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"CFD-BASED PERFORMANCE EVALUATION OF SOLAR STILL CONFIGURATIONS FOR SUSTAINABLE WATER DESALINATION"

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ABSTRACT

The escalating global demand for clean water, driven by population growth, urbanization, and industrialization, has led to a critical need for sustainable water purification technologies. Solar stills, which utilize renewable solar energy to distill water, offer a promising, low-cost solution for freshwater generation, particularly in coastal and arid regions. This study investigates the thermal and fluid dynamics performance of a solar still with two configurations—wooden wall and glass wall—using Computational Fluid Dynamics (CFD) analysis. A detailed meshing and simulation setup were developed to predict water evaporation and vapor behavior inside the still. Results indicate that the glass-walled configuration achieved a higher vapor volume fraction (0.92) compared to the wooden-walled version (0.82), with a slightly elevated inner wall temperature of 325 K versus 316 K. Basin temperatures were nearly identical in both setups (~329.8 K), confirming stable heat retention. The study confirms that optimizing wall materials and structural design significantly enhances the thermal performance and water yield of solar stills. The findings contribute to the development of efficient and eco-friendly desalination systems suited for resource-limited environments.

Key Words: *Artificial Neural Networks, Power, Transmission line, economical.*

I. INTRODUCTION

Throughout the world, water supplies are at or near capacity owing to rising demand driven by urbanization, population growth, and agricultural expansion. There is an interest in locating some feasible hubs for purifying water in order to solve this problem. A solar-powered still is a useful tool for purifying seawater and other salty water for human consumption.

As the world's population grows, likewise, the necessity for potable water, and assessments of that resource's quality have grown more stringent. The desalination sector has flourished in numerous nations across the world where sources of clean water are scarce. The annual global supply of water that has been desalinated is expected to reach 54 billion m3 by 2020. The fundamental problem of the twenty-first century is thought to be improving the efficacy and suitability of water decontamination innovation to generate pure water and secure nature in a cost-effective manner. Water in cities is filtered through many remarkable layers of MSF, MED, and RO, and an electric field is generated across these levels. Dissolving salts are able to travel through the films, but water is unable to. This piece provides an overview of the factors (climatic, operational, and plan parameters) and upgrades (wicks, inside and outside condensers, inward and outer reflectors, stage change materials, stepped sun oriented still, and another strategy improved the yield of the sun-based still using nanoparticles) that have affected the effetiveness of solar-powered stills up until the end of 2014.

Along with food and oxygen, water is one of humanity's most basic need. Only a fraction of the water on Earth is liquid

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condition at any one time, yet almost all of that may be contaminated with diseases and poisons. That's why water filtration is so crucial. Furthermore, regular cleansing systems are easily compromised or bartered away by disasters of all kinds. Untreated Water has a broad variety of diseases and hazardous chemicals, making it difficult for people to plan such events while also protecting their family from potential injury. In order to get pure water, everyone has to seek for the solution to the top problem using the existing energy sources.

II. LITERATURE REVIEW

The total quantity of new water is decreasing, It has a significant role in the scarcity of water in several regions of the world. Population growth and wasteful freshwater use, and rising global temperatures are all contributing factors. Due to a lack of precipitation in many parts of the globe, many animals have perished. This is because many water sources have dried up, leaving animals and people without access to the water they need to survive. Only around 0.3% of the water resources on Earth are easily accessible. as fresh water. The total quantity of new water is decreasing, which is a major contributor to water scarcity in certain parts of the globe. Inefficient use of fresh water, population growth, and rising global temperatures are all contributing factors. Due to a lack of precipitation in many parts of the globe, many animals have perished. This is because many water sources have dried up, leaving animals and people without access to the water they need to survive. Only around 0.3% Fresh water is easily accessible from the world's water resources. Potable water scarcity is quickly rising on the list of global concerns. Since the sea is the major source of replenishable water, desalinating salt water seems to be the most workable solution. Desalination methods demand a lot of energy, and many poor nations simply cannot afford them while suffering from severe water shortages. Fortunately, many of these countries are located in quite secure areas. So long as effective improvements are developed to make efficient use of the sun's energy, solar-powered desalination may be a viable choice.

Directly, in a solar still, or indirectly, where the heat energy from a solar energy system is transferred to a desalination machine, solar energy may be used to make fresh water.

There have been several attempts to develop and improve the efficiency of solar-powered desalination systems, particularly solar stills. After all, the efficiency of the still is calibrated to the delta water temperature. Some studies have suggested linking the still to solar-based gatherers to increase the temperature of the water within the still. The results indicated a shift in the way the still was performed. The unfortunate inert heat of build up to nature and the sensible heat redirected by the condensate are two of the primary reasons for the poor productivity of solar based stills, which is roughly 30-40% [1]. The still's efficiency has been drastically improved by the use of latent heat from construction to pre-heat the food water. Researchers have investigated a radical improvement in still performance by transferring latent heat from one phase to another, as in multi-impact stills. Several researchers have investigated the possibility of disappearing at low temperatures in a vacuum, reporting significant modifications to the framework's performance. However, they used to hoover pumps, which add a significant amount of energy consumption to the system.

Refining using sunlight is a serious effort at innovation. Arab chemists are credited with making the first significant use of stills in 1551. Over the next several centuries, scholars and naturalists like Della Porta (1589), Lavoisier (1862), and Mauchot (1869) used stills. In the mining community of Las Salinas in what is now northern Chile (Region II), the major "standard" sun oriented still plant was established 1872 by the Swedish expert Charles Wilson. This was a large bowl type still in use today to provide fresh water to a nitrate mining community via the use of salty food water. Wooden inlets were used in the facility, and the bottoms were stained black with logwood colour and alum. The total space of the refinery was 4,700 square metres. This facility regularly supplied over 23,000 litters of purified water per day during the summer, or 4.9 kilogramme per square metre of still surface area. Solar Still refers to a technique for water distillation that uses sunlight rather than electricity. SS effectively purifies both saltwater and raw sewage. Successful removal of salts/minerals (Na, Ca, As, Fe, Mn), bacteria (E. coli, cholera, botulinus), parasites (helminths), heavy metals (TDS), and TDS are all possible with a solar-oriented still [2]. Sun-powered energy warms water, evaporates it (leaving salts and organisms behind), and accumulates as mists to fall back to earth as water; this is the essential core mechanism at action in a solar-powered still.

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The still's bowl contains water that needs to be purified till it's almost full. The glass cover lets in the sun's energy, which is normally absorbed by the still's bottom. This inner surface is made of a darker substance to better absorb and store sunlight. The air that is trapped between the water's surface and the glass warms becomes more humid. The boiling water's steam leaves the basin and collects in the space between the glasses. This method leaves the original water devoid of all of the minerals and microbes that were in it. Concentrated water flows down the angled glass surface, into a collecting trough, and then into a storage container. To ensure proper flushing of the bowl water and to remove excess salts abandoned during the dissipation process, a daily amount of sustain water should be added that normally exceeds the distillate output. If the still only produced 3 You will need liters of water add 9 litres of make-up water so that you have enough to flush the toilet.

III. METHODOLOGY

It is customary to have a computer mimic the behavior of f gasses and liquids susceptible to boundary conditions that come into touch with surfaces. Faster supercomputers may lead to better answers. Intricate simulation scenarios, sonic or turbulent flows, are made more realistic and faster with the help of the software system uncovered by the current study. Such software systems undergo structural experimental validation from the outset, with final validation returned in comprehensive testing, such as flight tests.

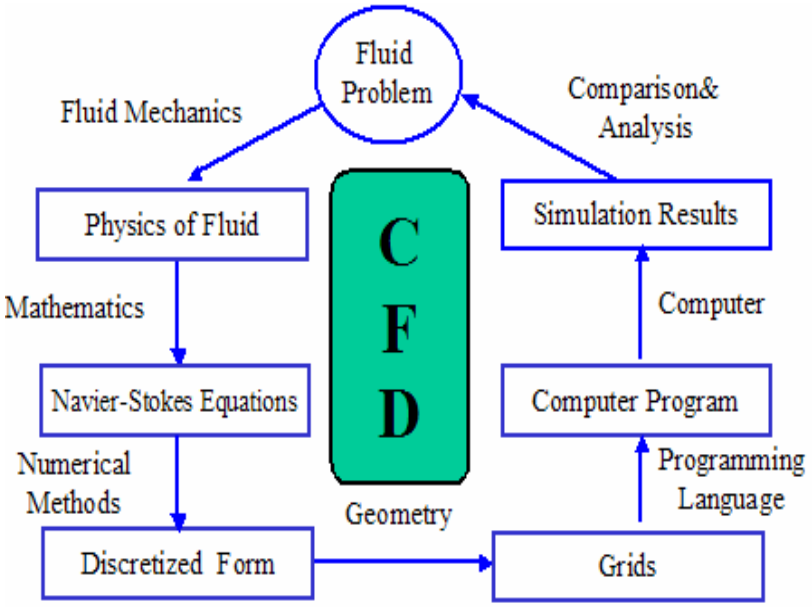

Figure 1 Process of CFD

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Figure 2 Solar still glass wall new set up

Figure 3 Solar still wood exiting set up

Table No. 1 Geometry of solar still

Width	1 mm
Length	1 mm
Wood thickness	8mm
Glass thickness	4 mm
Glass Slope	30°

3.1 Meshing

The process of meshing in CFD is crucial. This process involves removing a great deal of very minor components and nodes from the CAD geometry. Spacetime components and a network of nodes called a mesh. The efficiency and speed of the analysis are both affected by the mesh size and orientation. The accuracy of a CFD analysis improves as the number of components is increased, albeit at the expense of analysis speed.

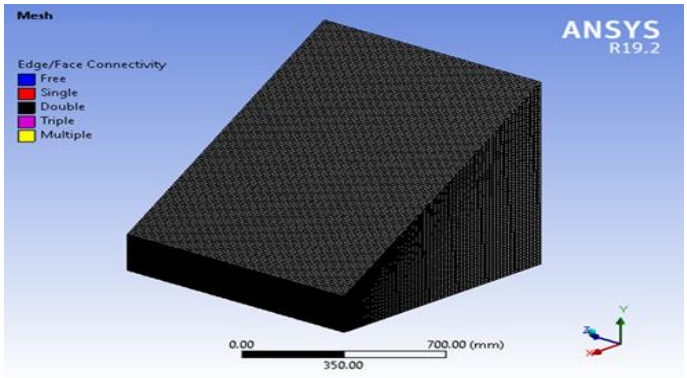

Figure 4 Mesh Model

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IV. Result and Discussion

4.1 Simulation Results

To examine how well the Solar still evaporates and produces water, a numerical simulation was run. Water is used in the solar still as the working fluid. The following are the features of dispersion within the Solar still:

Table No. 2 simulation result of solar still

S. No.	Results	Single slope with wooden wall	Single slope with glass wall
1	Water vol. fraction	0.33	0.25
2	Vapour vol. fraction	0.82	0.92
3	Glass wall temp.	315.7 K	316K
4	Basin Temp	329.7K	329.8K
5	Side wall temp	324K	324K
6	Inner wall temperature	316K	325K

4.2 Single slope with wooden wall

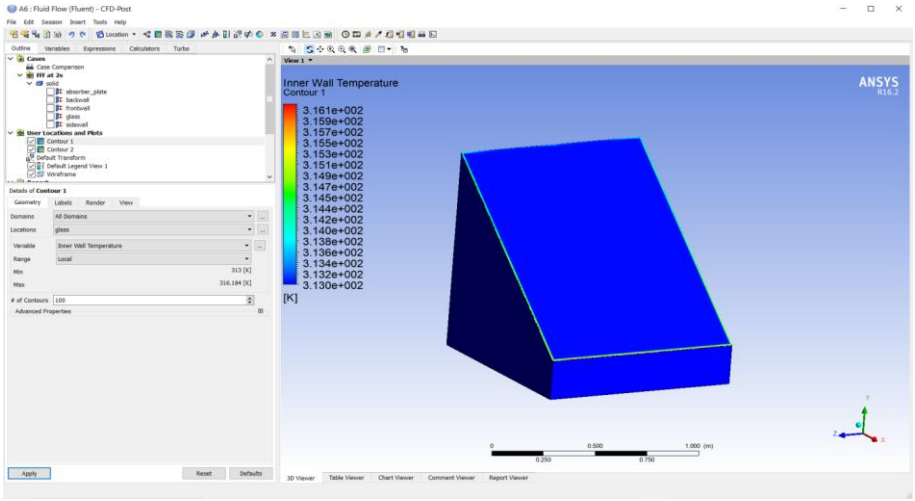

Fig. 5 The temperature of the glass inner wall derives from a single slope

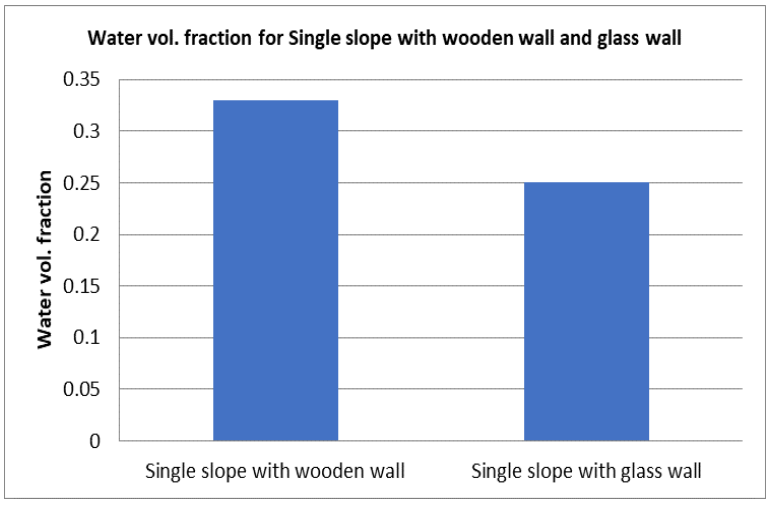

Fig. 6 Water fraction for a single slope with a wooden and a glass wall

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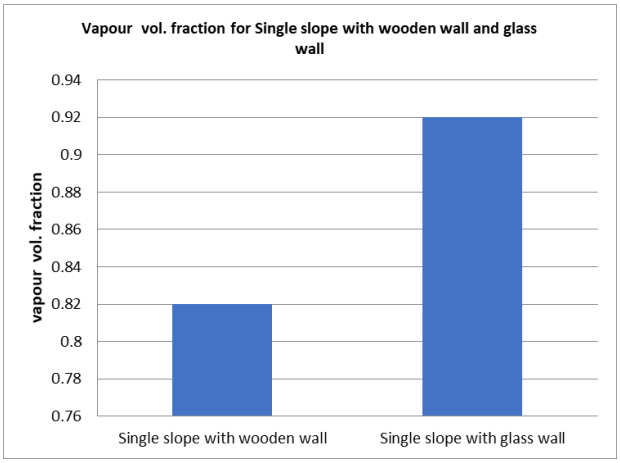

Fig. 7 Vapour fraction for a single slope with a hardwood and a glass wall

V. CONCLUSION

This study evaluated the comparative performance of two solar still configurations—one with wooden walls and the other with glass walls—through CFD simulation. The results demonstrated that the glass-walled still exhibited superior vapor generation and higher inner wall temperatures, indicating enhanced heat absorption and distillation efficiency. With a vapor volume fraction of 0.92 and increased internal temperature, the glass-based model outperformed the wooden counterpart, which had a vapor volume fraction of 0.82. These insights highlight the importance of material selection and geometric design in improving solar still performance. Overall, the research supports the viability of solar-powered desalination as a sustainable and accessible water purification method for regions facing freshwater scarcity.

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