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Modeling and computational approach for optimized design on single slope solar stills

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Abstract - *This review paper is focused on the application of design software in solar still system. The endeavour has been made on the utilization of design software in the solar still system. The application of design software provides an easy path to create and examine the unique mathematical models used and foreseeing the best appropriate performance parameters for the enhanced production rate of distilled water for the still system. Because of additional time taking and high costing of manufacture of exploratory setup of solar distillation system have strongly motivated scholars to do work based on numerical and computations. Computational fluid dynamics (CFD) can be most broadly utilized for the investigation of temperature distribution pattern and moist airflow patterns with the help of boundary conditions for designing the system under consideration. The application of CFD simulations strategy is being finished with the assistance of ANSYS, Fluent, and TRNSYS. MATLAB, FORTRAN is very needful programming tools for the development of such mathematical models for the prediction of flow parameters. Optimization techniques are also discussed in this article for performance improvement parameters giving better yield output of solar stills. All recent employed and developed software for the utility of solar still system is discussed in this correspondence. This detailed review of various simulation software and programming-based applications in solar still system will help to researchers and scientists, academicians.*

***Key Words*: Solar Still, Simulation, CFD, FORTRAN, MATLAB, COMSOL.**

1. INTRODUCTION

Water is fundamental for each living element on the earth. Our every day need exercises like farming, modern and homegrown requirements rely on water. Consequently, there is a need to extract drinkable water from the saline water[1]. Sunlight based energy is an endless wellspring of energy which is available in bounty and contamination free. Regular earth gets a lot of energy from the sun. Sun powered refining is one of the procedures to remove drinkable water from saline water with the assistance of solar radiation, which is liberated from the utilization of fossil fuels[2]. Sunlight based still deals with the rule of sun powered refining and gives consumable water fora direct human utilization. This refining system depends on the vanishing and buildup peculiarity. The distillate yield gathered at gathering channel is new water[3]. For the better presentation, it is required toado a parametric assessment and its examination. Thea plan of sun based still can be improved with the help of relevant programming. Computational liquid dynamics(CFD) examine and research the stream example of soggy air and temperature appropriation, stress example of nearby divider and damp zone. CFD based reenactment programming is likewise being utilized for the expectation of practices of stream design close to the divider, and gathering cover. The recreations got during CFD works shows the zones in a sun oriented still where buildup, dissipation happens the same dampness zone, consolidating zone, vanishing zone and so on It additionally gives the data with respect to the temperature of the slanted glass cover, water temperature, and fume temperature etc[4]. A programming language, for example, Fortran is being utilized in the reproduction cycle for the arrangement of energy conditions. Comsol Multiphysics coding utilized for mathematical reenactments for sun based still. MATLAB is a fundamental device utilized for the advancement of numerical models and to assess the boundaries considered in the recreation interaction. There are so many audit papers Ianthe sun oriented still, butanone of them went through the utilization of plan programming and mathematical displaying procedures applied in the sun based still. This survey and improvement strategies. This article additionally examines the distinctive sort Solara stills stream conduct, speed design, boundaries impacts on refining rate, the impact of tendency point on rate, shear pressure examination close to the divider. In this paper, the whole data with respect to fume zones, shear pressure zones, buildup zone, their temperatures ranges are talked about. Distinctive lattice type, plan modeler in computational work, diverse streamlining methods in the field of CFD has been examined in this article.

2. SIMULATION TECHNIQUES OF DIFFERENT SOLAR STILLS

2.1. CFD simulation

Khare et al. developed a 3D CFD model to understand the evaporation and condensation phenomena in a passive type single slope solar still[5]. It utilizes the finite volume method (FVM) to change over the administering conditions into numerically solvable algebraic equations. The hexahedral meshing is shown in Fig.1., which comprise of aggregate 1.5 million cells (components) at a development rate of 1.2.

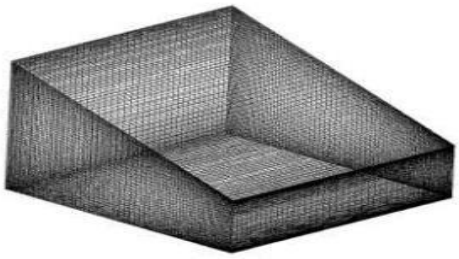

Fig.1. Meshed structure of the solar still for CFD simulation[6]

Simulation results show that with an increase in solar radiation with reflecting mirror leads to enhancement of productivity by 22%. Rahbar et al. worked on 2D CFD simulation for tubular solar still for the estimation of heat and mass transfer coefficients[7]. ANSYS-FLUENT14.0 used to simulate flow behavior inside the tubular solar based still. CFD simulation indicates a recirculation region of water vapor with a clockwise heading inside the still. Shakaib et al. used CFD FLUENT software for 3D modeling to study fluid flow behavior in natural convection solar still[8]. The geometry portion is created and meshed in Gambit software.

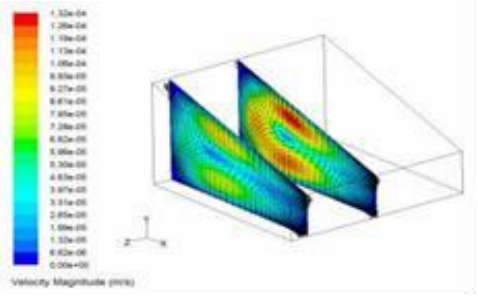

Fig.2. Velocity contours in solar still[8].

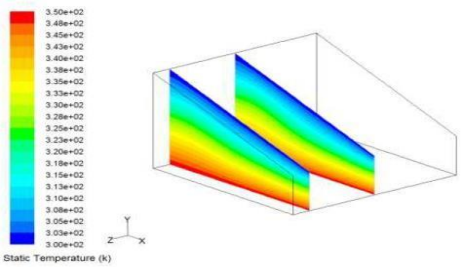

Fig.3.Temperature profiles on two planes[8].

The fine mesh contains cells of about 1×10^5, and Ra for simulation was 1000.Simulation results show that on the plane which is close to the wall, the velocities are lower. The simulation is shown in Fig.2,3. The results from computational work were compared to the Dunkle relation of dimensionless numbers[9]. Maheshwari et al. performed CFD analysis for a single basin double slope solar still in solid works[10]. The meshing work for this model is being done in ANSYS ICEM CFD technology of tetrahedral type which is generated with 35362 nodes, 170791 elements. Numerical analysis was done to predict the temperature distribution and water volume fraction inside the solar still. Muddasser et al. performed Computational fluid dynamics (CFD) modeling work for the single slope solar still[11]. A 3-D model was created in ANSYS FLUENT workbench using design modeler. Ra (Rayleigh number) of 1200 was used. Flow pattern for the velocity, heat transfer coefficients were determined from the simulation work.

2.2. ANSYS CFX simulation

Singh & Mittal performed a simulation work on a passive single-slope solar distiller to find a suitable tilt angle for better productivity results. The simulation work is completed with the help of ANSYS CFXa13. The geometric model is created in the ANSYS CAD module and imported into the ANSYS meshing module to generate the mesh. Apply boundary conditions to solve momentum and continuity equations. For the simulation process of the solar distiller, a double concentrating glass cover with a slope equal to 15oa and 30o is selected. The simulation is performed at a temperature difference between 40-60oC, with an interval of 2oC between each reading. Considering that the droplets on the condensing cover form adhesion force, it is observed that the condensing cover inclined at 30o obtains high convection and evaporation heat transfer coefficient. The 30° slope condensing hood is 29.4% more efficient than the 15° slope. Panchal et al. Use ANSYS CFX tools for modeling and simulation technology to represent the model of the passive single-slope solar static device [13]. The geometry of the two-phase 3D model and its meshing are completed with the help of ANSYS Workbench 10. The tetrahedral mesh type and number of cells used is 84121. Occurs due to buoyancy. In addition, this buoyancy is caused by the density difference caused by the temperature difference of the mixture in the gas phase droplets. The climatic conditions of the Mehsana working system (23°12' N, 72°30'aS). The results show that, due to errors, there are certain differences in the yield and water temperature between the experimental results and the simulated results, which are reported as 6% and 10.25%, respectively.

Setoodeh et al. Use CFD simulation tool to build a three-dimensional two-phase model to show the evaporation and condensation process of single-slope solar distiller [14]. The model was developed in the framework of the volume of liquid (VOF) of fluid water (a mixture of air and water vapor under quasi-static conditions). The model geometry and its meshing are done using ANSYS Workbench 11. The tetrahedral meshing type is used. The simulation was carried out using 47179 nodes. The energy balance equations considered in the numerical simulation are heat transfer, mass transfer and continuity equations. The results obtained from CFD are obvious because it is an efficient and clear design modeling software. Modi et al. They conducted their research work using CFD [15] to optimize the performance parameters of solar window sills. In order to effectively design the solar distiller, the transportation parameters of the basin-type solar distiller are determined. The simulation results are compared with the experimental results, and it is found that the two are in good agreement. T V Arjunan et al. The calculation work was done for the performance analysis of the passive single-slope solar distiller [16]. Use ANSYS CFX 13 software for CFD analysis. Model the model geometry in ANSYS Workbench 13. A two-phase three-dimensional model of liquid water and its mixture with air is created in the volume of the fluid (VOF). The mesh is created with a tetrahedral type mesh. The evaporation and condensation phenomena were simulated using CFD technology. The simulation results and experimental work have been verified, and it is found that there is a good consistency between them. The average errors of the evaporation and convection heat transfer coefficients are 5.5% and 3.01%, respectively.

2.3. MATLAB programming

Tiwari and Tiwari conducted experimental work to predict the influence of water depth on the evaporation heat transfer coefficient of passive single-slope solar distiller [17]. A PC program has been written with MATLAB version 7.0 software to solve the thermal model. The solution of the equation gives the values of hourly convective heat transfer coefficient (hcw), evaporative heat transfer coefficient (hew), Dunkle convective heat transfer coefficient (hcwDUNK) and Dunkle evaporative heat transfer coefficient (hew DUNK) [18]. Due to Dunkle's limitations and the assumptions made during the formation of the energy balance equation, the results of the matrix solution differ greatly from the experimental data. Mahendron and others. Engaged in the numerical analysis of the double-slope solar distiller [19]. The brackish water is mixed with granular activated carbon. To show the simulation model Simulink toolbox was used. Abed et al. worked for the improvement of performance of a passive type single slope solar still[20]. The sun based still is being joined with the sun based gatherer for heat move improvement rate to get a better return. The outcome shows that the yield increases with a sun oriented gatherer. Also deviation was recorded for 11.3% of the exploratory worth in vanishing temperature. The numerical model created shows the connection between the authority region and bowl region. Hamadou et al. have inspected for a functioning kind single incline sun powered as yet having a copper warming plate at bowl for upgraded heat move rate[21]. In this demonstrating procedure Chilton-Colburn model and Dunkle model, both were utilized under consistent state condition. MATLAB program created on the order to address the non-direct differential express conditions in grid structure. Enhancement strategy was utilized to observe the reasonable boundaries like windspeed, bay temperature, liquid exchange rate, relative stickiness, water bowl profundity. Halima et al. performed work on warm demonstrating for dynamic kind single incline sun based still combined with pressure heat pump[22].The numerical model created with the mass and energy balance conditions. Results have exhibited that the productivity of the yield in dynamic sunlight based still is 75% higher than traditional uninvolved sort sun powered still. For the arrangement of the differential condition, fourth request Runge-Kutta (R-K) strategy is being utilized. Hence, MATLAB is a significant apparatus for the arrangement of the situations determined for the hotness move inside the sun powered still.

2.4. FORTRAN

El-Samadony et al. used FORTRAN programming language to show virtual experience program for the examination of radiation shape factor on still efficiency and radiation heat move inside the sunlight based still[23]. For the ideal arrangement of the energy balance condition, the retrogressive distinction recipe of the main request was utilized. Result exhibits that as the glass cover incline point expands, the radiation shape factor decreases and along these lines usefulness increments up to 18.8%. Ileri et al. worked for sun oriented stills to dissect the impact of glass cover thickness on the usefulness yield[24]. Warm demonstrating was created for the sunlight based still and for the arrangement of these situations programming, FORTRAN-77 was utilized.

For observing the underlying foundations of radiative hotness move coefficients for glass and water temperature Newton Raphson strategy was utilized. Adhikari et al. accomplished an exploration work for the multi-stage stacked plate sun based still. Thermophysical properties have

been assessed for the assessment of hotness move coefficients. For the estimation of temperatures and checking the perceptions, HP-BASIC language is utilized. A PC program is being written in FORTRAN-77 to assess the consistent state temperature of water and comparing yield. Zerrouki et al. worked for the mathematical reenactment of slim film sun oriented still combined with the customary sun powered still in series[25]. For the arrangement of the non-direct conditions, a PC program was written in FORTRAN-90 language. Runge-Kutta strategy was applied to this programming procedure. Examination result shows that distillate yield is more when contrasted with the ordinary still framework.

2.5. COMSOL Multiphysics Simulation

Table.1: Functions, application and limitations/Benefits of different softwares in a solar still

Model	Function	Application	Limitation/Benefits
CFD Fluent/Ansys	CFD Fluent is simulation software which gives the idea about the fluid flow behavior and heat transfer inside the solar still.	The forecast of correct shape and size should be possible effectively and can save money by taking out time of rehashed creating and broad exercise.	Learning of software like CFD is time-tedious and geometry meshing is likewise time taking methodology for the accurate result.
MATLAB	MATLAB is a mathematical modeling, programmable programming and it is utilized for the solution Of nonlinear differential equations accurately with taking very less time.	This software exceptionally valuable to create mathematical models to predict the temperature of water, glass, humidity; yield. It Is additionally valuable for testing of different models.	MATLAB mathematical Modeling based programming Requires excellent skills of coding. It requires a long investment to create and test the models.
FORTRAN	FORTRAN programming Language is Used in mathematical Modeling to resolve partial differential equations.	It very well may be Utilized for Execution Investigation of solar still systems. also saves cost by Minimizing material usage for optimized system design. It can also optimize structural Execution with exhaustive examination furthermore, reduce out expensive and lengthy trial-and-error exercise.	This programming is developed in a prototype software like visual languages such as Mat lab and IDL(Interactive Data Languages) and then at that point port this code to FORTRAN
COMSOL MULTIPHY	It is simulation-based software and it gives entire thought of the heat transfer profile and fluid flow pattern inside the solar still system.	This software can be utilized to anticipate the air-moisture movement through the basin to the glass surface Inside the still system. It can likewise be utilized for the optimized design parameters.	When contrasted with CFD fluent, this software is quite easy to learn.

Maalem et al. utilized COMSOL Multiphysics recreation programming to investigate the hotness move inside the trapezoidal sun based still framework. For the displaying reason, three non-adiabatic dividers are being considered[26]. The energy balance conditions were settled by the limited component technique. Abed et al. worked for the desalination interaction in rounded kind uninvolved sun powered still. Hypothetical displaying was ruined the assessment of glass cover temperature, water surface temperature, muggy air temperature, the creation yield of the sunlight based still framework. For the recreation work, comsol Multiphysics programming 5.0awas utilized. The entire calculations were ruined two cases for example with protection of outside divider and another is with protection. It was extremely useful to anticipate the various temperatures of the sun oriented still framework. The use of programming, its advantages, and constraint have been recorded in Table 1.

3. CONCLUSIONS

This paper investigated the examination deals with different plan programming and programming dialects in a sun oriented still application for the plan boundaries. Fundamental spaces of their application are towards the streamlining of plan boundaries. Utilization of programming not just lessens the utilization of time for trial work yet additionally save the expense.

CFD ANSYS/familiar is the recreation programming for perception of stream boundaries like the dissemination of the air-fume blend, temperature shapes inside the sunlight based as yet, consolidating and vanishing zones of sun oriented still. Programming reenactment gives a representation with respect to stream boundaries inside the sun oriented still speed circulation, shear pressure stream investigation, stream designs close to vertical dividers inside the sunlight based still framework. MATLAB can be utilized for the progression of numerical models of sun based still framework for various boundary instruments. Comsol Multiphysics programming, TRNSYS, FORTRAN are the programming-based reenactment programming are broadly utilized for the arrangement of the fractional differential condition of energy balance. These programming dialects help to foresee the diverse hotness move coefficients, the temperature of the dividers of sun powered stills, water temperature inside the sunlight based stills. Subsequently, recreation models given by researchers in the field of sun based refining processes would be profitable in ongoing improvements around here..

4. FUTURE SCOPE

From the literature survey, it has been concluded that enormous work has been done experimentally solar stills. But there has been a little work done in the field of computational work in solar stills. From this review

article, it can be suggested for the future scope of CFD work:

- CFD simulation work can be developed for double slope solar still, wick type solar still and multi-effect solar stills.
- The various parameters for CFD work can be as the inclination angle of the glass cover, basin absorption, height between the glass cover and the water surface which effect the yield output of solar still.
- A geometrical optimization technique can also be done with help of CFD modeling work of solar still.
- CFD modeling work should likewise be possible with changing the orientation of glass surface and varying other parameters.
- CFD work can be shown in solar stills for the determination of entropy generation inside the system.
- CFD simulations can be done to visualize the effect of storage materials in productivity.
- In these days, the use of nanoparticles in the solar still has been investigated for the enhancement of yield. Modeling technique and simulations can be done for various nanoparticles in different types of solar still.
- Fans are being used for forced convection, so CFD work can also be performed to identify the enhancement rate.

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