Simulation and Optimization of a counterflow Tunnel Dehydrator

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1. Introduction

A widely used class of vegetable dehydration systems are the "tunnel-and-truck" dehydrators [1], where the prepared material lies over horizontal trays stored in trucks which move discontinuously in opposite direction of the air flow. This way the driest product is facing the inlet hot and dry air blowed to the system. When product of one truck is ready, is removed from the tunnel leaving space for advance the remaining truck one place forward. This way, a new truck full of wet product can be inserted at the end of the tunnel.

This paper presents a simulation model of a particular dryer design [2], see Figure 1, including the tunnel, a fan and a heating coil. Additionally there is some energy saving equipment like a recovery heat exchanger and recirculation damper. The simulation model is then applied to the determination of optimal operating conditions.

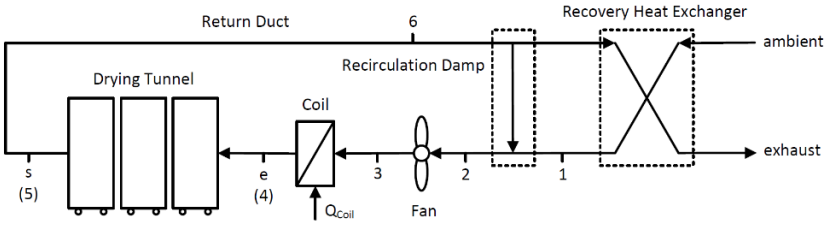

Figure 1. Schematic of the system components.

2. Model description

A transient simulation model was developed in EES [3] taking into consideration the main mass and heat transfer processes. Moisture sorption isotherm (MSI) curves using the GAB model [4] are taken from literature and extended to the required temperature range in order to emulate the dehydration process as shown in Figure 2.

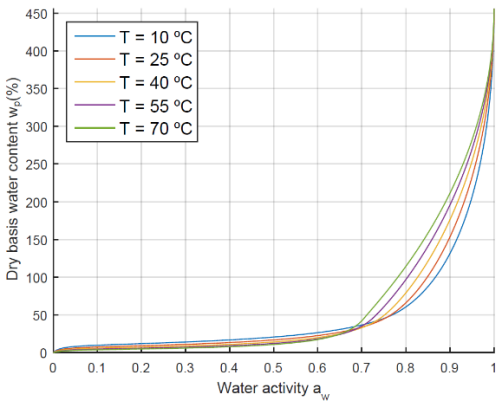

Figure 2. Example of moisture sorption isotherm curve (for mango) used to model product drying process.

3. Results and discussion

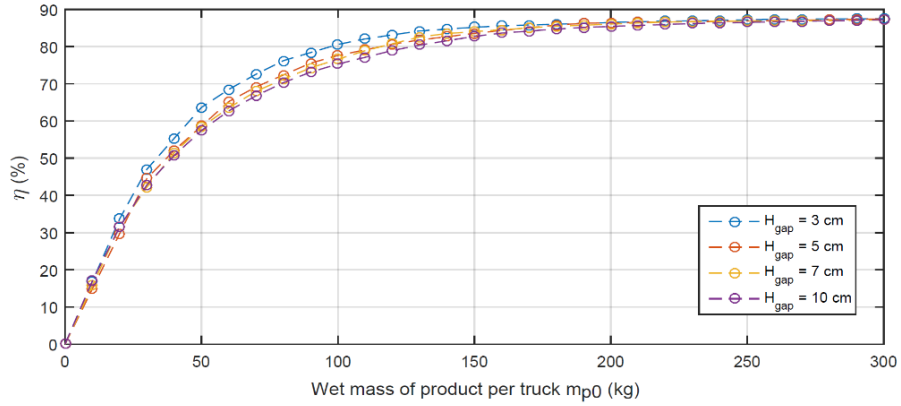

Figure 2. Efficiency of the dehydration process against mass allocated per truck. An optimal length of the tunnel can be calculated according with the mass and type of product deposited over each truck.

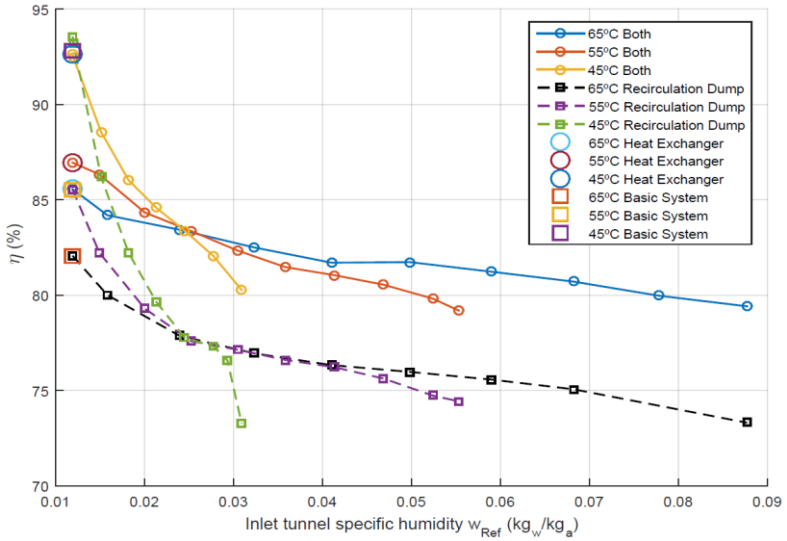

Figure 1. System efficiency according to exterior humidity, energy saving system used and temperature set point. Evaluation of the most appropriate combination of energy saving system as a function of the tunnel dimensions and climatological conditions.

4. Conclusions

The developed model can predict the drying process as a function of the kind of product, environmental conditions, tunnel geometry and the energy saving equipment used. This tool will be used to study of the optimal design configurations for specific uses.

5. References

[1] W.. Van Arsdel, Tunnel-and-truck dehydrators, as used for dehydrating vegetables, en: Veg. fruit dehydration, a Man. plant Oper., 1944. doi:10.1007/s13398-014-0173-7.2.

[2] J.M. Sojo-Gordillo, Análisis termoenergético de una planta modular de deshidratación de alimentos. Trabajo Fin de Grado. ETSII. Universidad de Málaga., (2016).

[3] S. Klein, Engineering Equation Solver (EES), (2015). www.fchart.com.

[4] C.T. Akanbi, R.S. Adeyemi, A. Ojo, Drying characteristics and sorption isotherm of tomato slices, J. Food Eng. 73 (2006) 157-163. doi:10.1016/j.jfoodeng.2005.01.015.