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Managing Greenhouse Humidity with Ground Air Heat Exchange Systems

Reyhaneh Nazmabadi [1], Ali Hakaki-Fard [2]
[1,2]Department of Mechanical Engineering, Université Laval, Québec City, Canada
* ali.hakkaki-fard@gmc.ulaval.ca

ABSTRACT

Greenhouses are essential for ensuring food security in Canada, as the harsh climate makes outdoor agriculture impossible. Preventing excessive humidity levels in Canadian greenhouses during winter is challenging and increases energy consumption. This challenge arises because natural ventilation, a common method for reducing humidity, brings in cold outdoor air that must be reheated, leading to higher energy demands. This study investigates the potential of Ground Air Heat Exchangers (GAHEs) as an energy-efficient solution for greenhouse dehumidification. In this approach, greenhouse air is circulated through horizontal GAHEs buried underground. As warm, humid greenhouse air flows through the GAHE, it transfers heat to the cooler underground environment. When the air temperature drops below its dew point, water vapor condenses on the internal surfaces of the exchanger, reducing the absolute humidity of the air before it is recirculated back into the greenhouse. This process effectively removes excess humidity while minimizing energy losses compared to conventional ventilation methods. A numerical model is developed to assess the performance of GAHEs in controlling greenhouse humidity. This model is then used to optimize the system and conduct a parametric study. Since Canada has different climate zones, and climate conditions affect greenhouse air properties and GAHE performance, the optimization in this study is tailored to various climate zones. Greenhouses also come in a variety of sizes, so this optimization is designed to ensure that the optimized GAHE is applicable to greenhouses of all sizes. Finally, the results of this study provide a practical, energy-efficient dehumidification strategy applicable to any greenhouse, regardless of its size or the climate zones in which it is established.

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