e-ISSN:2582-7219

INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY RESEARCH

IN SCIENCE, ENGINEERING AND TECHNOLOGY

Volume 7, Issue 5, May 2024

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

Impact Factor: 7.521

6381 907 438 6381 907 438 ijmrset@gmail.com www.ijmrset.com

| ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 7.521| Monthly Peer Reviewed & Referred Journal |

| Volume 7, Issue 5, May 2024 |

| DOI:10.15680/IJMRSET.2024.0705097 |

Design and Development of Indirect Evaporative Cooling System

Sagaresh Misal[1], Rohit Takre[2], Aadil Shaikh[3], Shantanu Parkhi[4], Prof. Gorde R. S.[5]

Student, Department of Mechanical Engineering, JSPM's Imperial College of Engineering and Research, Wagholi, Pune, India[1,2,3,4]

Assistant Professor, Department of Mechanical Engineering, JSPM's Imperial College of Engineering and Research, Wagholi, Pune, India [5]

ABSTRACT: The quest for efficient and environmentally friendly air conditioning solutions has led to the exploration of alternative methods to traditional cooling systems like vapor compression and evaporative coolers. Indirect evaporative air-cooling emerges as a promising contender, offering both economic viability and sustainability. Unlike direct evaporative cooling, where air comes into direct contact with evaporating water, the indirect method maintains constant air humidity while achieving cooling through the absorption of latent heat. By preventing direct contact between air and water, this system addresses concerns of increased humidity in conditioned spaces, a common drawback of conventional evaporative coolers. Moreover, it circumvents the high energy consumption and heat waste associated with vapor compression systems, making it an attractive solution for energy-efficient cooling. One innovative approach involves a shell and tube configuration, where tubes submerged in earthen pots filled with water facilitate air cooling. As ambient air passes through these tubes, it is chilled by the surrounding water, which in turn is cooled through evaporative processes facilitated by the porous nature of earthen pots. This abstracts the heat from the water, resulting in temperature reduction within the pots. This method presents a promising avenue for achieving effective air conditioning without the drawbacks of conventional systems, offering a blend of efficiency, sustainability, and cost-effectiveness.

KEYWORDS: Convective air cooling, forced draught, Indirect evaporative air-cooling system, Shell and tube arrangement, Vapour compression system, Evaporative air cooler, Latent heat of evaporation, Humidity control

I. INTRODUCTION

The quest for efficient and sustainable cooling solutions has become increasingly urgent in today's world, marked by soaring temperatures and rapid urbanization. Traditional air conditioning methods, such as vapor compression systems, while effective, are notorious for their high energy consumption and environmental impact. As a response to these challenges, alternative cooling technologies are gaining traction, with indirect evaporative cooling emerging as a promising contender. Unlike direct evaporative cooling methods that introduce moisture into the conditioned space, indirect evaporative cooling systems offer a unique advantage: they cool the air indirectly, thus avoiding the issue of humidity buildup. By harnessing the latent heat of water evaporation, these systems can significantly reduce energy consumption and mitigate environmental strain while maintaining optimal indoor comfort levels.

The concept of indirect evaporative cooling revolves around the principle of transferring heat to a secondary air stream without increasing humidity levels. This makes it particularly suitable for regions characterized by arid or semi-arid climates, where humidity control is paramount. The key innovation lies in the design of systems that effectively harness the cooling potential of water evaporation while keeping humidity levels in check. One such method involves a shell and tube arrangement, where air from the external environment is passed through tubes submerged in water-filled earthen pots. As the air comes into contact with the cool water, its temperature drops, without introducing additional moisture into the space. This approach not only addresses the energy inefficiencies and environmental concerns associated with traditional cooling methods but also offers a sustainable solution tailored to the specific needs of different climates and environments.

Efforts to optimize and refine indirect evaporative cooling systems represent a crucial step towards realizing their full potential as viable alternatives to conventional air conditioning. Through a combination of theoretical analysis, computational simulations, and experimental validation, researchers aim to develop systems that maximize energy

| ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 7.521| Monthly Peer Reviewed & Referred Journal |

| Volume 7, Issue 5, May 2024 |

| DOI:10.15680/IJMRSET.2024.0705097 |

efficiency, minimize environmental impact, and ensure consistent thermal comfort. By delving into the intricacies of system dynamics and optimization strategies, this research endeavors to pave the way for a future where cooling technologies are not only effective but also sustainable, offering a pathway towards a cooler, greener, and more comfortable world.

II. RELATED WORK

In the pursuit of more efficient and environmentally friendly air conditioning solutions, researchers and engineers have extensively explored alternative methods to conventional cooling systems such as vapor compression and evaporative coolers. While these systems have served their purpose, they often come with drawbacks that hinder their widespread adoption. For instance, direct evaporative cooling, while effective in lowering temperatures, can elevate humidity levels in conditioned spaces, which may not be desirable in certain environments. Additionally, traditional vapor compression systems are known for their high energy consumption and heat waste, contributing to both operational costs and environmental impact. Thus, there exists a pressing need to address these limitations and develop novel approaches that offer improved performance and sustainability.

One of the key challenges faced by existing air conditioning systems is the balance between cooling effectiveness and humidity control. Direct evaporative coolers, while efficient at reducing temperatures, tend to increase humidity levels in the conditioned space, which can lead to discomfort and potential issues such as mold growth. On the other hand, vapor compression systems, although effective at maintaining humidity levels, are notorious for their energy inefficiency and reliance on refrigerants with high global warming potential. This dichotomy underscores the need for innovative solutions that can achieve effective cooling without compromising on humidity control or exacerbating environmental concerns.

Furthermore, the reliance on conventional cooling technologies poses significant challenges in terms of scalability and resource utilization. Traditional air conditioning systems often require extensive infrastructure and energy-intensive processes, limiting their deployment in resource-constrained or off-grid settings. Moreover, the environmental impact of these systems, particularly in terms of greenhouse gas emissions and water consumption, necessitates a shift towards more sustainable alternatives. Therefore, there is a critical need for research and development efforts aimed at devising novel cooling solutions that are not only efficient and cost-effective but also environmentally benign and accessible to a wide range of users.

III. PROPOSED METHODOLOGY

The proposed methodology for the development and assessment of an indirect evaporative air-cooling system involves a multi-faceted approach encompassing design, simulation, and experimental validation.

Firstly, the design phase entails the conceptualization and layout of the indirect evaporative cooling system. This includes the selection of components such as the blower, piping, and earthen pots, as well as the configuration of these elements to ensure optimal air and water flow. CAD software is utilized to draft detailed schematics, allowing for precise assembly and integration of the system components. Computational fluid dynamics (CFD) simulations are then employed to model the airflow, heat transfer, and humidity distribution within the system. These simulations facilitate iterative design improvements by predicting system performance under various operating conditions.

Subsequently, the designed system undergoes experimental validation to assess its performance in real-world scenarios. Key performance indicators such as cooling capacity, energy efficiency, and environmental impact are measured and analyzed. Controlled experiments are conducted to evaluate the system's effectiveness under different ambient conditions and operating parameters. Comparative studies with conventional cooling technologies provide insights into the potential energy savings and environmental benefits offered by the indirect evaporative cooling system.

Overall, the proposed methodology integrates design, simulation, and experimental validation to develop and evaluate an indirect evaporative air-cooling system. By leveraging CAD software for design and CFD simulations for performance modeling, the system can be optimized for efficiency and sustainability. Experimental validation then provides empirical evidence of the system's performance, allowing for informed decisions regarding its implementation in real-world applications.

| ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 7.521| Monthly Peer Reviewed & Referred Journal |

| Volume 7, Issue 5, May 2024 |

| DOI:10.15680/IJMRSET.2024.0705097 |

IV. PROPOSED SYSTEM WORKING

The proposed indirect evaporative air-cooling system operates through a series of interconnected circuits and components to achieve efficient cooling while maintaining thermal comfort. The system comprises three main circuits: the primary air circuit, the secondary air circuit, and the water circuit. Atmospheric air is drawn into the system by the blower, which is powered by an electric motor. Within the primary air circuit, the air passes through a filter and enters the section header, where it is divided into branches. One branch directs air into the tubes submerged in the earthen pots filled with water, facilitating heat exchange between the air and the cooled water. Meanwhile, another branch blows excess air onto the surface of the earthen pots to enhance cooling efficiency.

The heart of the cooling process lies within the earthen pots, acting as the heat exchange medium. Water within the pots is cooled through the evaporative effect caused by wind blowing over the wet surface of the pots, dissipating latent heat. The tubes submerged in the water then transfer this cooled temperature to the air passing through them, effectively cooling the air before it is discharged into the conditioned space. The tubes, coiled and arranged to maximize surface area contact with the water, ensure efficient heat exchange between the air and water. As the air travels through the tubes, it undergoes a temperature reduction, contributing to the overall cooling effect of the system.

Both the section header and discharge header play critical roles in directing and managing the airflow within the system. The section header distributes incoming air to the tubes within the earthen pots and regulates airflow through various branches. Additionally, it facilitates the distribution of excess air to enhance the cooling effect on the earthen pots' surfaces. On the other hand, the discharge header collects the cooled air from the outlet of the tubes and delivers it to the conditioned space, ensuring consistent and effective cooling. Furthermore, the water pump within the water circuit serves to recirculate water within the earthen pots, maintaining a continuous supply of cooled water for efficient heat exchange with the incoming air. Overall, the system's components work synergistically to achieve energy-efficient cooling while leveraging the natural cooling properties of water and earthen pots.

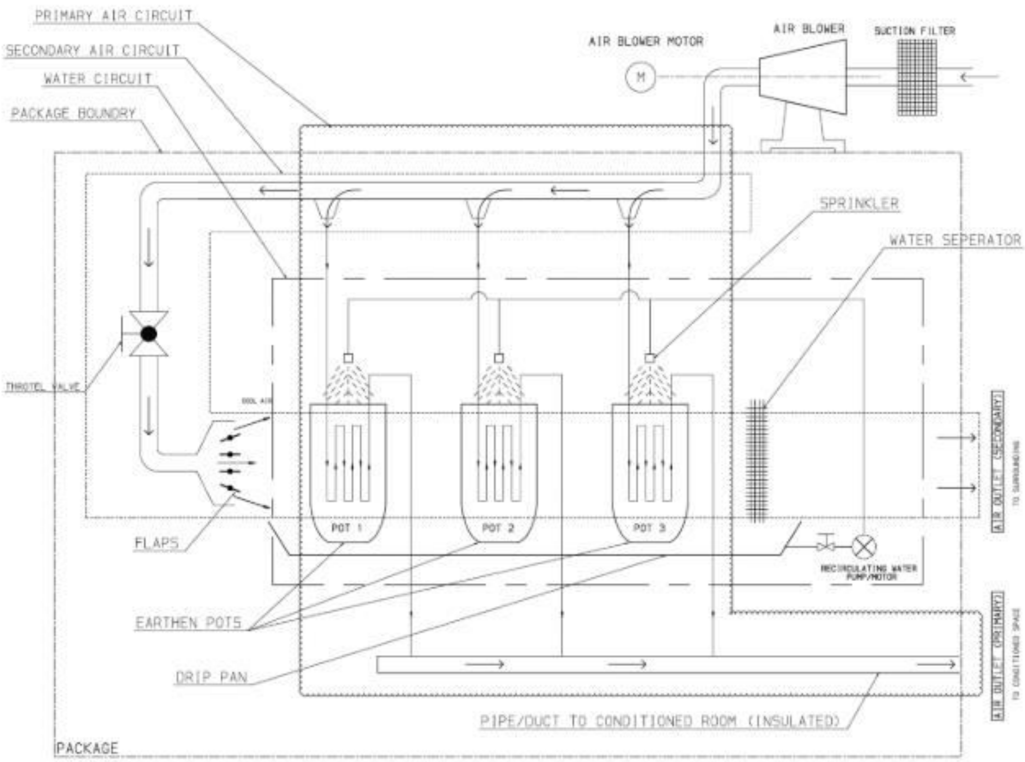

Fig: SYSTEM PFD

| ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 7.521| Monthly Peer Reviewed & Referred Journal |

| Volume 7, Issue 5, May 2024 |

| DOI:10.15680/IJMRSET.2024.0705097 |

IV. CONCLUSION

In conclusion, the design and development of an indirect evaporative cooling system present a compelling avenue to meet the escalating need for sustainable cooling solutions. Through harnessing the innate principles of water evaporation, this system offers a proficient and eco-conscious alternative to conventional air conditioning methodologies. By sidestepping the limitations associated with traditional technologies, such as heightened humidity levels and substantial energy consumption, indirect evaporative cooling demonstrates considerable potential for widespread adoption across various sectors. However, continued research and development endeavors are essential to fine-tune system performance, tackle existing challenges, and facilitate the broad integration of indirect evaporative cooling into diverse applications. With concerted efforts in optimization and advancement, the realization of a more sustainable and efficient cooling paradigm becomes increasingly attainable.

REFERENCES

1. Muhammad A., Muhammad W. S., BEN X., Muhammad I., Energy-efficient indirect evaporative cooler design framework: An experimental and numerical study Reviews, 2023
2. Rabah B., Omar A., Hatem I., John C., Design and performance analysis of a regenerative evaporative cooler for cooling of buildings in arid climates, 2018
3. Bhushan C., Tushar S., Shubham P., Prof. Anil D., A Review on Evaporative Cooling Technology, 2015
4. J. Ortega C., Ortega C., Cortes C., Ortega C., A primitive method for cooling water: does the shape matter? 2021
5. Danyal R., Ethan M., Leon G., Eric V., A heat and mass transport model of clay pot evaporative coolers for vegetable storage, 2020
6. Bogdan P., Mugur B., Raluca P., Potential of indirect evaporative cooling to reduce the energy consumption in fresh air conditioning applications, 2015
7. Brijendra S., Ravi K., Satish K., Review Study for Performance Analysis of an Evaporative (Pot in Pot) Cooling System, 2023
8. Ars`ene C., Victor Levy Dit V., Aude C., Nicolas P., Nicolas T., Heat transfer and evaporative cooling in the function of pot-in-pot coolers, 2018
9. Oyedepo S., Fayomi, O., Dirisu, J., Efemwenkiekiea U., Arhagba A., Experimental Analysis of Evaporative Cooling Water in Porous Clay Vessels Under Varying Ambient Conditions, 2021
10. Harish H., Krishne G., Thermal Analysis of Clay Pot, 2014
11. Ashutosh M., Tarun K., Gautam D., Siddharth C., Evaporative Cooling of Water in a Small Vessel under Varying Ambient Humidity, 2006
12. Evi S., Nandy P., Engkos K., Development of indirect evaporative cooler based on a finned heat pipe with a natural-fiber cooling pad, 2023

INNO SPACE

SJIF Scientific Journal Impact Factor

ISSN INTERNATIONAL STANDARD SERIAL NUMBER INDIA

निस्केयर NISCAIR

INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY RESEARCH

IN SCIENCE, ENGINEERING AND TECHNOLOGY

| Mobile No: +91-6381907438 | Whatsapp: +91-6381907438 | ijmrset@gmail.com |

www.ijmrset.com