Experimental, Design and CFD simulation to obtain optimum inclination angle for solar still

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Abstract-A sun powered despite everything distils water by utilizing the warmth of the sun to dissipate water with the goal that it might be cooled and gathered in this manner sanitizing it. They are utilized in territories where drinking water is inaccessible with the goal that spotless water is acquired from filthy water/saline water or from plants by presenting them to daylight. In present research, optimum angle (glass inclination angle) (26, 30 and 35) for maximum efficiency by CFD simulation has to be carried out and optimum design is manufactured for experimental setup. Validation of experimental and CFD simulation results are performed to determine the volume fraction rate (air, water vapour and water), efficiency, glass cover temperature, water temperature and production rate of water is to pserformed.

Keywords—CFD, Solar still, Inclination angle

I. INTRODUCTION

Now a days, experiencing that the absence of consumable water is one of the serious issue in networks. The greater part of the water repository is saline or have destructive microorganisms, subsequently that water is not consumable. Thus, sun power can be utilized as a lasting helpful source since its creation is free of cost and its use have no side effect on the earth. So that the use of sunlight-based stills can be used even its distillation rate is low. Expanding sun powered still proficiency is our assignment with the end goal of higher new water creation rate, setting an ideal framework and bringing down initial expense. Some people can be accomplished by having an appropriate scientific model of sun-oriented stills for examining various parameters. Sun oriented stills are modest, have low support and they are an ideal decision to meet states of numerous circumstances. Moreover, they are anything but difficult to utilize and can be built outside where they are utilized. Due to these incredible favorable circumstances, the researchers get anxious to contemplate them attempting to get a decent and through view. Desalination of the abundant seawater is considered as one of the most significant specialized answers for the water deficiencies in ample pieces of the world. The two techniques as of now being used for this reason for existing are dissipation and film turn around assimilation strategies. Vanishing is more vitality devouring contrasted with the opposite assimilation technique. The last includes higher capital speculation and force utilization stays an issue with respect to both the strategies. Any foreseen world limitations on carbon dioxide emanation are probably going to impede the more extensive scale utilization of both the techniques. Under such considerations, sustainable power source use in seawater desalination is the most sensible other option. The best two contenders for such use is wind and sun powered energies. Numerous sorts and geometrical states of sun-based stills for seawater have been utilized for a long time. Creation is likewise connected with the warm effectiveness of the still itself. This productivity may run from 40 to 60%, contingent upon still development, surrounding temperatures, material used, wind speed and sunlight-based vitality accessibility. Incline of straightforward spread; the point at which the straightforward spread is set affeccts the measure of sun-based radiation entering a sun based still. At the point when daylight strikes glass straight on, about 90% of the light goes through tip of the glass bit, with the goal that it strikes at a brushing edge of 80°, and just a couple of percent is lost. A glass spread that is close to 5 to 7 cm from the water surface will permit the still to work productivity. On the other side, as glass-to-water separation expands, heat misfortune because of convection gets more prominent, by making the still's proficiency drop. Some significant stills have been constructed following the low incline structure idea for the glass spread, double sided, yet utilizing a short, steeply slanting bit of the glass at the back.

II. LITERATURE REVIEW

Tahir Mahmoodet al. [1], In this paper it presents learn at researching the sun based still parameters utilizing CFD demonstrating and trial approval. This problem can be liked to by changing over unbearable water into consumable through a sun-based refining process sun powered despite everything is exceptionally doled out for this reason. Effectiveness of a sun powered still categorically relies upon its plan parameters, for example, divider material, chamber profundity, width and incline of the z gathering surface. It uncovers that ANSYS-FLUENT is a powerful tool to investigate the effectiveness of the new structures of all kinds of the sunlight-based refining frameworks. To deliver distillate yield, the vanishing and build-up in a sun based despite everything need to occur at sensibly great rates. One of the production information demonstrated lower speeds at the front and back surfaces and such stream practices are commonly wanted for superior sun-oriented stills. The introduced research uncovered a nearby understanding among the re-enactment and test information,

indicating that the presentation assessment of a sun powered despite everything is really straightforward with ANSYSFLUENT.

A. A. Azoozet al. [2], This paper presents the trial results on the exhibitions of ten sun powered stills with various glass tendency edges. The tendency edges chose are 10–55 in steps of 5^0. The results show that the points somewhere in the range of 30^0 and 35^0 might be related with the least still presentation while those somewhere in the range of 20^0 and 25^0 give the ideal execution to the extent the perfect water efficiency and cost feasibility are concerned. The stills with tendency points in the scope of 30^0–35^0 are probably going to create less spotless water under a similar climate conditions contrasted with those with other tendency edges. In any case, there is by all accounts no genuine preferred position of utilizing stills with huge tendency points because of the bigger material and development costs. It is reasoned that the ideal glass tendency plot for a sun oriented despite everything is around 25^0.

Hosney Ara Begumet al. [3], This paper itself presents the exploration work manages a near investigation of bowl type desalination units and straightforward PVC sheet put at various tilt edges. Bowl type sun-oriented stills were made with two kinds of top spread, straightforward PVC sheet and glass sheet. Advisability of these two-bowl type sunlight-based stills were learned at various tilt points of the top straightforward spread with ground surface 13^0, 23^0 and 35^0. The normal measure of refined water created expanded with the tilt plots for the two kinds of spread materials, that for glass being a lot higher than that for PVC spread. The uncovered zone of the two stills were 0.51 m^2. Efficiency of sunlight-based force still with both straightforward PVC sheet spread and glass spread increments with the tilt point between the deliberate scope of 13^0 and 35^0. The expansion with the tendency of the top spread is normal therefore the drops show signs of improvement odds of streaming down in light of gravity. Be that as it may, if the tendency is additionally expanded, a point may come when the beads will fall inside the still, before it arrives at the assortment trough, which will diminish the yield also. Consequently, an ideal tilt point might be normal, however the current examination didn't go past 34^0.

S.Varun rajet al. [4], This paper presents investigation of the impact of water limit on the aggregate vitality equalization of the refining framework. An endeavor has been made to discover the impact of water limit on inward and outside warmth move for a sun powered refining framework. The distillate yield diminishes altogether with the expansion of water profundity in the bowl of the sunlight based still. A solitary incline bowl type sun powered despite everything is created with inward components of 1200mm x 500mm (successful territory 0.6 m^2) and the glass is tilted at 10° concerning the flat. In higher water levels, the most extreme temperature of the bowl water, fume and water is recorded in the late evening hour between 15 hrs and 18 hrs while lower levels are accomplished from the center of evening. As the water gravitation diminishes from 55 mm to 12 mm the profitability expanded by 12%. The biggest temperature (83.9°C) of the sunlight based despite everything is recorded at internal divider surfaces and is practically steady for all water levels and the following biggest temperature is recorded at fume side (78.4°C). The most reduced temperature is at the base side of the still (32.2°C). The greatest hourly yield (0.320 kg/hr) is gotten from lower water profundity (10mm) between 12hrs-13hrs and the least most extreme hourly yield (0.204 kg/hr) is from higher profundity (60mm) at 16.3hrs-17hrs.

D. Sathishet al. [5], In this article the exhibition of traditional sunlight based despite everything is contrasted and that of adjusted sun oriented still in which metal grid structures are utilized as a reasonable warmth stockpiling media, in this way it spares the overabundance vitality created during day time and uses the reasonable warmth vitality from the metal framework structure at the night or evening. The metal framework structure is affected in the bowl where saline water is deteriorates. In the sunlight based as yet, during less long stretches of sun powered force, the delicate warmth was discharged from the metal grid. Endeavours are made to utilize the most extreme measure of sun-based vitality occurrence and to utilize the reasonable warmth aggregated in the structures of the metal network structures. It is seen that normal still profitability and productivity in the modernized still with metal grid increments altogether with less expense for this adjustment since it is exceptionally modest and easy to get to. Side and base warm misfortunes are immaterial, impartial measure of night profitability, more advantageous productivity at a lower water profundity in the bowl was accomplished and it is ease in development and it tends to be admirably applied to profound bowl stills.

III. Problem Statement

Use of fossil fuels increases the pollution. They are non renewable. Solar energy is best instead of these. The use of solar energy in distillation of saline water to produce potable water due to the increase of fossil fuel cost it has become wide spread, their usages are prohibited by their cost. This required study on the modelling of basin solar still for an efficient design. Hence a three-dimensional, two-phase model is to be developed for evaporation and condensation processes in solar still by using computational fluid dynamics (CFD) method to simulate the model. The optimum design obtained by CFD simulation is manufactured for experiments and validation of both the simulation and experiments results are performed.

IV. OBJECTIVES

1. To find out optimum angle (glass inclination angle) (26, 30- and 35-degree angle)for maximum efficiency by CFD simulation, later manufacturing of optimum design for experimental results.
2. Validation of experimental and CFD simulation results to determine the volume fraction rate (air,

water vapor and water), efficiency, and production rate of fresh water.

3. The effect of depth of the basin water is to be studied.
4. Comparison of experimental and CFD simulation results to check the parameters impact on the performance of solar still.

V. METHODOLOGY

Step 1:- Starting the work of this project with literature survey. Gathered different authors research papers which are relevant to this topic. After studying these papers, we learnt about solar still inclination angle details in deep.
Step2:- On the second stage the selection of optimized solar still design which are required for our project are decided.
Step 3:- In that stage the 3D Model and drafting was made on the CATIA software.
Step 4:- Computational Fluid Dynamics (CFD) simulations of vortex tube with single input nozzle and multiple input nozzle will be done on the ANSYS Fluent software.
Step 5:- The manufacturing of optimized model to be made, after that experimental reading are note down with the help of thermocouple.
Step 6:- Comparative analysis between the experimental & CFD results & then the results & conclusion will be drawn

DESIGN OF SOLAR STILL

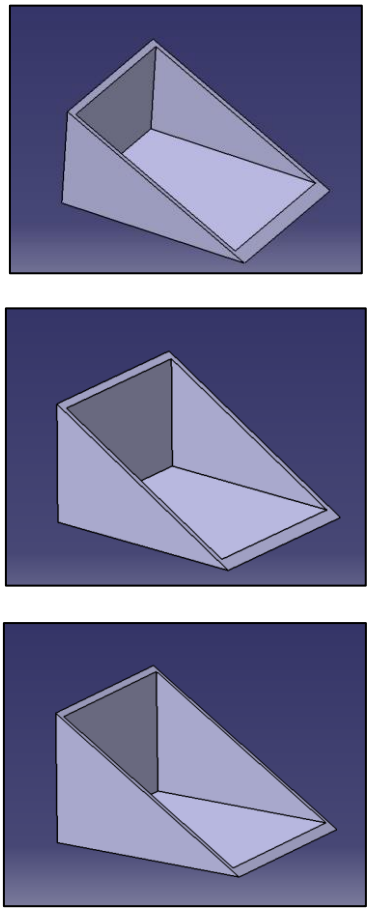


Fig.CATIA model of different inlet geometry of the solar still.

Computational fluid dynamics (CFD) is a branch of fluid mechanics which uses numerical analysis and data structures to analyze and solve problems that are involved in fluid flows. CFD is recognized as the part of the computer-aided engineering (CAE). Number of tools are used today in all industries. Its approach is to modelling fluid flow phenomena allows equipment designers to have the power of a virtual wind tunnel on their desktop computer.

CFD PROCEDURE

- First of all bounding box is created across solar still profile for the simulation of velocity and pressure distribution across surface of solar still.
- Meshing is performed for CFD simulation.
- Named selection is performed in CFD for defining air inlet, outlet and blade surface of the solar still.
- In general box model gravity is defined in perpendicular direction. The energy is kept on to perform conservation of mass, momentum and energy equation to solve.
- In viscous model k epsilon, realizable and standard wall function is selected to maintain turbulence flow.
- From solar calculator solar rays are incident.
- Hybrid initialization is performed.
- 1000 number of iterations is considered.

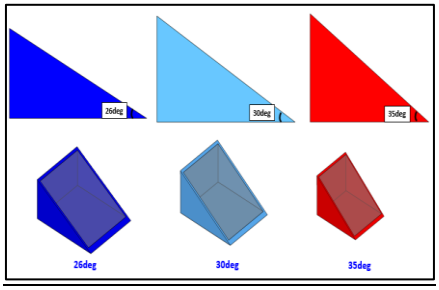


Fig. Geometry with different inclination angle

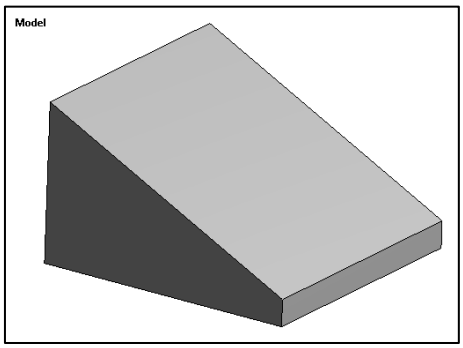


Fig. Volume extracted for CFD simulation

Mesh

ANSYS Meshing is one of the important parameter in CFD.It may be a all-purpose, automated high-performance product, intelligent. It produces the foremost acceptable Mesh for correct, economical metaphysics solutions. A mesh well

matched for a selected analysis may be generated. Full controls over the options regular generate the mesh are accessible for the skilled users who needs to fine-tune it.

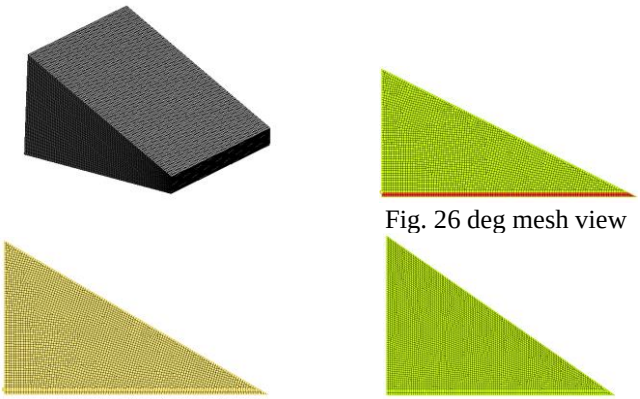


Fig. 26 deg mesh view

Fig. 30 deg mesh view

Fig. 35 deg mesh view

Fig. Geometry and meshing solar still

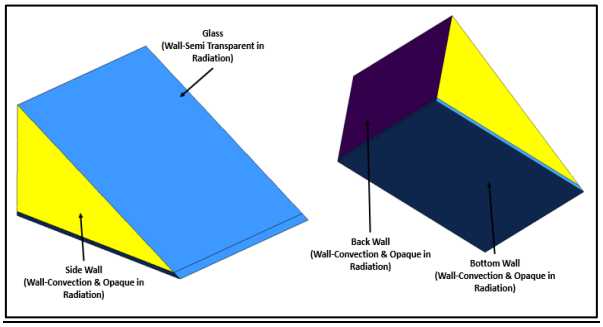
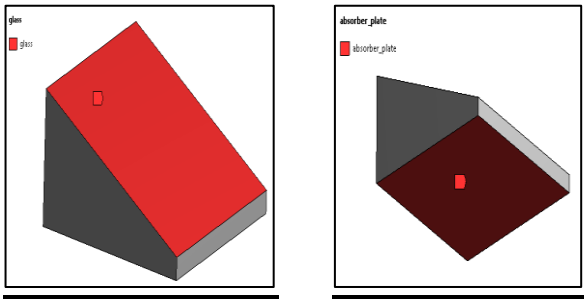


Fig. Boundary condition



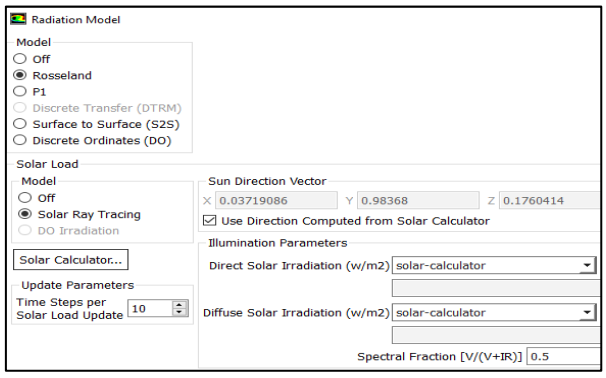


Fig. Named selection details

Boundary Condition

A boundary condition for our model will be as like the setting of a well-known values for a displacement or an associated load. For a specific node you will be able to set either the load or the displacement but not each. The main types of loading obtainable in Finite Element Analysis (FEA) include pressure, temperature and force. These may be applied to surfaces, edges, nodes, points and components or remotely offset from a feature.

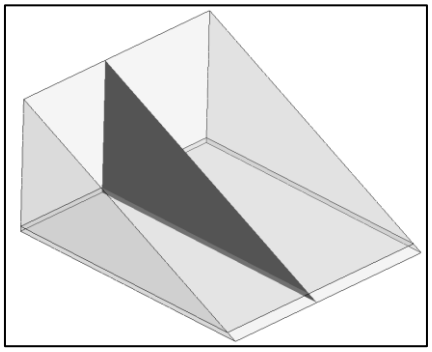


Fig. Wall heat transfer coefficient contour

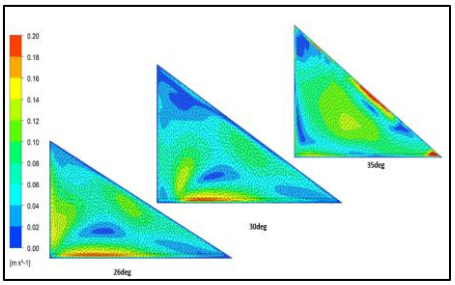


Fig. Contour of Velocity Magnitude on Mid Plane (Velocity Range 0-0.2m/s)

The buoyancy in flow due to natural convection is observed and it shown by black colored vector arrows.The hot air/vapor travels upward and the high dense fluid is traveling towards bottom corner in every design.The velocity of fluid is increasing with respect to change in angle.

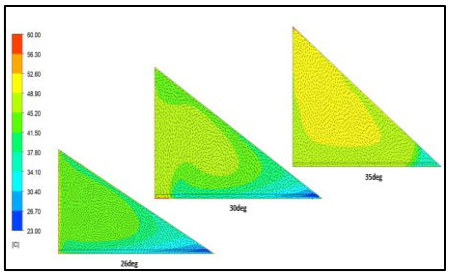


Fig. Contour of Temperature on Mid Plane (Temperature Range 23degC – 60degC)

The buoyancy in flow due to natural convection is observed and it shown by black colored vector arrows. The hot air/vapor

travels upward and the high dense fluid is traveling towards bottom corner in every design. The temperature of fluid is highest in highest inclination angle case. The higher temperature will help to produce more vapor which will be accumulated on glass.

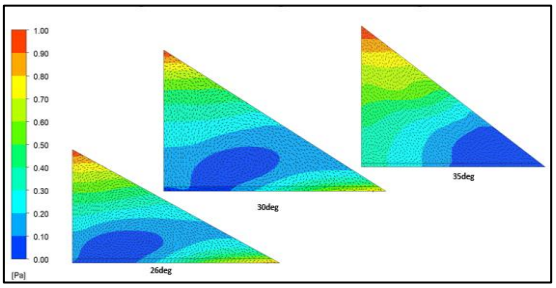


Fig. Contour of Pressure on Mid Plane (Auto Range)

The black coloured vector shows the buoyancy in flow due to natural convection. The pressure of fluid is increasing with increase in inclination angle because inside area is increased and as the amount of vapor is increased inside still which shows that the pressure has increased. The pressure value is less than atmospheric pressure due to atmospheric condition but the area of maximum pressure is highest in higher inclination angle case.

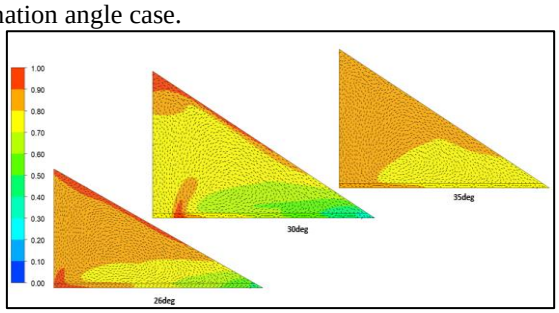


Fig. Contour of Vapor Fraction on Mid Plane
(Fraction Range 0 - 1)

The buoyancy in flow due to natural convection is observed and it shown by black colored vector arrows.The vapor amount is increasing with increase in inclination angle whereas it is also observed that there is no major difference between vapor amount and the vapor fraction is varying by 10-15% with increase in angle.

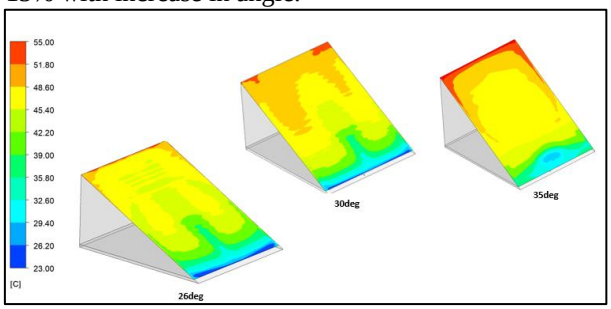


Fig. Contour of Temperature on Mid Plane
(Temperature Range 23degC – 55degC)

The temperature is higher on top crooner of the glass as the hot fluid is traveling to higher location due to buoyancy effect and cold fluid traveling downwards. The glass temperature is maximum for higher inclination angle case. The difference between temperature is ~10-15% in every inclination angle case.

EXPERIMENTAL TESTING PROCEDURE

- In present CFD simulation were performed to obtain optimum inclination for manufacturing and most absorbing angle for sunlight rays.
- Dimension of solar still with 35-degree angle were cut using steel sheet of respective dimension properly.
- Each section was welded with proper arc welding and glass is kept at top surface with outlet pipe to collect vaporized vapour and condensed water for drinking purpose.

Fig. Experimental setup

In present manufacturing of solar still is performed with optimum angle of 35-degree inclination angle. Temperature at respective location is plotted using thermocouple namely Temperature at glass surface- around 34 degree Celsius Temperature at base plate or water of solar still- 31- 33-degree Celsius.

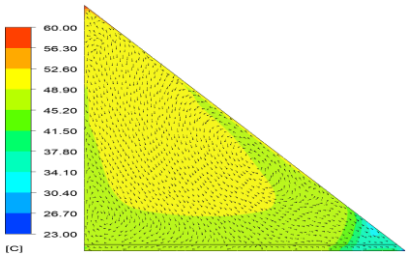


Fig. CFD temperature distribution for 35-degree inclination angle

The temperature of fluid is highest in highest inclination angle case. The higher temperature will help to produce more vapor which will be accumulated on glass.

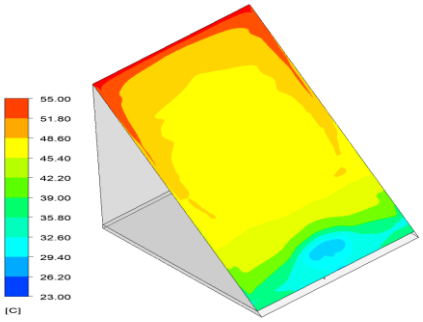


Fig. CFD temperature distribution for 35-degree inclination angle on glass surface

Table. Comparison of CFD and experimental result

Parameter	CFD (TEMPERATURE)	EXPERIMENTAL (TEMPERATURE)
GLASS SURFACE	32 – 35.80	34
WATER OR BASE PLATE	34- 37	31-33

VI. CONCLUSION

1. In present investigation we designed the optimum inclination angle for solar still. It is investigated to obtain optimized geometry to perform experimental analysis.
2. The traveling velocity of fluid inside still is increasing with respect to change in angle.
3. The pressure inside solar still is increasing due to increase in velocity with increase in inclination angle.
4. The vapor amount is increasing with increase in inclination angle. It is also observed that there is no major difference between vapor amount and the vapor fraction. It is varying by 13-15% with increase in angle.
5. The temperature of fluid is highest in highest inclination angle case. The higher temperature will help to produce more vapor which will be accumulated on glass.
6. The glass temperature is maximum for higher inclination angle case. The difference between temperature is ~10-15% in every inclination angle case.
7. We may conclude that the higher inclination angle will help to improve the performance of solar still but please note that the variation will not be more than 10-15%.
8. In CFD simulation solar still following water vapour fraction, eddy viscosity, turbulence kinetic energy along with velocity contour have been plotted as it is visualized.
9. In experimental testing of solar still temperature at respective location were measured using thermocouple and CFD simulation result were probe at location and also it is observed that both results are in nearly same in range.

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