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THE INFLUENCE OF THE MATERIAL PROPERTIES ON THE DRYING PROCESS OF CROP

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S y n o p s i s. In the course of drying process of crop it is expected to strive for reducing the outlet energy loss, which depends mainly on the drying potential of the exhausting air.

To calculate and optimize the drying process a discretized mathematical model has been elaborated and validated for lucerne. The solution includes the temperature and moisture distribution of the air as well as of the material.

A sophisticated computer program was developed for simple simulation and also for studying the behaviour of the system under the influence of parameter changes.

INTRODUCTION

The drying of agricultural crops is one of the methods to preserve the quality of the material. The possibility of safe and long-time storage could be reached by artificial drying. Since the energy requirement is relatively large, the application of energy-saving methods is strongly recommended.

In this context, we need to optimize the operating conditions, minimizing the energy consumption, and to develop new energy-efficient dryers.

For this purpose the mathematical modelling and the computer simulation are good tools. Without these, we could only study the simpler effects and conditions using an empirical approach. By means of the sensitivity analysis the dryer performance can be investigated.

During the continuous drying of crop consisting of significantly different parts, such as central/kernel and surface/shell layers, especially in the falling rate period, a fairly great moisture difference may occur between the layers. Meanwhile, the drying rate is mainly determined by the internal moisture diffusion in the piece of a material, i.e. grain, stem, etc.

Consequently, one of the possible ways to reduce the energy loss is to include breaks/intermissions in the process and let the material be equalized in moisture, and repeat the forced drying from a better stage.

The strategy of the intermittent drying should be developed by considering the internal properties of the material to be dried, the optimal energy consumption, and the limitation of the total drying time.

In the following, as an example, some aspects of intermittent drying of lucerne will be shown.

THE DRYING MODEL

To calculate the drying process of different crops a static bed type mathematical model has been developed. It is assumed similarly as in many investigations that the deep bed of crop consists of a series of thin layers and the layer by layer calculation is proposed and solved numerically.

Accordingly, it is required to derive the appropriate drying equations for thin layer using the mass and energy balances and the sorption isotherms which can be determined in laboratory drying experiment [2, 3].

Due to the intermittent drying the internal moisture diffusion in the pieces of material, i.e. leaf and stem, is very crucial, so a two-component discretized model has to be applied.

In order to solve the set of drying equations an implicit finite difference scheme was apllied taking into consideration the convenient initial and boundary conditions. During the drying intermissions the equation system can be calculated with the assumption of a small, practically zero air flow rate.

The solution includes the temperature and moisture distribution of the air and the material, as well as the energy consumption at specified time intervals.

COMPUTER SOLUTION

To predict and optimize the behavior of the intermittent drying process a sophisticated computer program was written.

After the parameter initialization in every time point the air and material temperatures and moisture contents are calculated. Then the optimization subroutine is called to estimate the beginning and as well as the interval of the break, on the basis of optimal energy consumption and, simultaneously, at the minimal drying time expansion.

The scanning time of simulation can be determined by the time constants of the drying process. Because of the relatively slow changes in the static bed, approximately τ = 300 s was sufficient to be applied.

After reaching the desired average final value for the material moisture content the procedure is terminated automatically.

To accomplish the control strategy it is advisable to use a microcomputer which, at the same time, serves as the controller for the dryer itself.

APPLICATIONS

Experimental study of the model

The validity of the two-component model was checked on the basis of short time laboratory measurement.

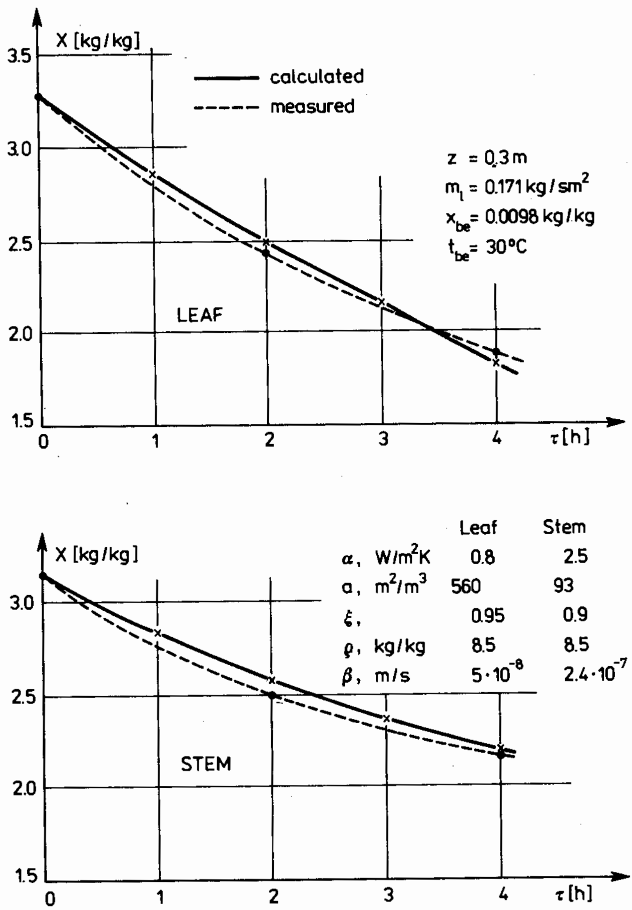

Fig. 1. Moisture distribution of lucerne component during the first period of drying

The main parameters were as follows:

- depth of lucerne: 0.3 m
- mass flow rate of air: 0.1714 kg/sm^2
- absolute humidity of inlet air: 0.0098 kg/kg
- temperature of inlet air: 20^oC
- initial moisture content of leaf: 3.29 kg/kg d.b.
- initial moisture content of stem: 3.14 kg/kg d.b.

The space step was 0.075 m and the time step was 15 s.

The results can be seen in Fig. 1. At the beginning of simulation the drying curves are nearly linear due to the fact that the moisture content of components is above the critical value.

Influence of the transport coefficient

To investigate the behavior of drying process it is very important to determine the values of transport coefficients. Beside the measurement, sometimes, the

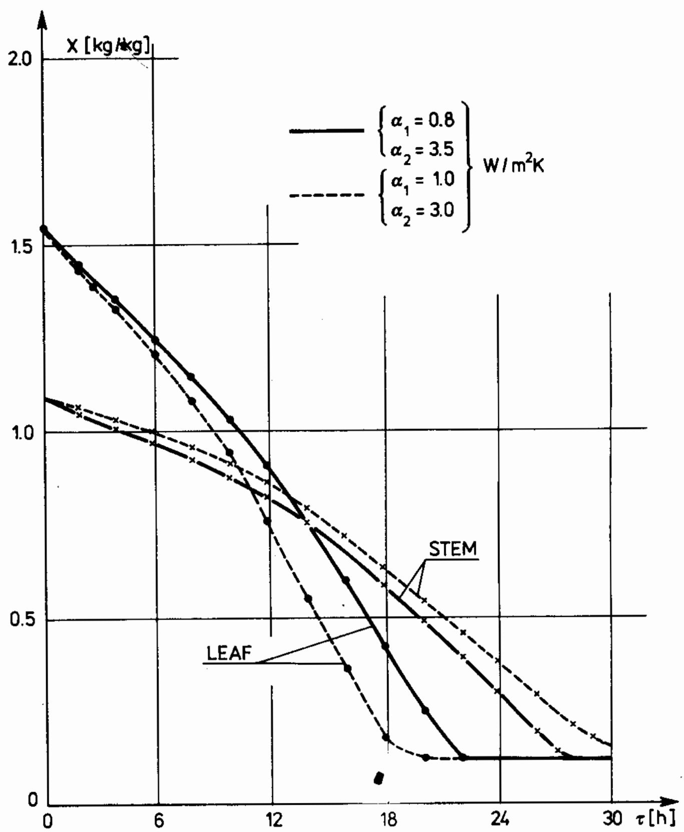

Fig. 2. Influence of heat transfer coefficient on the drying process

simulation model gives assistance for identyfying the parameters of physical system.

In the following the sensitivity of heat convection coefficient, α was analysed.

The main data were as follows:

- depth of lucerne: 0.35 m
- mass flow rate of air: 0.171 kg/sm^2
- absolute humidity of inlet air: 0.0105 kg/kg
- temperature of inlet air: 30^oC
- initial moisture content of leaf: 1.55 kg/kg d.b.
- initial moisture content of stem: 1.1 kg/kg d.b.

The space step was 0.0875 m, the time step was 15 s.

The results relating to two different α pairs are shown in Fig. 2. It can be seen that the parameter changes yield the narrowing and the widening of the band of drying curves.

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WPŁYW WŁASNOŚCI MATERIAŁOWYCH NA PROCES SUSZENIA PLONÓW

S t r e s z c z e n i e

W procesie suszenia ziarna spodziewane są straty energii, które zależą głównie od potencjału suszenia. Jedną z dróg redukcji strat energii jest utrzymanie zniszczeń (przerw w procesie), ażeby materiał był w równowadze wilgotnościowej. Należy opracować strategię przerywanego suszenia uwzględniającą wewnętrzne właściwości materiału poddanego suszeniu, optymalną konsumpcję energii i ograniczenie całkowitego czasu suszenia.

Zbudowano dwuparametrowy dyskretny model matematyczny służący do wyliczenia i optymalizacji procesu suszenia. Rozwiązanie uwzględnia temperaturę i rozkład wilgotności powietrza jak też i materiału. Opracowano program komputerowy dla prostej symulacji, a także dla studiowania zachowania się układu pod wpływem zmiennych parametrów. Program napisano w języku Basic i wprowadzono na mikrokomputer.

И. Фаркаш

ВЛИЯНИЕ МАТЕРИАЛЬНЫХ СВОЙСТВ НА ПРОЦЕСС СУШКИ УРОЖАЕВ

Р е з ю м е

В процессе сушки зерна ожидаются потери энергии, зависящие, главным образом, от потенциала сушки. Одним из путей редуцирования потерь энергии является удержание разрушений (перерывов в процессе) чтобы материал находился во влажностном равновесии. Стратегия прерываемой сушки должна учитывать рассмотрение внутренних свойств материала, подвергнутого сушке, оптимального потребления энергии и ограничения полного времени сушки. Представлено способ подсчета и оптимализации процесса сушки, 2-параметровую дискретную математическую модель. Решение учитывает температуру и распределение влажности воздуха как и материала. Компьютерная программа развита для простой имитации и также для изучения реагирования системы под влиянием изменчивых параметров. Программа написана на языке Basic и введена в микрокомпьютер.