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Comparative experimental analysis and modelling of a flower greenhouse equipped with a desiccant system

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ABSTRACT

Two identical flower greenhouses operating near Bergamo (northern Italy) have been equipped with an innovative and a traditional air conditioning system respectively.

The innovative air conditioning system based on H_2O–LiCl desiccant consists of an integrated dehumidification and regeneration unit. In the dehumidification part the strong solution absorbs the ambient air humidity. Heat recovery is performed on the desiccant regeneration process enabling to heat the ambient air previously dehumidified. Auxiliary unit heaters driven by hot water complete the sensible heat needs of the greenhouse. The same unit heaters are used to perform sensible heating in the traditional greenhouse.

Natural ventilation through roof opening is the only method to control the humidity in the traditional greenhouse but it is also used in the innovative one to integrate the desiccant system.

The experimental comparison shows a 10% average primary energy saving for the desiccant-based system with respect to the traditional one in the winter season.

The numerical model allowed to simulate the greenhouses and to evaluate the savings potential of the desiccant-based system with different operating approaches. The dependance of performance of the greenhouse cover material on the humidity condensation was shown to strongly affect the contribution of the desiccant system.

1. Introduction

Winter air conditioning of flower greenhouse requires a high amount of energy due to the large difference between inside set point and outside temperatures and to the poor thermal insulation of the envelope. Moreover the humidity control needed in order to limit phytopathological issues is usually operated by enhancing the natural or mechanical ventilation rate with outside air, which results in higher energy needs.

The use of a desiccant-based air conditioning system ensures a refined control of the thermo-hygrometric conditions inside the greenhouse together with potential energy saving linked to reduced ventilation rate and to heat recovery on desiccant regeneration. Moreover the treatment by liquid desiccant has direct a sanitising effect on the air, removing up to 99% of the dust and microbial content (Kovac et al. [1]).

Some drawbacks could however follow from tighter humidity control and reduced internal humidity. As Pieters and Deltour [2] pointed out, analyzing the importance of modelling, the condensation on the inside of the cover especially for cover materials with large long wave radiation transmittance plays an important role in reducing the dispersion and energy needs. This suggests that the humidity reduction given by liquid desiccant systems could lead to worse energy performance when inside condensation is reduced.

This paper presents an experimental comparative analysis for a flower greenhouse in winter season between the Ventilated Latent Heat Converter (VLHC), an innovative air conditioning system based on H_2O–LiCl desiccant which simultaneously converts the latent heat to sensible heat (G. Assaf [3] and G. Assaf and N. Zieslin [4]), and a traditional air conditioning system based on canalized unit heaters. Two identical flower greenhouses operating near Bergamo (northern Italy) have been equipped with a traditional and an innovative air conditioning system. The thermo-hygrometric conditions inside both the greenhouses have been monitored together with the energy consumption of each air conditioning system during the winter season.

A simulation model of the whole greenhouse both considering the VLHC and the traditional system has been implemented to evaluate and optimize the savings potential and the control

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