Investigations For Sustainable Greenhouses: Mitigating Environmental Impact

モタズ, マブルーク モハメド サラマ

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氏　　名　：

Name　　　　Motaz Mabrouk Mohamed Salama

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環境負荷を軽減する持続可能な温室に関する研究

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Thesis Summary

Sustainable greenhouses have emerged as a vital element in the future of agriculture, addressing global concerns such as resource depletion, climate change, and food security. These eco-friendly structures integrate cutting-edge solutions such as renewable energy sources, water-efficient systems, and advanced climate control technologies, with the aim of minimizing ecological footprints and maximizing agricultural output. By integrating renewable energy sources like solar, wind power, geothermal energy, biomass, and biofuels, sustainable greenhouses mitigate carbon emissions, lower energy costs, and ensure year-round cultivation. In addition, the implementation of smart agricultural technology, such as precision farming and Internet of Things (IoT) based monitoring systems, facilitates efficient resource allocation inside greenhouse environments. These technologies maximize productivity while minimizing resource consumption, aligning with the principles of sustainability and resource efficiency.

A part of this work reviews the evolution of the sustainable greenhouse concept through recent research on the integration of greenhouses with renewable energy sources, specifically addressing heating, cooling, and water supply. Additionally, it explores recent research work related to the concept of the energy-water-food (EWF) nexus and the smart technologies in the field which play a significant role in fostering sustainable agriculture and promoting the responsible utilization of the Earth's limited resources. This review contributes to a better understanding of the evolving landscape of sustainable agriculture, offering insights that can inform policy decisions and promote a more resilient and sustainable future.

A research study has explored the use of a slurry comprising coal, oil, and water as an alternative fuel. The investigation aims to assess its thermal performance and environmental impact as a potential solution for areas lacking access to renewable energy resources. This approach seeks to efficiently and eco-friendly exploit existing fossil fuels in locations where such resources are readily available. The research involved experiments on specific flames, maintaining a constant input heat throughput while varying the air/fuel ratios for three primary oil/coal/water mixtures based on mass distribution. These mixtures are defined as follows: Case 1 (pure oil; serving as the reference case), Case 2 (80% coal, 10% oil, 10% water), and Case 3 (70% coal, 15% oil, 15% water). The data revealed that Case 2 demonstrated a noteworthy increase in both heat transfer to the cooling jacket and combustion efficiency, accompanied by a decrease in NOx emissions. However, further elevating the coal and water ratio in the fuel mixture (Case 3) led to a significant decline in overall combustion characteristics, indicating an upper limit for coal and

water loading ratios at only 10%. The findings suggest that oil-coal-water slurries hold considerable promise as an alternative energy source.

A mathematical model for an M-Cycle indirect evaporative cooler has been proposed to evaluate its potential as a cooling method for reducing thermal loads in greenhouses during the summer. The study assesses the M-Cycle's performance under various weather conditions and greenhouse locations. Results show that the system can create an optimal environment for plant development in hot and dry conditions (25 to 45℃, humidity ratio below 11.2 g/kgDA). The M-Cycle effectively provides conditioned air for plants with temperature requirements of 20-30℃ and a relative humidity range of 60 to 80%, requiring adjustments in water flow rate and temperature for sensible heat transfer. As seawater distillation is considered a potential solution for water scarcity, in another study, we try to use the concept of M cycle heat exchanger to apply the humidification and dehumidification processes necessary for the water distillation concept, However, only evaporation process (Humidification) is only included. An experimental study was conducted to investigate the evaporation phenomena of seawater along the wet channels of M cycle heat exchanger to give insights about the using of seawater instead of freshwater in indirect evaporative cooler before trying to recover the freshwater droplets and exclude the brine during a subsequent dehumidification process. Results reveal that higher humidity ratios at the same dry bulb temperature led to a reduced driving force for seawater evaporation, resulting in lower evaporation rates. Additionally, air velocity influences the evaporation rate, with higher velocities correlating to increased rates, particularly at low humidity ratios. Calculated water evaporation rates indicate that the highest rates occur at lower humidity ratios, decreasing as humidity ratio increases under constant temperatures. Optimal conditions for maximum seawater evaporation rates depend on both temperature and air velocity.