the analyzed system is 0.64.

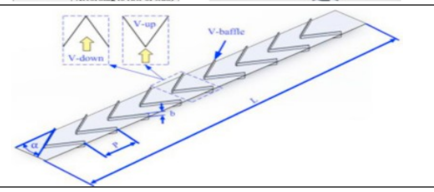
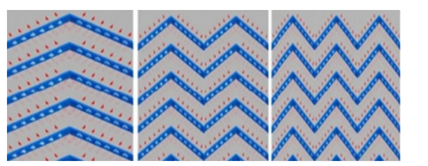
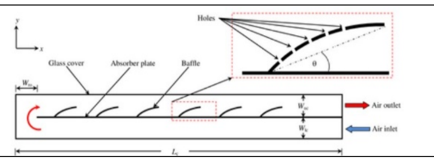
The study on the solar air heater system with an absorbing plate containing sequential matrix baffles was conducted at three varied mass flows of 0.017, 0.014 and 0.009 kg/s, causing along the channel of various Reynolds numbers [32]. The exergy and energy efficiency of the system was computed in accordance with thermodynamics laws, first and second. Experimental data point out that daily energy efficiency ranged from 20.7% to 26.8%, while daily exergy efficiency ranged from 10.7% to 19.5%.

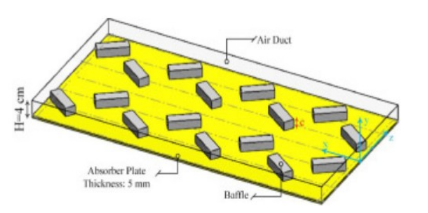
TABLE I. DIFFERENT BAFFLES EMBEDDED WITH ABSORBER PLATE IN SAHS

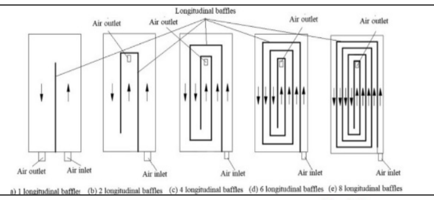
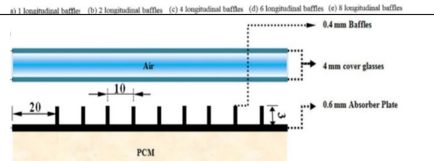
<table>
<tr><th>No.</th><th>SAH Type/ Reference</th><th>Absorber Plate Geometry</th><th>Operating Parameters</th><th>Optimized Parameters</th><th>Key Results</th></tr>
<tr><td>1</td><td>SAH with rectangular baffles on the absorber plate [18]</td><td>
</td><td>e = 17.5-24.5 mm;
B_R = 0.7; 0.824; 0.919; 0.979;
P = 50; 100; 150; 20 mm;
P_R = 2; 4; 6; 8;
α = 30°; 45°; 60°; 75°;
Re = 4000; 5000; 8000; 12,000; 15,000; 18,000;
I = 4.701-5.710%.</td><td>B_R = e/H = 0.7;
P_R = 2;
Q = 1000 W/m^2;
t = 0.4 mm;
Pr = 0.708;
Re = 5000;
m = 0.04 kg/s.</td><td>Thermohydraulic performance factor (THPF): 0.857;
Friction factor (f): 2.16%.</td></tr>
<tr><td>2</td><td>SAH with staggered baffles on the absorber plate [19]</td><td>
</td><td>m = 0.017-0.06 kg/s;
Re = 2370-8340;
I_R = 670; 982 W/m^2.</td><td>e = 20 mm;
w = 60 mm;
t = 0.5 mm;
P = 50 mm;
Re = 2370; 8340.</td><td>Thermohydraulic performance factor (THPF): 0.75;
Friction factor (f): 5%.
Thermal efficiency: 92.5%.</td></tr>
<tr><td>3</td><td>SAH with transverse triangular baffles on the absorber plate [20]</td><td>
</td><td>e = 20; 40; 60 mm;
l = 65; 120 mm;
P = 120; 150; 180 mm;
Re = 8000-20,000;
Nu = 1.244-3.374.</td><td>e = 20 mm;
l = 120 mm;
P = 150 mm;
Re = 8000.</td><td>Thermohydraulic performance parameter (THPP): 1.001;
Friction factor (f): 6.211%.</td></tr>
<tr><td>4</td><td>SAH with inclined baffles on the absorber plate [21]</td><td>
</td><td>e = 7.5; 10; 12.5; 15 mm;
P = 40; 80; 120; 160;
Re = 5000-20,000;
a = 30°; 60; 90; 120°;
P_r = 2; 4; 6; 8;
B_r = 0.375; 0.500; 0.625; 0.750.</td><td>Re = 5000;
a = 90°;
P_r = 6;
B_r = 0.375;
Q = 1000 W/m^2;</td><td>Thermal efficiency: 93.28%;
Thermohydraulic performance parameter (THPP): 1.01;
Friction factor (f): 2.91%.</td></tr>
<tr><td>5</td><td>SAH with delta-shaped baffles on the absorber plate [22]</td><td></td><td>P_t/b = 0.6-1;
Re = 2500-12,000;
P_l/e = 3-5.</td><td>e/H = 0.8;
α = 45°;
P_l/e = 3;
Re = 11,382;
P_t/b = 0.6.</td><td>Thermal enhancement factor (TEF): 2.26;
Nu/Nu$_0$: 6.94;
f/f$_0$: 29.</td></tr>
<tr><td>6</td><td>SAH with perforated plus-shaped baffles on the absorber plate [23]</td><td>
</td><td>m = 0.009; 0.011 kg/s;
I_R = 1152.5; 1041 W/m^2.</td><td>m = 0.011 kg/s.</td><td>Thermal efficiency: 75.11%;
Drying efficiency: 28.28%.</td></tr>
<tr><td>7</td><td>SAH with inclined and transverse twisted baffles on the absorber plate [24]</td><td>
</td><td>Re = 4000; 8000; 12,000; 16,000; 20,000;
y = 6; 9; 12; 15 mm;
p = 12; 18; 24; 30; 36 mm;
p/w = 4.0; 6.0; 8.0; 10.0; 12.0;
y/w = 2.0; 3.0; 4.0; 5.0;
N =5; 7; 8; 9.</td><td>Re = 4000;
w = 3 mm;
δ = 0.8 mm;
y = 15 mm;
p = 18 mm;
p/w = 6.0;
α = 60°;
y/w = 5.0;
AR = 10.</td><td>Thermal performance factor: 1.98;
Nu/Nu$_s$: 3.74;
f/f$_0$: 7.17.</td></tr>
</table>

No.	SAH Type/ Reference	Absorber Plate Geometry	Operating Parameters	Optimized Parameters	Key Results
8	SAH with hollow trapezoidal baffles on the absorber plate [25]		H = 36; 28; 20 mm; α = 16°; 8°; 0°; L = 45; 35; 25 mm; β = 15°; 10°; 0°; S = 26; 20 mm; Re = 17,000; 11,000; 5000.	H = 20 mm; α = 16°; L = 25 mm; β = 0°; Re = 17,000; S = 26 mm.	Friction factor (f): 3.37%. Nu: 259.47.
9	SAH with sine type wave baffles on the absorber plate [15]		Re = 3000-18,000.	α = 45°; P/e = 10; Re = 15,000; e/D_h = 0.271.	Thermo-hydraulic performance (THP): 2.05; Nu/Nu_s: 3.60; Friction factor (f): 25%.

10	SAH with glazed-bladed baffles on the absorber plate [26]		I_R = 750-1120 W/m^2;
			m = 0.013, 0.022, 0.031, 0.04 kg/s.
				l = 200 cm;
				h = 8 cm;
				n =800;
				m = 0.04 kg/s.
					Thermal efficiency: 86.76%.

11	SAH with V-baffled tapes on the absorber plate [27]		Re = 4120-25,800; R_B = 0.20; 0.15; 0.10; R_P = 1.5; 1.0; 0.5;	R_B = 0.15; Re = 10,000; α = 30°; R_P = 1.0.	Thermal performance enhancement factor (TEF): 2.07; Friction factor (f): 45%.
12	SAH with V-perforated baffles on the absorber plate [28]		Re = 4000-9000; W_D/W_B = 1.0-6.0.	W_D/H_D = 10; W_D/W_B = 5.0; H_B/H_D = 0.5; P_B/H_B = 10.0; O_B/H_B = 0.44; β_O = 12%; α = 60°.	Thermohydraulic parameter performance: 3,41; Friction factor (f): 14.75%.
13	SAH with curved perforated baffles on the absorber plate [29]		D_h = 1; 2; 3 mm; θ = 7°; 12°; 17°; 22°; 27°; m = 0.03; 0.05; 0.07 kg/s.	D_h = 3 mm; θ = 7°; δ_{bf} = 1 mm; m = 0.03 kg/s.	Thermal efficiency: 77%; ΔP: 1.7 N/m^2.

14	SAH with cuboid baffles on the absorber plate [30]		a/H = 2.5; 3;
			b/H = 0.8; 1;
			c/H = 0.7; 0.9;
			s/H = 1.5;
			θ = 90°; 67.5°; 22.5;
			Re = 5080; 7620; 10,160;
			m = 0.02; 0.03; 0.04 kg/s.
				a/H = 3;
				b/H = 0.8;
				c/H = 0.7; 0.9;
				s/H = 1.5;
				θ = 90°; 67.5°;
				Re = 5080; 10,160;
				m = 0.02 kg/s.
					Thermohydraulic performance factor: 3.43;
					Thermal efficiency: 68.9%.

15	SAH with longitudinal baffles on the absorber plate [31]		n = 1; 2; 4; 6; 8; m = 0.00812; 0.01177; 0.01344; 0.01569; 0.01961; 0.02353; 0.02746 kg/s.	n = 1; δ = 1 mm; m = 0.01961 kg/s.	Effective efficiency: 64%.
16	SAH with sequenced array baffles on the absorber plate [32]		m = 0.009; 0.014; 0.017 kg/s;	n = 27; δ = 0.4 mm;	Energy efficiency: 26.8%; Exergy efficency: 19.5%.

IV. CONCLUSIONS

The current review unveils the amount of work carried by researchers to augment the thermal capacity of solar air heaters [33], [34]. The paper presents a succinct review of different baffles embedded with the absorber material, utilized by researcher to intensify thermal performances and heat transfer in SAHs. Solar air heaters equipped with obstacles type baffles have high thermal efficiencies because the air on the absorber plate is no longer laminar but becomes a turbulent current [35]. The contact of the air with the absorption surface takes place for a longer period, increasing the friction factor thus determining a higher air temperature exiting the system, temperature closer to that of the absorber plate. The existence of turbulent currents brings the emission air temperature close to the temperature of the absorption surface, therefore achieving an efficient heat transfer. Defining the optimal parameters of baffles used in a solar air heater leads to a decrease in pressure which is desirable to achieve better performances. Development of SAHs will definitely contribute to energy preservation and support a sustainable environment.

NOMENCLATURE

e, H Baffle height (mm);
w, S Baffle width (mm);
l, y, L Baffle length (mm);
t, δ, δ_{bf} Baffle thickness (mm);
n Number of baffles;
D_h hole diameter (mm);
P_l/e Longitudinal length of baffles;
P_t/b Relative transversal length of baffles;
P/e Relative baffle roughness pitch;
e/D_h Relative baffle roughness height;
W_D/W_B Relative baffle width;
H_B/H_D, c/H Relative baffles height;
P_B/H_B, s/H Relative baffles pitch;
a/H Relative baffle length;
O_B/H_B Relative hole position;
β_O Open area ratio (%);
R_B, b/D Baffle height ratios;
R_P, P/D Baffle pitch ratios;
B_R, e/H, B_r Blockage ratio;
P, p Inter-baffle spacing, pitch (mm);
P_R, P/H, P_r Inter-baffle spacing ratios;
a, α, Upper part baffle angle of inclination (°);
θ Baffle of attack angle (°);
β Inclination angle (°);
Re Reynolds number;
Pr Prandtl number;
I Turbulent intensity (%);
Q Uniform heat flux (W/m^2);
I_R solar radiation of (W/m^2);
Nu/Nu_s, Nu/Nu_0 Nusselt number ratio;
f/f_s, f/f_0 Friction factor ratio;
m Mass flow rate (kg/s);
AR, W_D/H_D Aspect ratio;
ΔP Pressure drop (N/m^2).

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