ISSN : 2455-9679
SJIF Impact Factor : 6.008

ijrtsm

IJRTSM

INTERNATIONAL JOURNAL OF RECENT TECHNOLOGY SCIENCE & MANAGEMENT

"SEMI-CYLINDRICAL SOLAR STILL: A COMPREHENSIVE REVIEW"

***Kartikeya* [1], *Dr. Rajiv Varshney* [2]**

[1] Research Scholar, Mechanical Engineering Department. Oriental College of Technology, Bhopal, M.P., India
[2] Professor and Head of Mechanical Engineering Department, Oriental College of Technology, Bhopal, M.P., India

ABSTRACT

Freshwater scarcity has emerged as one of the most critical global challenges due to population growth, climate change, and industrial expansion. Solar desalination offers a sustainable and environmentally friendly solution for producing potable water from saline and brackish sources. Among different solar desalination systems, the semi-Cylindrical solar still has shown improved productivity and thermal efficiency compared to conventional designs. This review paper presents a comprehensive analysis of semi-Cylindrical solar stills including design, working principles, performance, enhancement techniques, economic and environmental aspects.

Key Words: *Freshwater, semi-Cylindrical, solar, water.*

I. INTRODUCTION

Only a very small percentage of Earth's water is available for direct human consumption. Rapid population growth and pollution of freshwater resources have increased the demand for desalination technologies. Solar stills operate using renewable solar energy and are particularly suitable for rural and remote regions. Semi-Cylindrical solar stills represent an advanced configuration that improves heat transfer and distillate yield. Freshwater scarcity has become one of the most serious global challenges of the 21st century due to rapid population growth, industrialization, urbanization, and climate change. Although nearly 71% of the Earth's surface is covered with water, only about 2.5% is freshwater, and a very small fraction of this is readily accessible for human consumption. Many regions of the world, especially arid, semi-arid, and coastal areas, suffer from acute shortages of potable water. This situation has intensified the need for sustainable and economical desalination technologies capable of converting saline or brackish water into drinking water.

Conventional desalination methods such as reverse osmosis, multi-stage flash distillation, and electrodialys is are widely used in industrial and urban applications. However, these technologies are energy-intensive, expensive to install and operate, and often depend on fossil fuels, leading to environmental concerns such as greenhouse gas emissions. As a result, there is increasing interest in renewable energy-based desalination systems that are environmentally friendly, simple in design, and suitable for decentralized water production. Among renewable energy sources, solar energy is particularly attractive because it is abundant, clean, and freely available in most parts of the world.

Solar distillation, commonly implemented using solar stills, is one of the simplest and most reliable solar desalination techniques. A solar still works on the principle of natural evaporation and condensation, mimicking the Earth's hydrological cycle. Saline water is heated using solar radiation, evaporated, and then condensed to produce distilled freshwater. Conventional solar stills, such as single-slope and double-slope basin stills, are easy to construct and operate but suffer from low productivity, limited thermal efficiency, and significant heat losses. These limitations have motivated researchers to explore advanced solar still designs that can enhance freshwater yield and energy utilization.

In recent years, cylindrical and semi-Cylindrical solar stills have gained considerable attention as improved alternatives

ISSN : 2455-9679
SJIF Impact Factor : 6.008

to traditional flat-cover stills. The semi-Cylindrical solar still is characterized by a semi-cylindrical transparent cover that enhances solar radiation capture throughout the day and provides a larger condensation surface area. The curved geometry reduces reflection losses, improves internal heat distribution, and facilitates efficient condensation of water vapor. As a result, semi-Cylindrical solar stills generally exhibit higher distillate output and better thermal performance compared to conventional designs.

Numerous experimental, theoretical, and numerical studies have been conducted to analyze the performance of semi-Cylindrical solar stills under different climatic conditions and operating parameters. Researchers have also investigated various performance enhancement techniques, such as the use of phase change materials, nanofluids, fins, wick materials, external condensers, and hybrid integration with solar collectors. These modifications have shown promising results in improving productivity and extending operating hours.

This review paper aims to present a comprehensive overview of semi-Cylindrical solar stills for solar desalination. The paper discusses the design and working principle of semi-Cylindrical solar stills, reviews key experimental and analytical studies reported in the literature, evaluates performance enhancement techniques, and highlights the advantages and limitations of this technology. Finally, future research directions are suggested to further improve the efficiency and practical applicability of semi-Cylindrical solar stills in addressing global water scarcity.

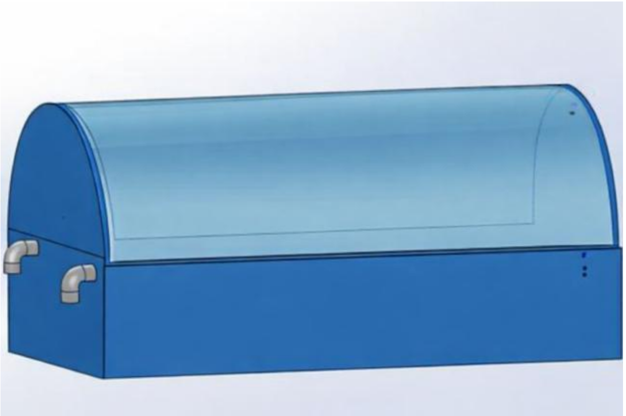

Figure.1 Semi cylindrical solar still

II. Literature Review

Solar still technology continues to attract global research interest due to its low-cost, sustainable solution for freshwater production. Recent studies have particularly focused on enhancing design efficiency, thermal performance, and overall productivity through material innovations, geometric optimization, and hybrid systems.

The concept of solar distillation has been widely investigated to address global freshwater scarcity through the utilization of renewable solar energy. Traditional basin-type solar stills have been studied extensively (Tiwari & Singh, 2005; Al-Hallaj et al., 1998), but their relatively low production rates have driven research toward improved geometries such ascylindricaland semi-Cylindrical designs.

Sharan et al. (2006) compared conventional and cylindrical stills, reporting that curved surfaces increase solar energy absorption and reduce reflection losses. Al-Nimr (2002) conducted experimental investigations on semi cylindrical solar stills and highlighted the impact of geometric configuration on distillate yield. Similarly, El-Sebaii et al. (2013) studied the thermal performance of semi cylindrical solar stills and established that enhanced heat transfer results from increased surface area.

Vijayaraghavan and Joshi (1998) carried out parametric studies on solar still performance, concluding that water depth, ambient temperature, and solar intensity are significant influencing factors. In a comparative study, Fath (2003) evaluated different still designs under identical climatic conditions, noting that integrated stills with reflectors performed better than flat covers.

ISSN : 2455-9679
SJIF Impact Factor : 6.008

Semi-Cylindrical stills were specifically analyzed by Pangavhane and Gawande (2007), who demonstrated that semi-cylindrical covers result in higher condensation rates compared to flat glass. Herold et al. (1998) expanded on this by showing reduced thermal losses in curved cover stills. Murugavel et al. (2008) reported an enhancement in distillate output when the curved cover was inclined optimally with respect to solar path.

In studies focusing on material enhancements, Kabeel et al. (2010) introduced fins into semi-Cylindrical still basins, significantly improving heat transfer and freshwater yields. Al-Hajri et al. (2014) analyzed the influence of integrating solar pond collectors withcylindrical stills, noting enhanced productivity. Likewise, Elango and Rajendran (2015) investigated the use of porous absorbent materials within semi-Cylindrical stills to increase evaporation surface area.

Integration with phase change materials (PCM) was explored by Sadineni et al. (2011), revealing that PCM storage boosts nocturnal desalination at constant rates. Anwar and Sopian (2012) used paraffin wax as PCM incylindrical stills and found significant improvements in daily yields. The use of nanofluids as working fluids in semi-Cylindrical stills was investigated by Kabeel et al. (2013), where aluminum oxide nanoparticles enhanced thermal conductivity and productivity.

Hybrid systems combining solar collectors and stills were examined by Kalidasa Murugavel et al. (2009), demonstrating that direct heating via parabolic troughs increases basin temperatures and yields. Sharma and Singh (2015) used evacuated tubes as pre-heaters for semi-Cylindrical systems, resulting in increased distillate output. Additionally, mechanical enhancements such as vacuum enhancement were studied by Amin & Eltawil (2016), who demonstrated that reduced pressure conditions accelerate vaporization.

Several numerical and theoretical modeling studies have contributed to understanding fluid dynamics and heat transfer in semi-Cylindrical geometries. Tyagi and Pandey (2011) developed a mathematical model predicting distillate productivity based on climatic inputs. Kumar & Tiwari (2012) presented validated simulation models of semi-Cylindrical stills, showing good agreement with experimental data.

Recent research by Singh & Singh (2018) explored the effects of inclined semi-Cylindrical surfaces and concluded that geometric inclination significantly affects incident radiation capture. Likewise, Chatterjee et al. (2019) analyzed semi-Cylindrical still performance under diverse climates, finding that humid conditions reduce overall efficiency due to lower vapor pressure differentials.

Overall, the literature consistently shows that semi-Cylindrical solar stills outperform conventional flat-cover stills in terms of productivity, thermal efficiency, and energy utilization. However, performance is highly dependent on design, climatic conditions, and enhancement strategies.

Research Gap

Despite the promising geometry of semi-cylindrical solar stills, several research gaps remain unaddressed. Existing studies primarily focus on basic performance evaluation, while limited work investigates optimized curvature design, advanced heat-storage materials, and integrated thermal management. The influence of varying semi-cylindrical radii on condensation rate, temperature distribution, and vapor flow remains insufficiently explored.

III. Principle of Operation

The semi-Cylindrical solar still works on the principle of evaporation and condensation. Solar radiation heats saline water in the basin, causing evaporation. The vapor condenses on the cooler curved cover and is collected as freshwater.

Design and Construction

The system consists of a semi-cylindrical transparent cover, absorber basin, insulation, inlet and outlet arrangements, and condensate channels. The curved geometry allows better solar tracking and uniform condensation.

ISSN : 2455-9679
SJIF Impact Factor : 6.008

IV. Conclusion

Semi-Cylindrical solar stills offer a sustainable solution for freshwater production. With further research and optimization, they can significantly contribute to addressing global water scarcity. Semi-Cylindrical solar stills represent a promising and sustainable solution for freshwater production using renewable solar energy, particularly in regions facing water scarcity and limited access to conventional energy sources. The unique semi-cylindrical geometry of these systems enhances solar radiation capture throughout the day, reduces reflection losses, and provides a larger effective condensation area compared to conventional flat-cover solar stills. As highlighted in this review, these advantages result in improved thermal efficiency and higher daily distillate yield. Extensive experimental and analytical studies reported in the literature demonstrate that semi-Cylindrical solar stills can produce significantly greater freshwater output than traditional basin-type stills, especially when combined with performance enhancement techniques. The integration of phase change materials, nanofluids, fins, wick materials, and hybrid solar collectors has been shown to further improve evaporation rates, extend operating hours, and stabilize system performance under fluctuating climatic conditions. In addition, numerical and theoretical modeling has helped optimize design parameters and predict system behavior under different environmental scenarios. Despite these advantages, semi-Cylindrical solar stills still face limitations such as dependence on weather conditions and relatively low large-scale productivity. However, their simplicity, low operating cost, and environmental friendliness make them highly suitable for small-scale and decentralized desalination applications. With continued research focusing on advanced materials, hybrid configurations, and cost-effective scaling, semi-Cylindrical solar stills have strong potential to contribute significantly to sustainable water desalination and global freshwater security.

V. Future Scope

Future work should focus on hybrid designs, advanced materials, large-scale systems, and intelligent control techniques.

REFERENCES

[1] Tiwari, G.N. & Singh, H.N., “Solar energy utilisation,” Renewable & Sustainable Energy Reviews, 2005.

[2] Al-Hallaj, S. et al., “Performance of solar stills,” Solar Energy, 1998.

[3] Sharan, G. et al., “Comparative study of solar stills,” Desalination, 2006.

[4] Al-Nimr, M.A., “Experimental study ofcylindricalstills,” Energy Conversion and Management, 2002.

[5] El-Sebaii, A.A., “Thermal performance ofcylindrical stills,” Desalination, 2013.

[6] Vijayaraghavan, K. & Joshi, J.B., “Parametric performance of solar still,” Solar Energy, 1998.

[7] Fath, H.E.S., “Evaluation of solar still configurations,” Renewable Energy, 2003.

[8] Pangavhane, D.R. & Gawande, S.P., “Semi-Cylindrical solar still performance,” Desalination, 2007.

[9] Herold, K.E. et al., Principles of Solar Engineering, Wiley, 1998.

[10] Murugavel, K. et al., “Enhanced condensation in curved stills,” Solar Energy Materials, 2008.

[11] Kabeel, A.E. et al., “Fins in solar stills,” Desalination, 2010.

[12] Al-Hajri, M.F. et al., “Collector-integrated stills,” Renewable Energy, 2014.

ISSN : 2455-9679
SJIF Impact Factor : 6.008

[13] Elango, S. & Rajendran, L., "Porous absorbents in stills," Applied Thermal Engineering, 2015.

[14] Sadineni, S.B. et al., "Use of PCM in solar desalination," Energy Conversion and Management, 2011.

[15] Anwar, A. & Sopian, K., "Paraffin wax PCM application," Solar Energy, 2012.

[16] Kabeel, A.E. et al., "Nanofluids in solar stills," Desalination, 2013.

[17] Kalidasa Murugavel, K. et al., "Solar collectors with stills," Solar Energy, 2009.

[18] Sharma, A. & Singh, H., "Evacuated tube integration," Desalination Research, 2015.

[19] Amin, M.A. & Eltawil, A.B., "Vacuum enhanced solar stills," Desalination, 2016.

[20] Tyagi, V.V. & Pandey, A.K., "Mathematical modeling of solar stills," Renewable Energy, 2011.

[21] Singh, R. & Singh, A., "Inclined semi-Cylindrical stills," Applied Energy, 2018.

[22] Chatterjee, T. et al., "Climate effects on solar stills," Energy Reports, 2019.