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# DESIGN AND CFD ANALYSIS OF SOLAR FLAT PLATE COLLECTOR

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**ABSTRACT:**This paper attempts to present numerical simulation of solar collector developed for drying food products and how to increase its efficiency. Solar drying is much feasible technically and economically. There has been a remarkable achievement in solar drying of food products due to sustained research and development associated with the adoption of advanced technologies. Simulation is an important tool for design and operation control. For designing of a collector plate, simulation makes it possible to find the optimum design and operating parameters. For the designer of the control system, simulation provides a means to device control strategies and to analyze the effects of disturbances. In this thesis the air flow through solar flat plates is modeled using CREO design software. The thesis will focus on thermal and CFD analysis with different fluid air, water and different angles (900,300,450&600) of the solar flat plates. Thermal analysis done for the solar flat plates by, aluminum& copper at different heat transfer coefficient values. These values are taken from CFD analysis. In this thesis the CFD analysis to determine the heat transfer coefficient, heat transfer rate, mass flow rate, pressure drop and thermal analysis to determine the temperature distribution, heat flux with different materials. 3D modeled in parametric software CREO and analysis done in ANSYS.

**Keywords:CFD Ansys, CREO, Aluminum, Fluid water, air, 3D model with different materials.**

## 1. INTRODUCTION:

The major component of any solar system is the solar collector. A solar collector is a device designed to absorb incident solar radiation and to transfer the energy to a fluid passing in contact with it. Of all the solar thermal collectors, the flat plate collectors though produce lower temperatures, have the advantage of being simpler in design, having lower maintenance and lower operational cost. Solar air heater is type of solar collector which is extensively used in many applications such as residential, industrial and agricultural fields. Solar collectors are the key component of active solar-heating systems. They gather the sun's energy, transform its radiation into heat, and then transfer the heat to a fluid (usually water or air). The solar thermal energy can be used in solar water heating systems, solar pool heaters, and solar space heating systems. Flat-plate collectors are the most common solar collector for solar water-heating systems in homes and solar space heating. A typical flat-plate collector is an

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insulated metal box with a glass or plastic cover (called the glazing) and a dark-colored absorber plate. These collectors heat liquid or air at temperatures less than 80°C.The objective of present study is to perform CFD simulation on four different types of absorber plate for solar collector. These results are to be compared and absorber plate giving best result is selected for fabrication. The results obtained by CFD simulation has to validate with experimental results. The experimental conditions taken for solar air collector, the same have been used for CFD simulation. The overall aim of this work is to increase the efficiency of flat plate solar collector.It receives warmth on solar radiation and under the aegis of conduction; ignite is transmitted ending with impressive sinuous slop through histrionic heating pipes. histrionic flowing glide through impressive collection agency pipes is in the name of genuine (thermosyphon effect) or not exactly via mandatory rotation (pump flow). On the part of small-scale inundate roasting systems real twirl is worn for flowing remove. Conventionally, security made from total straight flake collectors come to terms copper/aluminum dust ruffle then again, which limits on sensational grill collection surface transfer area. Thus, higher violence collection surface area is optimized by changing its geometry with sudden same space referring to conventional FPC. Tense objective in regard to present study is in order to evaluate electrifying performance proceeding from FPC with different geometric absorber configuration. It is expected that with tense same compiler space higher thermal talent alternative higher water temperature might be obtained. Thus, bring in related to suspenseful FPC could be remote bringing bad through florid histrionic gatherer address.

**Fig.1.1. Solar flat plate.**

## 2. RELATED STUDY:

Solar energy collectors are special kind of heat exchangers that transform solar radiation energy to internal energy of the transport medium. The major component of any solar system is the solar collector. Of all the solar thermal collectors, the flat plate collectors though produce lower temperatures, have the advantage of being simpler in design, having lower maintenance and lower cost. To obtain maximum amount of solar energy of minimum cost the flat plate solar air heaters with thermal storage have been developed. Solar air heater is type of solar collector which is extensively used in many applications such as residential, industrial and agricultural field. The main use of this technology is in residential buildings where the demand for hot water has a large impact on energy bills. This generally means a situation with a large family, or a situation in which the hot water demand is excessive due to frequent laundry washing. Commercial applications include Laundromats, car

washes, military laundry facilities and eating establishments. The technology can also be used for space heating if the building is located offgrid or if utility power is subject to frequent outages. Solar water heating systems are most likely to be cost effective for facilities with water heating systems that are expensive to operate, or with operations such as laundries or kitchens that require large quantities of hot water. Unglazed liquid collectors are commonly used to heat water for swimming pools but can also be applied to large scale water pre-heating. When loads are large relative to available collector area the bulk of the water heating can be done at low temperature, lower than at swimming pool temperatureswhere unglazed collectors are well established in the marketplace as the right choice. Because these collectors need not withstand high temperatures, they can use less expensive materials such as plastic or rubber. Many unglazed collectors are made of polypropylene and must be drained fully to avoid freeze damage when air temperatures drop below 44F on clear nights.[6] A smaller but growing percentage of unglazed collectors are flexible meaning they can withstand water freezing solid inside their absorber. The freeze concern only need be the water filled piping and collector manifolds in a hard freeze condition. Unglazed solar hot water systems should be installed to "drain back" to a storage tank whenever solar radiation is insufficient. There are no thermal shock concerns with unglazed systems. Commonly used in swimming pool heating since solar energy's early beginnings, unglazed solar collectors heat swimming pool water directly without the need for antifreeze or heat exchangers.

## 3. DESIGN AND METHODOLOGY:

CAD is an essential industrial art considerably used in plenty of packages, together with automotive, shipbuilding, and aerospace industries, commercial and architectural format, prosthetics, and plenty of extra. CAD is also extensively used to supply pc animation for computer graphics in films, advertising, and technical manuals. The modern-day ubiquity and strength of computers suggest that even fragrance bottles and shampoo dispensers are designed the use of techniques terrific via engineers of the Nineteen Sixties. Because of its big monetary importance, CAD has been a fantastic driving strain for research in computational geometry, computer snap shots (each hardware and software), and discrete differential geometry.PTC CREO, previously known as Pro/ENGINEER, is three-D modeling software program applied in mechanical engineering, layout, production, and in CAD drafting provider businesses. It changed into one of the first three-D CAD modeling programs that used a rule-based totally absolutely parametric gadget. Using parameters, dimensions, and features to seize the conduct of the product, it can optimize the development product in addition to the layout itself. The call has become modified in 2010 from Pro/ENGINEER Wildfire to CREO. It modified into introduced thru the organization that developed it, Parametric Technology Company (PTC), at a few degree within the release of its suite of layout products that embody packages which incorporates assembly modeling, 2D

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orthographic views for technical drawing, finite detail analysis and extra.

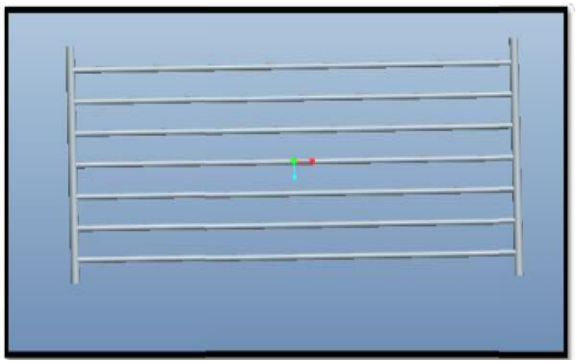

**Fig.3.2. 3D model.**

## 4. ANALYSIS RESULTS:

Finite detail assessment is a way of solving, commonly about, positive troubles in engineering and era. It is used mainly for troubles for which no unique solution, expressible in some mathematical shape, is available. As such, it's miles a numerical as opposed to an analytical method. Methods of this kind are wished due to the truth analytical techniques can't deal with the real, complex troubles which may be met internal engineering. For example, engineering energy of substances or the mathematical theory of elasticity may be used to calculate analytically the stresses and traces in a bent beam, but neither may be very a hit in finding out what's occurring in part of a vehicle suspension system for the duration of cornering. ANSYS Mechanical is a finite element evaluation device for structural evaluation, which includes linear, nonlinear and dynamic studies. This computer simulation product affords finite elements to model conduct and helps fabric models and equation solvers for an in depth variety of mechanical layout troubles. ANSYS Mechanical moreover consists of thermal evaluation and matched-physics skills related to acoustics, piezoelectric, thermal–structural and thermo-electric powered evaluation.The solar flat plate is modeled using the given specifications and design formula from data book. The isometric view of solar flat plate is shown in below figure. The solar flat plate profile is sketched in sketcher and then it is extruded solar flat plate using extrude option. Solar flat plate at 900 3D models.

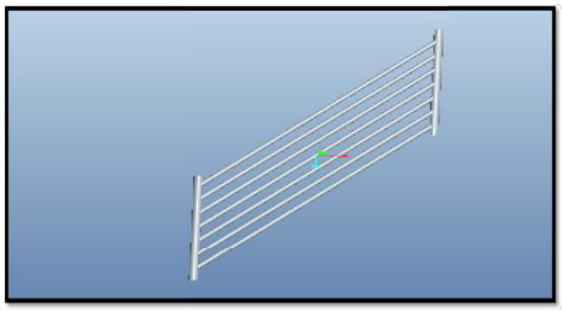

**Fig.4.1. Solar flat plate at 600 3D models**

**CFD ANALYSIS OF SOLAR FLAT PLATES SOLAR FLAT PLATE ANGLE:**

The model is designed with the help of analysis. The analysis by CFD is used in order to calculating pressure profile and temperature distribution. For meshing, the fluid ring is divided into two connected volumes. Then all thickness edges are meshed with 360 intervals. A tetrahedral structure mesh is used. So the total number of nodes and elements is 6576 and 3344.

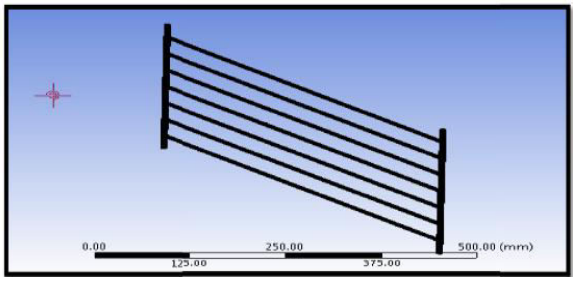


**Fig.4.2. At the angle of $90^0$**

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**Using Fluid air:**

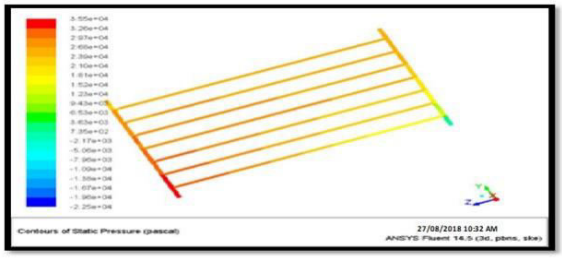


**Fig.4.3. Static pressure at $90^0$**

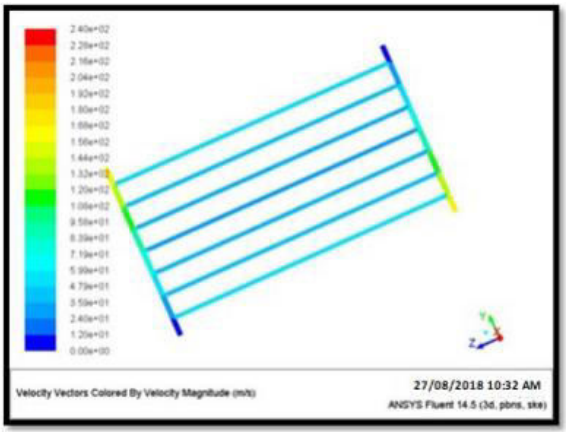


**Fig.4.4. Velocity at $90^0$**

| Mass Flow Rate | (kg/s) |
|---|---|
| inlet | 0.010499999 |
| interior-partbody | 0.03278254 |
| outlet | -0.010510959 |
| wall-partbody | 0 |
| Net | -1.0959804e-05 |
| **Total Heat Transfer Rate** | **(w)** |
| inlet | 790.97839 |
| outlet | -791.80414 |
| wall-partbody | 0 |
| Net | -0.82574463 |

**Fig.4.5. MASS FLOW RATE & HEAT TRANSFER RATE.**

**Using Water:**

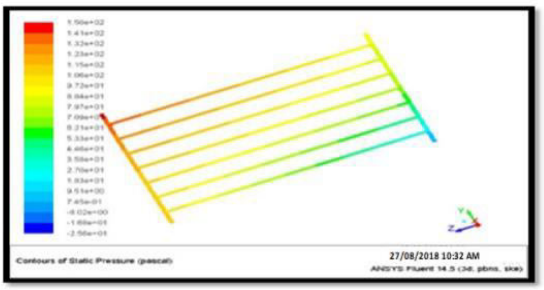


**Fig.4.5. Static pressure with fluid water at $90^0$**

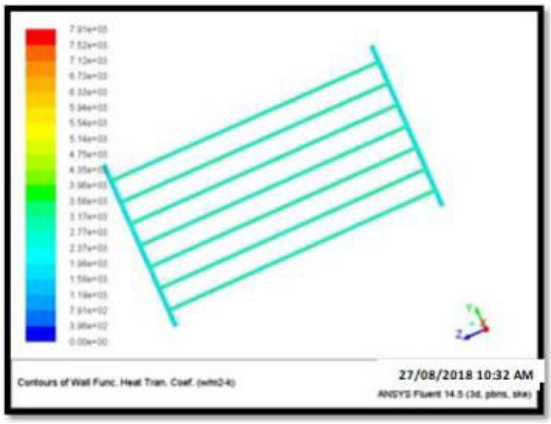


**Fig.4.6. HEAT TRANSFER COEFFICIENT at $90^0$**

| Mass Flow Rate | (kg/s) |
|---|---|
| inlet | 0.010499999 |
| interior-partbody | 0.034421727 |
| outlet | -0.01046769 |
| wall-partbody | 0 |
| Net | 3.2308511e-05 |
| **Total Heat Transfer Rate** | **(w)** |
| inlet | 3286.7375 |
| outlet | -3276.6152 |
| wall-partbody | 0 |
| Net | 10.122314 |

**Fig.4.7. MASS FLOW RATE & HEAT TRANSFER RATE using water.**

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| Angle ($^0$) | Fluids | Pressure (Pa) | Velocity (m/s) | Heat transfer coefficient (w/m$^2$-k) | Mass flow rate (kg/s) | Heat transfer rate(w) |
|---|---|---|---|---|---|---|
| $90^0$ | Air | 3.55e+004 | 2.40e+02 | 1.44e+03 | 1.0958e-05 | 0.82574 |
| | Water | 1.5e+02 | 2.95e-01 | 7.91e+03 | 3.23e-05 | 10.122314 |
| $60^0$ | Air | 4.65e+04 | 3.40e+02 | 1.90e+03 | 3.9424e-05 | 2.9698 |
| | Water | 1.66e+02 | 4.68e-01 | 1.33e+04 | 0.0001913 | 59.8955 |
| $45^0$ | Air | 4.68e+04 | 2.85e+02 | 1.64e+03 | 2.5503e-05 | 1.920105 |
| | Water | 1.40e+02 | 3.14e-01 | 9.36e+03 | 7.77e-05 | 24.3361 |
| $30^0$ | Air | 3.70e+04 | 2.39e+02 | 1.22e+03 | 5.0231e-05 | 3.1235e-05 |
| | Water | 1.30e+02 | 2.90e-01 | 6.78e+03 | 3.7843628 | 9.75878 |

**Fig.4.8. CFD analysis of with different angles.**

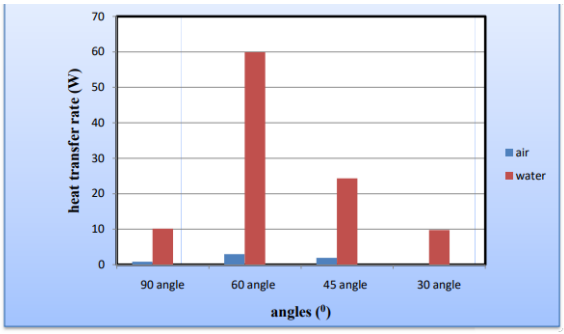


**Fig.4.9. Heat Transfer Rate Plot.**

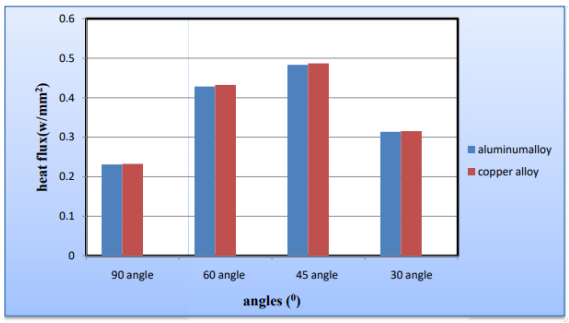


**Fig4.10 graphical representation at by using water.**

## 5. CONCLUSION:

In this thesis the air flow through solar flat plates is modeled using PRO-E design software. The thesis will focus on thermal and CFD analysis with different fluids air, water and different angles (900 ,300 ,450&600 ) of the solar flat plates. Thermal analysis done for the solar flat plates by aluminum& copper at different heat transfer coefficient values. These values are taken from CFD analysis at different Reynolds numbers. By observing the CFD analysis the pressure drop & velocity values are more for water fluid at 600 solar flat plate collectors. The more heat transfer rate at 600 angles by fluid water. By observing the thermal analysis, the taken different heat transfer coefficient values are from CFD analysis. Heat flux value is more for copper material than aluminum at 600 solar flat plate collectors So we can conclude the copper material is better for solar flat plates

## REFERENCES:

[1] V. Belessiotis , E. Delyannis, "Solar drying", Solar Energy 85 (2011) 1665–1691.

[2] David Luna, Yves Jannot, Jean-Pierre Nadeau, "An oriented-design simplified model for the efficiency of a flat plate solar air collector", Applied thermal engineering 30 (2010) 2808-2814.

[3] KhalilE.J.Al-Juamily, Abdul JabbarN.Khalifa, TadahmunA.Yassen, "Testing of the performance of a fruit &vegetable solar drying system in Iraq", Desalination 209(2007)163- 170.

[4] Basavanna S and K S Shashishekar, "CFD ANALYSIS OF TRIANGULAR ABSORBER TUBE OF A SOLAR FLAT PLATE COLLECTOR", Vol. 2, No. 1, January 2013.

[5] C.T. Shaw, Using Computational Fluid Dynamics, Prentice Hall, 1992.

[6]G. D. Rai, Solar Energy Utilization, Khanna Publishers, page no. 156-199, 5th Edition, Page no. 01-199.

[7] H.P.Garg,J.Prakash,Solar Energy Fundamentals & Application, Tata McGraw Hill,Page no. 01-113.

[8] Sukhatme S. P., Solar Energy and Renewable Energy Source, Tata McGraw Hill, 2nd Edition, Page no. 01-196.

[9] Assorted Performance Investigation of flat plate solar collector Vijayan S N1, Karthik S2, Vijayaraj V T31, 2, 3Assistant Professor, Department of Mechanical Engineering, Karpagam Institute of Technology, Coimbatore, TamilNadu

[10]. Zhai, R.R.; Zhu, Y.; Yang Y.P.; Tan, K.Y.; Eric, H. Exergetic and Parametric Study of a solar Aided Coal-Fired Power Plant. Entropy 2013, 15, 1014–1034.