Review Paper on Plate Drying System for Commercial Dish Washing Machine

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Abstract - This review paper explores the development of an automated Plate Drying System for commercial dishwashing machines, aiming to improve both hygiene and operational efficiency in kitchen environments. Traditional dishwashing machines often leave plates wet, necessitating manual drying, which increases labor and poses hygiene risks. The proposed system utilizes high-velocity air blowers, infrared heating, and optimized airflow, all controlled by a PLC equipped with real-time humidity and temperature sensors to efficiently remove moisture from various plate materials without causing damage. Designed to be modular, energy-efficient, and low-noise, the system can either integrate into existing setups or function independently. Through CFD simulations and experimental testing, the system's performance is optimized to reduce drying time, energy consumption, and manual labor, presenting a sustainable solution for modern food service operations.

***Key Words*:** Plate Drying System, Commercial Dishwashing, Infrared Heating, Forced Convection, Automated Drying, Energy Efficiency, PLC Control, Moisture Removal, Hygiene Improvement, Airflow Optimization.

1.INTRODUCTION

Commercial dishwashers play a crucial role in high-demand environments such as restaurants, hotels, hospitals, and catering businesses, where quick and hygienic cleaning of kitchenware is essential to maintaining health standards and operational efficiency. These dishwashers come in various configurations, including under-counter, door-type, conveyor, and flight-type models, each designed to meet the specific needs of different scales of operation. They consist of key components such as wash and rinse arms, heaters, conveyors, and filtration systems, all working in tandem to ensure the thorough cleaning of plates, utensils, and other kitchen tools. The dishwashing process typically involves multiple stages, including washing, rinsing, and sanitizing, with machines operating at high temperatures or using chemical sanitizers to eliminate bacteria and other pathogens, ensuring compliance with health regulations. The drying phase is just as critical as the cleaning stages, as it prevents water spots, bacteria growth, and unpleasant odors, ultimately ensuring that dishes are both hygienic and ready for reuse. Traditionally, drying has been achieved using heated air or blowers, but as the need for energy-efficient, faster drying methods grows, blower-based drying systems have gained popularity. These systems use high-speed air instead of relying on heat alone, offering the benefits of enhanced drying efficiency, reduced energy consumption, and faster turnaround times for kitchenware. This project focuses on the integration and optimization of blower systems in commercial dishwashers, aiming to improve the drying process while also enhancing overall hygiene, reducing labor costs, and increasing the operational performance of these essential kitchen machines.

2. LITERATURE REVIEW.

James B. Francis [1] ("The invention of the Francis turbine optimized water flow, a principle later applied to centrifugal blowers") – Francis' work in fluid dynamics laid the foundation for advancements in blower blade designs, enhancing efficiency in air-moving systems, particularly in ventilation and industrial fans.
Henri Coanda [2] ("Coanda's discovery of the Coanda effect revolutionized airflow control") – Coanda's discovery of the Coanda effect enhanced air circulation and reduced energy consumption in high-efficiency blowers. His work significantly influenced the development of modern ventilation systems, including bladeless devices.
Charles Taylor [4] ("As a key figure in aircraft propulsion, Taylor's work on propeller aerodynamics contributed to the design of axial flow fans") – These blowers are crucial in HVAC, cooling towers, and jet engines, optimizing airflow at high speeds.
Auguste Rateau [5] ("Rateau's development of turbo blowers and compressors, particularly in multi-stage turbines") – His contributions to centrifugal blowers, widely used in steam turbines and HVAC, remain critical in industrial air compression.
Smith J. [12] ("Smith's study on belt drives emphasized optimizing belt tension, pulley size, and transmission efficiency") – It offered valuable insights for the design of belt systems that minimize energy loss in systems like commercial dishwashers.
Anile Kumar Gupta [13] ("Gupta and Kumar's research on belt drive system efficiency highlighted the role of material elasticity and pulley configurations in reducing energy losses") – Their work provided practical guidelines for enhancing the efficiency of belt-driven machinery.
Chen and Li [14] ("Their study explored the impact of pulley diameter on belt drive performance") – Noting that larger pulleys improve torque transmission and reduce energy losses, these findings are significant for the optimization of commercial dishwashing machine components.
Robert Brown [15] ("Brown's article on high-duty industrial applications highlighted strategies to optimize power transmission under heavy loads") – His research into material selection, tension adjustments, and pulley alignment is crucial for enhancing the reliability of systems like dishwashers.
Park Seung Lee [16] ("Lee's study focused on flat belt durability in continuous operating conditions, such as in commercial dishwashers") – His findings underscore the importance of material quality and optimal tensioning to prolong belt lifespan.
Zhang Wang [17] ("This research analysed how the centre distance between pulleys affects tension and overall efficiency in belt-driven systems") – Optimizing this distance improves energy transfer and system performance, which is directly applicable to commercial dishwashing machinery.

Michael Varenberg [19] ("Varenberg's research into energy losses in belt drive systems identified key phenomena such as detachment waves at the belt-pulley interface") – His work emphasizes the importance of optimizing belt designs to minimize energy loss in mechanical applications like dishwashers.
D.H.G.R. Howard [20] ("Howard's studies in belt drive dynamics examined how factors like belt slippage and friction affect performance in industrial settings") – His insights into material properties, flexibility, and tensile strength contribute to optimizing belt drives for efficient power transmission.
K.S. Rao [21] ("Rao's research in belt drive dynamics focused on material selection and operational conditions") – Offering strategies to reduce wear and energy losses in industrial machinery, his work is vital for enhancing the durability and efficiency of belt-driven systems.
James Watt [22] ("Watt's contributions to the steam engine and power transmission mechanisms laid the groundwork for modern mechanical systems") – Although his work did not directly involve belt drives, his efficiency improvements in steam power influenced the development of belt-driven machinery.
Leonardo da Vinci [23] ("Da Vinci's early sketches for power transmission systems using gears, pulleys, and belts") – His designs had a profound influence on the development of mechanical engineering, including systems used in modern dishwashers.
Hans Renold [24] ("Renold's innovations in chain technology influenced mechanical systems by improving power transmission in industrial applications") – While focusing on chains, his contributions to efficiency and durability are relevant for systems that rely on belt drives in commercial dishwashers.
George Westinghouse [25] ("Westinghouse's contributions to AC power transmission and electrical systems influenced the development of electrical-driven industrial machinery") – His work contributed to systems like commercial dishwashers.
Turan Gonen [26] ("Gonen's work on power system analysis and his writings on engineering applications provided key insights into optimizing power distribution in mechanical systems") – These insights can be applied to industrial machinery such as dishwashers.
Smith R.T. [27] ("Smith's research in belt-driven power systems emphasized improving efficiency by selecting advanced materials and ensuring proper belt tension and alignment") – This is crucial for the smooth operation of commercial dishwashers.
Murray L.H. [28] ("Murray's focus on eco-friendly materials for belt-driven systems highlighted sustainable practices in mechanical design") – His work contributed to the development of energy-efficient systems for industrial applications.

3. CONCLUSIONS

This review paper evaluated the performance of the plate drying system in commercial dishwashing machines, focusing on its efficiency in powering key components such as the wash pump, blower, and conveyor. The analysis revealed that power transmission efficiency is significantly influenced by factors like belt tension, pulley sizes, and load variations. Optimal belt tension and pulley configurations were found to enhance system performance, while excessive load or improper tension led to increased energy consumption and potential belt slippage. Additionally, the use of durable materials was shown to improve system longevity and reliability. In conclusion, optimizing belt tension, pulley arrangement, and material quality plays a crucial role in reducing energy consumption, lowering maintenance costs, and enhancing the overall efficiency and reliability of commercial dishwashing operations.

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