UNIVERSITÀ DEGLI STUDI DI SALERNO

Department of Industrial Engineering

Master's degree in food engineering

Study of a biodegradable, compost-based seedpot

Thesis in
Transport Phenomena

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Ai ciottoli di tutto il mondo, alla loro solidarietà e fratellanza.

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Abstract

This work aims to improve the process of producing biodegradable pots from compost. In the first prototyping phase, there was the study of the formulation and composition of the pot dough, while in the second phase involves the improvement of the moulding and drying process. In this thesis project, the focus is on the second part in particular, a careful analysis of the transport phenomena during the pot drying process was carried out with the subsequent construction of a model implemented in COMSOL Multiphysics®. The model was subsequently validated thanks to experimental data collected during the process about temperature, humidity, and mass.

The drying process is certainly one of the most energy-intensive process steps, so with the aim of optimising time and costs, several simulations were carried out with the model by modifying process parameters, such as temperature and air flow rate, to understand their influence on process efficiency.

In addition to the process, tests were also carried out on the finished pots, in particular compression tests at various moisture content to assess its mechanical strength, and tests on the electrical conductivity of the substrate contained in the pots.

Mechanical tests show that even a 5% decrease in water content can more than doubled young's modulus (E) and the final pot moisture should be around 12-14%, while conductivity tests showed that critical values are not reached for most crops in 27 days.

Chapter one

Introduction

In this chapter the main containers used in agriculture will be presented, listing their advantages and disadvantages. Furthermore, the state of the art will be described as regards the bio-containers and the objectives of the following work.

Chapter five

Conclusion

In This chapter summarizes what was carried out during the thesis work and are reported the relevant conclusions.

The objective of this work was to develop a biodegradable pot using compost and other by-products such as plant waste as material to offer the container market an alternative that would help reduce the plastic problem. After the study of the dough to make the pots, which was done prior to this study, the following work was concerned with studying all the subsequent stages, first and foremost, the most energy-intensive stage, i.e., drying.

For this reason, a model was developed to simulate this process. A study was made of the motion field using the k-omega model, heat transport and the diffusion of liquid water and vapor. This model was implemented on COMSOL Multiphysics®, where it will be possible to solve all the material and energy balances easily even when changing properties and boundary conditions. During the drying process, a series of data on temperatures, humidity and the mass of water lost were collected, thanks to which it was possible to validate the work. Once the model was validated, it was used to perform several simulations using different temperatures and air flow rates.

In the second part of this work, tests were conducted on the finished product. Mechanical tests were carried out, which showed the strong dependence of the pot resistance on the water content. In fact, at an average moisture content of 9.5% and 14.5%, the Young modulus was 26 MPa and 11 MPa, respectively. The electrical conductivity tests showed a maximum value of 1.82 mS/cm for the substrate, which is below the critical values for many cultures.

Thanks to the mechanical tests, it was possible to identify a final moisture content of the pot that corresponds to 12%-14%, while the elaboration of the model allows an optimisation of the process time because having set this final moisture point to be reached, it was seen with simulations that using air at 60 °C and an inlet velocity of 7 m/s it is possible to dry the pot in 90 minutes while with the same time and initial conditions the humidity is still 22%.

In conclusion, the validated model will allow the optimisation of the drying process during the design phase of the large-scale plant, thanks to the possibility of quickly simulating the process by changing the variables, while the mechanical and electrical conductivity tests were able to respectively identify the final moisture content of the pot and its non-toxicity for crops.

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