ADVANCES IN AGRICULTURAL DRYING IN POLAND

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In Poland organized research into the drying of agricultural products began with the establishment of the Drying Laboratory of the Institute of Mechanization and Electrification of Agriculture in Warsaw in 1954. In subsequent years similar problems began to be studied at the Institute of Plant Breeding and Acclimatization, the Institute of Agricultural Machinery, renamed the Industrial Institute of Agricultural Machinery, and the Grain Institute, renamed the Central Laboratory for the Technology, Processing and Storage of Grain. In 1957 the Institute of Mechanization and Electrification of Agriculture set up an Agricultural Products Drying Division with two laboratories. It now has four.

Lectures on agricultural product drying technology have been given at the Warsaw Polytechnic Institute since 1958. The course is followed by about 20 students each year, three or four of whom go on to obtain diplomas in the subject. The standard textbook is "Drying of Agricultural Products" [1].

Subjects for research include drying processes and drying technology and economics, especially in relation to grain, seed material and feed crops. The studies of drying processes are based on the work of Professor A. V. Luikov and his followers. They involve an investigation of the effect of the thermophysical properties of the products and the conditions and methods of drying and are as far as possible mathematical.

The object of this research is to develop new and improve old drying methods and apparatus. It involves a combination of technical and biological sciences.

Convective drying studies aim chiefly at determining the basic equations of the theory of heat and mass transfer in the drying process. After preliminary tests [2], the effect of drying agent velocity on the drying process of a thin layer of corn ears [3] and the effect of the psychrometric difference on lucerne [4] were investigated. Temperature distribution and moisture movement during convective drying were studied on ears of corn [5]. The effect of the position of the grain on the cob has also been investigated [6].

These experiments were essentially exploratory. The next step was to test the applicability of the equations of the theory of heat and mass transfer to the drying of individual elements (grains, roots, etc.).

The effect of temperature on the drying coefficient of corn, wheat and rice grains was investigated in [7]. It was expressed in the form of an exponential temperature function. The effect of drying agent velocity during the second stage was studied in relation to the wheat grain. Changes in air flow rate had only a slight effect, and that only at the beginning of drying, on the value of the drying index [8]. Temperature changes were investigated during the drying of corn grains. An equation was obtained for grain temperature as a function of air flow rate and drying rate [9]. This has made it possible to draw conclusions concerning the conditions under which it is possible to use a simplified moisture conduction equation (with an accuracy sufficient for practical purposes given a constant value of the internal moisture diffusion coefficient of the drying material).

An interesting question is the possibility of using simplified equations of heat and mass transfer. In order to use analytic solutions of the equations of the theory of heat and mass transfer it is necessary to determine:

a) the degree to which the different shapes of agricultural products can be replaced by shapes such as a sphere, finite and infinite cylinders, etc. for which an analytic solution of the diffusion equations with boundary conditions corresponding to agricultural requirements exists;

b) the extent to which the inhomogeneous structure of agricultural products affects the accuracy of results obtained using equations valid for homogeneous bodies;

c) values of the basic thermophysical properties of various products (e.g., internal moisture diffusion coefficient, moisture transport potential, etc.) as functions of the temperature and moisture content of the material;

d) the extent to which these coefficients vary during the drying process and when they can be treated as constants independent of the temperature and moisture content of the material.

This is the theme of reference [10] whose aim was to determine the extent to which a simplified analytic solution of the diffusion equation is suitable as the drying equation for corn grains (assumed to be parallelepipeds) or the extent to which the diffusion equation for an infinite cylinder can represent the drying equation for rhubarb [11]. In [12] the concept of a thin layer is examined. A thin layer is a monogranular layer of grain or a layer to which it is possible to apply the equations of convective drying of individual grains at rest in an air flow. The author gives a method of calculating the drying curve and the drying time and rate as a function of the initial and final moisture content of the dried material, grain size, grain shape, and the temperature, relative humidity and velocity of the drying agent. The results of numerous experiments confirm the correctness of this concept and hence the desirability of further study in this direction.

Convective drying has been studied in thick stationary layers [4, 6] and in a layer of corn ears moving in a counterflow [13].

Grain drying in a fluidized bed has been investigated chiefly with the object of obtaining parameters for designing dryers [14–16] and determining the effect of drying conditions in the bed (relatively high temperature and much greater drying rate) on the quality of the dried grain [17, 18].

The drying of feed in drum dryers has been investigated in order to determine the parameters controlling drying conditions, economics, and quality [19–21].

Infrared drying has been studied to determine its suitability for drying vegetable seed [22, 23].

In Poland various air heaters and air-heating systems have been tested [24, 25] to determine their efficiency and reliability.

The thermophysical properties of agricultural products significant in relation to the application of theoretical drying equations are now receiving much attention. In particular, the determination of the specific heat of dried products as a function of moisture content is being investigated [26]. It should be noted that the recommended linear formulas are invalid for a broader range of moisture contents. The effect of the moisture content of various seeds on their specific weight, size and viability is also being investigated as a function of temperature and heating time during the drying process [27, 28]. The thermal conductivity of a layer of granular agricultural products is likewise being studied [29]. Finally, the working conditions of dryer operators are being investigated from the standpoint of safety and health [30].

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