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RESEARCH ARTICLE

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ANALYSIS OF HEAT TRANSFER ENHANCEMENT IN DUAL PURPOSE SOLAR COLLECTOR FOR VARIOUS PARAMETERS

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ABSTRACT

The use of solar thermal systems in the agricultural sector to preserve vegetables, fruits and other crops has shown to be practical, economic and environmental friendly. Solar drying refers to a technique that utilizes incident solar radiation to convert it into thermal energy required for drying purposes. Dual purpose solar collector DPSC is found to be more effective than single water or air collector in many ways. The heated water and air is utilized for different industrial and household purpose. The various geometrical configurations such as structure of wait, air passages, and their material properties plays an important role in absorbing the solar heat effectively. It was found that inclusion of fins in the air passage increases air side heat transfer. Still the shape size number and orientation of fins are some of the variables based on which the heat transfer enhancement can be achieved. In this work a novel approach is attempted to understand and analyze the basic hydro and thermodynamic behavior of DPSC using computational fluid dynamics CFD.

Key Words:solar energy, dryer, radiation, Dual purpose solar collector, fins and heat transfer

1. INTRODUCTION

Solar energy is an inexpensive source of energy in most countries. Use of this source of energy can be spread with the increase of efficiency of solar systems. In liquid flat plate collectors, the inlet fluid temperature and profile of air flow path in solarcollector, air flow rate are two basic decisive parameters are considered. In the thermosyphon system with the increase in water temperature, heat delivery is decreased and performance will diminishes. In this context, the studied on increase in heat delivery of thermosyphon systems and [1]investigated on the performance of solar storage collectors. In Solar air collectors, enhancing the heat transfer from the surface area is the main objective. [2]Performed the analysis of finned collector and collector with tubes for drying applications. [3]Investigated the evaluation of a V-groove solar collector. Analyzed the effect of chamfering on heat transfer and friction characteristics of solar air heater. [4]It Presented the analysis of four types of air collectors with various channel's geometry. [5]Showed effective efficiency of solar air heater with different types of roughness elements on the absorber plate. Studied the performance evaluation of solar air heater having expanded metal mesh as artificial roughness on absorber plate.

fig 1.1(A) Dual Purpose Solar Collector

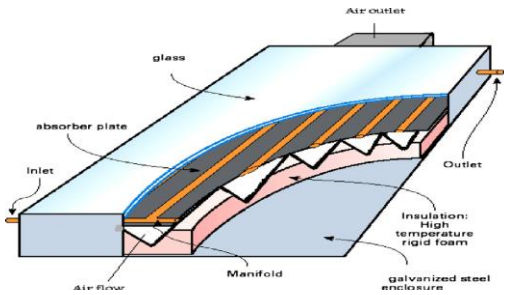
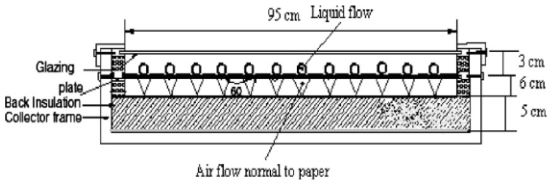


fig 1.1(B) Dual Purpose Solar Collector

In spite of many researches, no work on dual kinds of solar collector is seen. Dual purpose solar collector (DPSC) is an air and water collector joint with each other to a single collector shown in fig



1.1(A) and fig 1.1(B)This collector can attain high temperature with high heat delivery with a 50% reduction in space and cost.the effect of water inlet temperature, air flow rate and air channel geometry on heat exchange is investigated. [6]Used such a kind of formulation for unglazed transpired solar collectors. The benefit of this formulation is simplicity and ability of prediction for both water and air collectors with any geometry. In these equations, there is no efficiency factor. So, one can use these equations for all types and shapes of air and water flat plate collectors. In addition, absence of collector efficiency factor provides simplicity and speed in calculations. With reference of triangle profile [1] result and discussion, the following modifications are considered in the geometry to enhance the temperature rise at the outlet.

- Rectangular ducts
- Circular ducts
- Circular zig-zag ducts

2. Modeling and Meshing

Geometric model is generated in 'SOLID WORKS' which is very popular modeling software. The base case consists of triangular ducts from air passage and circular pipes for water flow.

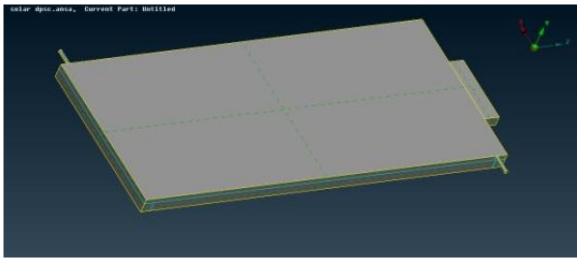


Fig 2.1 CAD model of DPSC

The generated model shown in fig 2.1 is exported to the further process in the form of IGES as it is a third party format which can be taken in to any other tools.

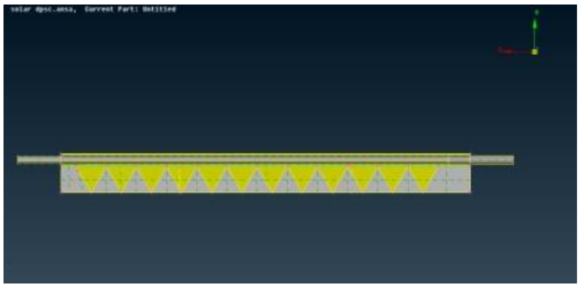


Fig: 2.2 showing the triangular ducts

Extracting the fluid region is the next step in which all the surfaces which are in the contact of fluid are taken alone and all other surfaces are removed completely. To keep the domain air /water tight some extra surfaces are created. This clean up is done in ANSA meshing tool which is very robust clean up tool. Extracted domain for vortex generation and finder assemblies are shown fig 2.2.

After cleaning up the geometry the surface mesh is generated in ANSA tool itself. All the surfaces are discredited using
tri surface element..

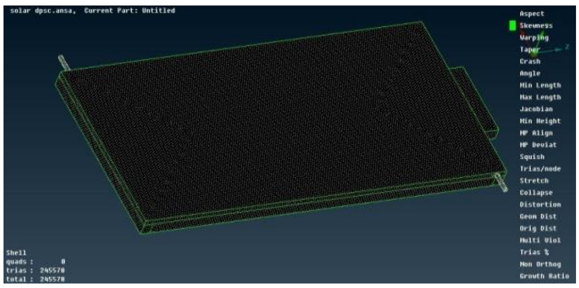


Fig 2.3 (A)Surface mesh on fluid domain

As the geometry has some complicated and skewed surfaces.

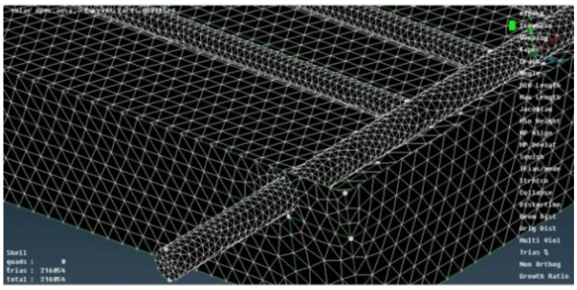


Fig 2.3 (B) Surface mesh on fluid domain (Enlarged view)

So tri surface elements are used to capture the geometry. The surface mesh is shown in fig 2.3(A) and fig 2.3(B) shows enlagged view of Surface mesh on fluid domain.

The Volume mesh is generated in T-Grid which is a robust volume mesh generator. Volume is dicretized using tetrahedron .Each and every cell centroid is the co-ordinate at which the navier-stokes system of equations are solved. The table 2.1 indicates the number of elements and quality of surface mesh and volume mesh

Table 2.1 Deatails of Mesh on DPSC with Triangle Profile

MESH	COUNT	QUALITY
SURFACE MESH	245578	0.6
VOLUME MESH	1147402	0.88

2.1 Rectangular ducts

Triangular ducts are replaced by the rectangular ducts for the air flow. This is in the veiw of expecting an improvement in the temperature rise.

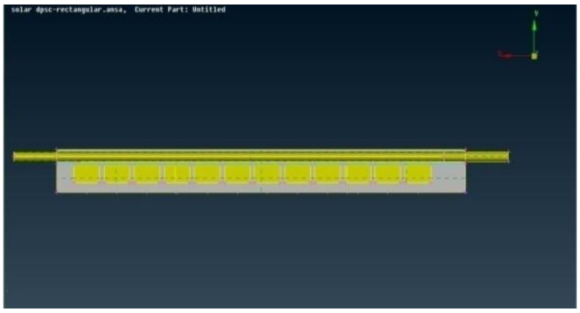


Fig: 2.1.1DPSCwith Rectangular ducts

Volume mesh is generated in T-Grid which is a robust volume mesh generator. Volume is dicretized using tetrahedron .Each and every cell centroid is the co-ordinate at which the navier-stokes system of equations are solved.The table 2.1.1 indicates the number of elements and quality of surface mesh and volume mesh

Table 2.1.1 Deatails of Mesh on DPSC with Rectancle Profile

MESH	COUNT	QUALITY
SURFACE MESH	253448	0.6
VOLUME MESH	1199930	0.89

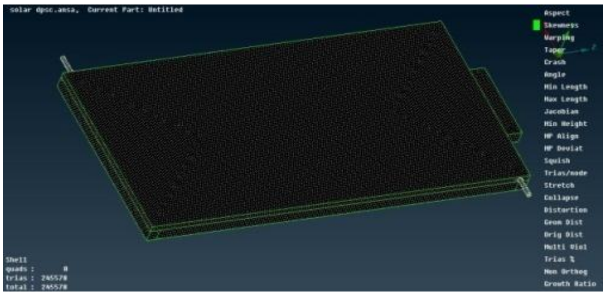
2.2 Circular ducts

Triangular ducts are replaced by the circular ducts for the air flow shown in fig2.2.1. This is in the veiw of expecting an improvement in the temperature rise.

Fig: 2.2.1 DPSCwith Circular ducts

Volume mesh is generated in T-Grid which is a robust volume mesh generator shown in fig 2.2.2. Volume is dicretized using tetrahedron.

Fig 2.2.2 Surface mesh on fluid domain (circular ducts)



Each and every cell centroid is the co-ordinate at which the navier-stokes system of equations are solved.The table 2.2.1 indicates the number of elements and quality of surface mesh and volume mesh

Table 2.2.1 Deatails of Mesh on DPSC with Circular Profile

MESH	COUNT	QUALITY
SURFACE MESH	257536	0.6
VOLUME MESH	1240369	0.88

2.3 Circular zig-zag ducts

Triangular ducts are replaced by the circular ducts in a zig-zag manner for the air flow shown in fig 2.3.1(A) and fig 2.3.1(B) . This is in the veiw of expecting an improvement in the temperature rise.

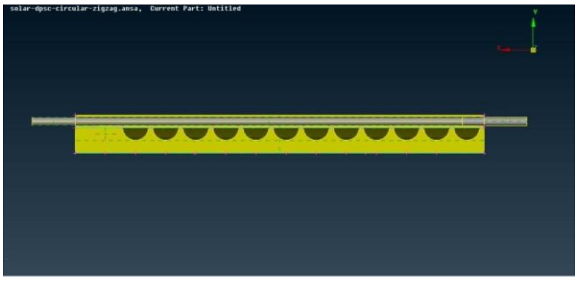


Fig 2.3.1(A) CAD model showing the zig-zag circular ducts

Volume mesh is generated in T-Grid which is a robust volume mesh generator.

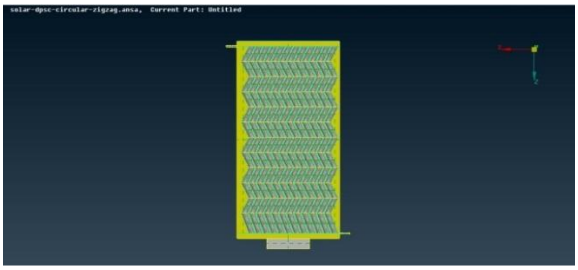


Fig 2.3.1(B) CAD model showing the zig-zag circular ducts

Volume is dicretized using tetrahedron .Each and every cell centroid is the co-ordinate at which the navier-stokes system of equations are solved shown in fig 2.3.2

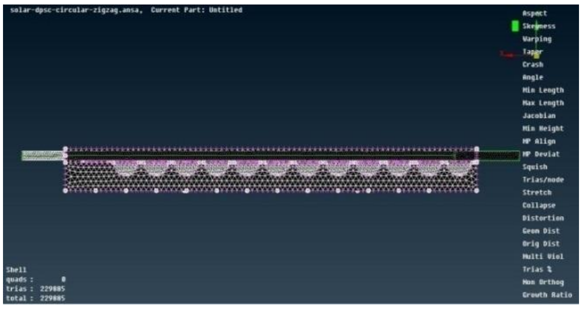


Fig 2.3.2 surface mesh on fluid domain (circular zig-zag ducts)

The table 2.3.1 indicates the number of elements and quality of surface mesh and volume mesh

Table 2.3.1 Deatails of Mesh on DPSC with Circular Profile with zig zag path

MESH	COUNT	QUALITY
SURFACE MESH	261918	0.6
VOLUME MESH	1268525	0.88

3. Assumptions and Boundary Conditions

Ansys-fluent is used as the solver for this case.The following assumptions are considered while solving the problem using Ansys-fluent software.

- Fluid is assumed to be 3-D, turbulent, Incompressible in nature
- Turbulence is model by K-ε model,standard
- Simple algorithm is used to solve the problem
- Segregated solver is used for pressure-velocity coupling
- The working fluid in the domain is water-liquid and air
- Foam is provided at the bottom of the air ducts.

3.1 Boundary Conditions for DPSC with Triangle Profile (Base Case)

For flow analysis, we consider the following parameters and boundary conditions.

- Inlet is assumed to be mass flow inlet
- For air, m°= 0.07 kg/s at 318 k
- For water, m°= 0.02 kg/s at 353 k
- The outlet is assumed to be pressure outlet at 0pascal
- The solar glass been provided with a heat flux = 900 W/m^2

3.2 Boundary Conditions for DPSC with Recatangular ducts

- Inlet is assumed to be mass flow inlet
- For air, m°= 0.07 kg/s at 318 k
- For water, m°= 0.02 kg/s at 353 k
- The outlet is assumed to be pressure outlet at 0 pascal
- The solar glass been provided with a heat flux = 900 W/m^2

3.3 Boundary Conditions for DPSC with Circular ducts

- Inlet is assumed to be mass flow inlet
  - For air, m°= 0.07 kg/s at 318 k
  - For water, m°= 0.02 kg/s at 353 k
- The outlet is assumed to be pressure outlet at 0 pascal
- The solar glass been provided with a heat flux = 900 W/m^2

3.4 Boundary Conditions for DPSC with Circular zig-zag ducts

- Inlet is assumed to be mass flow inlet
  - For air, m°= 0.07 kg/s at 318k

- For water, m°= 0.02 kg/s at 353 k
- The outlet is assumed to be pressure outlet at 0 pascal
- The solar glass been provided with a heat flux = 900 W/m^2

4. Result and Discusion

4.1 Temperature Countors for DPSC with Triangle Profile (Base Case)

The air and water outlet temperature shows a significant rise in the outlet. This agrees with the experimental data collected.shown in fig 4.1.1.

Fig 4.1.1 Temperature Distribution for DPSC with Triangle Profile (Base Case)

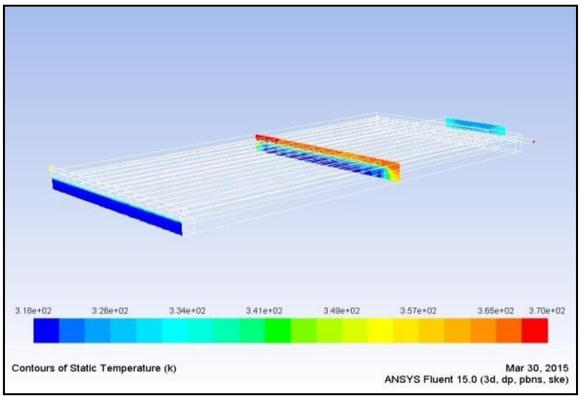


Table 4.1.1 Results of DPSC with Triangle Profile (Base Case)

Static Temperature	(k)
air-outlet-ext	327.83142
air_inlet	318
water_inlet	353
water_outlet	369.51807

4.2 Temperature Countors for DPSC with Recatangular ducts

The air and water outlet temperature shows a significant rise in the outlet. Yet this rise is similar to the base case results shown in fig 4.2.1

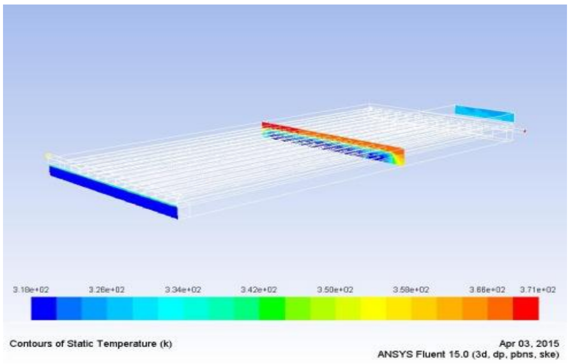


Fig 4.2.1 Temperature Distribution for DPSC with Rectangular Profile

This concludes that this modification shows only negligible amount of improvement in the heat transfer rate and hence the temperature rise.Table 4.2.1 indicates the results of DPSC with Rectangular Profile.

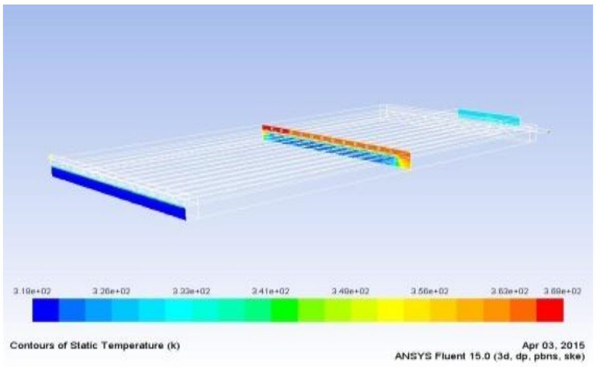
Table 4.2.1 Results of DPSC with Rectangular Profile.

Static Temperature	(k)
air-out-ext	326.90311
air_inlet	318
water_inlet	353
water_outlet	370.41739
Net	320.9393

4.3 Temperature Countors for DPSC with Circular ducts

The air and water outlet temperature shows a significant rise in the outlet. Especially the air outlet temperature shows a significant rise in the outlet shown in Fig 4.3.1(A) and Fig 4.3.1(B)

Fig 4.3.1(A) Temperature Distribution for DPSC with Circular Profile



This concludes that this modification shows a good considerable amount of increase in the temperature of air at the outlet.

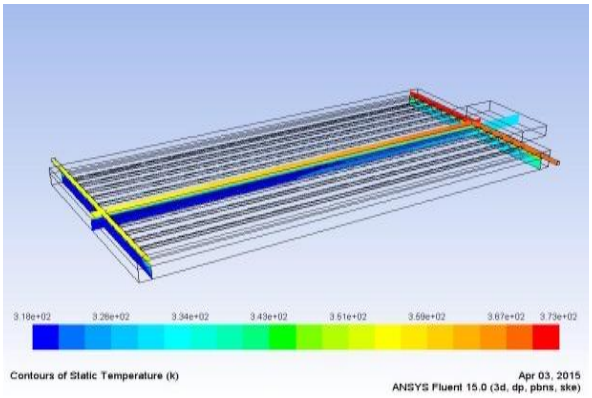


Fig 4.3.1(B) Temperature Distribution for DPSC with Circular Profile

Table 4.3.1 indicates the results of DPSC with Circular Profile.

Table 4.3.1 Results of DPSC with Circular Profile.

Static Temperature	(k)
air-outlet-ext	330.00839
air_inlet	318
water_inlet	353
water_outlet	367.88382
Net	321.84335

4.4 Temperature Countors for DPSC with Circular zig-zag ducts

The air and water outlet temperature shows a significant rise in the outlet. Especially the air outlet temperature shows a significant rise in the outlet than the previous modification shown in Fig 4.4.1(A)and Fig 4.4.1(B).

Fig 4.4.1(A) Temperature Distribution for DPSC with Circular Profile with Zig-Zag Path

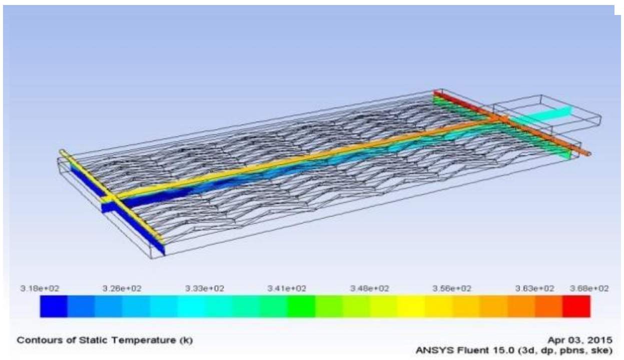


Fig 4.4.1(B) Temperature Distribution for DPSC with Circular Profile with Zig-Zag Path

This concludes that this modification showsa good considerable amount of increase in the temperature of air among the other modifications.

Table 4.3.1 indicates the results of DPSC with circular zig-zag duct

Table 4.3.1 Results of DPSC with circular zig-zag duct

Static Temperature	(k)
air-out-ext	334.90051
air_inlet	318
water_inlet	353
water_outlet	363.75568
Net	323.26709

4.5 Discussion

Table 4.5.1 Temperature Contour Comparison

Profile	**Air in K**	**Air Out K**	**Water in K**	**Water out K**
Triangle	318	327.83	353	369.52
Rectangle	318	326.90	353	370.42
Circular	318	330	353	367.88
Circular Zig-Zag	318	334.90	353	363.76

5. CONCLUSION

The analysis was made for dual purpose solar collector (DPSC) by using Fluent-14 Software with various profiles like Triangle, Rectangle, Circular and Circular zig-zag. This model has simple structure and can be used for both liquid and air collectors with any geometry and shape. This model was designed and made analysis; finally the result indicated that DPSC has more efficiency relative to single water and air collectors. In the comparison base case air inlet 318k air outlet 327k rectangle case air inlet 318k air outlet 326k circular case air inlet 318k air outlet 330k circular zig-zag case air inlet 318k air outlet 334k from the combination absorption circular zig-zag profile, has more efficiency compare to other profile because, the profile path is zig-zag manner the air flow rate is minimized. So heat transfer enhancement will increase at each bent of zig-zag profile.

REFERENCES

[1]. M.R. Assari, H BasiratTabrizi, I Jafari 'Experimental And Investigation Of Dual

Purpose Solar Collector' solar energy vol.85 pp : 601-608, 2011

[2]. M.R. Assari, H.BasiratTabrizi, H.Kavoosi, H.Moravej 'Design And Performance Of Dual Purpose Solar Collector'.ieees-3,2006

[3]. M.Augustusleon, M.Kumar,' 'Mathematical Modeling And Thermal Performance Analysis Of Unglazed Solar Collector' solar energy vol.81,pp;62-75, 2007

[4]. M.K.Gupta, A.Hawlader, 'Performance Evaluation Of a V-Groove Solar Air Collector'appl.therma.engg vol.26, pp;121-130 2006

[5]. M.K.Gupta, S.C.Kaushik 'Performance evaluation of solar airheater having expanded metal mesh as artificial roughness on absorber plate.vol.48 pp 1007-1016,2009

[6]. M.Hazami., S. Kooli, Lazaar, M., Farhat, A., Belghith, 'Performance of a solar storage collector' Desalination, vol.183, pp;167–172,2005