Int. Agrophysics, 1992, 6, 115-117

SHRINKAGE OF MALT BED DURING DRYING

B.K. Bala

Department of Farm Power and Machinery,
Bangladesh Agricultural Univcsity, Mymensingh, Bangladesh

A b s t r a c t. The shrinkage of malt bed during drying was determined experimentally from an initial moisture content of about 42 % (w/w). Air temperature and air flow rate during the experiments were 50 °C and 0.60 kg $m^{-2}s^{-1}$, respectively. It was found that the dependence of shrinkage on moisture reduction during drying can be described by a nonlinear equation for moisture reduction of about 34.5 % (w/w).

INTRODUCTION

Shrinkage of agricultural products during drying is an observable phenomenon and it may have a significant effect on drying rate and temperature distribution especially during deep bed drying of agricultural crops

Several researchers [2-5] have reported that shrinkage of cereal grain is linearly dependent on moisture reduction. It was observed that the shrinkage of malt is not a linear function of moisture reduction, but the rate of shrinkage decreases with the increase of moisture reduction [1].

THEORY

It is assumed that the rate of change of the shrinkage of a malt bed with respect to the reduction in moisture content dy/dx from initial moisture content is proportional to the difference between the maximum possible $y_0(\%)$ and the actual $y(\%)$ shrinkage:

$$dy/dx = k_s (y_0 - y) \qquad (1)$$

where k_s is shrinkage coefficient.

The solution of Eq. (1) gives:

$$y = y_0 [1 - \exp(-k_s x)]. \qquad (2)$$

This equation requires the determination of the shrinkage coefficient and the maximum possible shrinkage from experimental data.

MATERIALS AND METHODS

The experiments were conducted in the Department of Agricultural Engineering, University of Newcastle Upon Tyne, England, and the green malt used for these experiments was obtained from Pauls and Sanders, Ltd., Grantham. It was directly sent from the germination chamber and was already loaded for the experiment on arrival.

An aluminium cylinder of 15 cm diameter and 30 cm long filled with green malt was mounted on a rectangular box serving as an air mixing chamber. The whole set was placed on a balance so that the amount of moisture removed could be determined at any time during the drying process. As the balance was of the beam type fitted with a balance pan for counter weights, the effect of a flexible connecting tube could be eliminated. The schematic diagram of the experimental set-up is

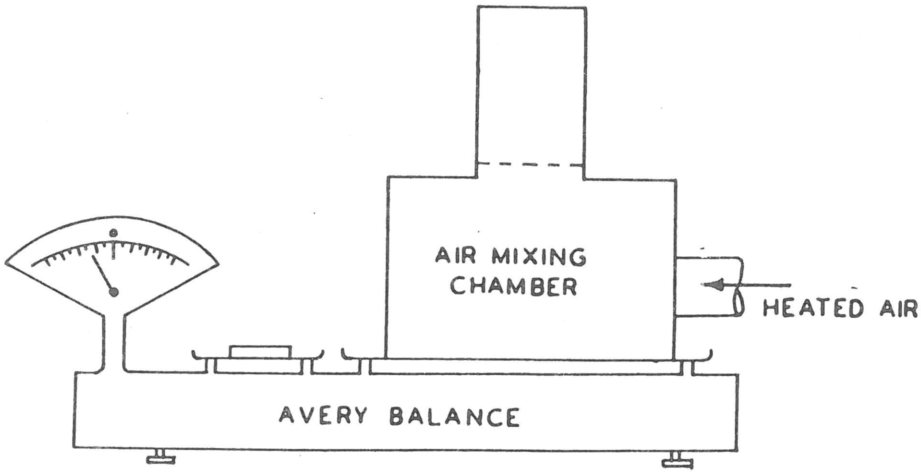

Fig. 1. Schematic diagram of experimental set up.

shown in Fig. 1. A stainless steel scale graduated in mm was placed inside the cylinder to determine the change in depth at any time during drying.

Two runs of experiments on the shrinkage of the malt bed were performed. The cylinder containing green malt was placed on the balance and heated air at a temperature of 50 °C and at a constant airflow rate of 0.6 kg $m^{-2}s^{-1}$ was passed through the grains. The scale indicator was set to zero by the use of a counter weight and water in a plastic cylinder. The depth of the grain bed was noted. A 20 g weight was placed on the pan containing the cylinder filled with grain. When 20 g of moisture had been removed, the scale indicator was again at the zero position. The bed depth and moisture removed were noted and another 20 g weight was placed on the pan containing the aluminium cylinder. This process was repeated until the drying rate approached zero.

RESULTS AND DISCUSSION

Shrinkage coefficient (k_s) and maximum possible shrinkage (y_0) were determined by direct least squares fitting of Eq.(2) to the experimental data. The following equation was developed for the shrinkage of the malt bed during drying:

$$S = 15.91[1 - \exp(-0.0966(M_0 - M))]$$

$$(S.E. = 0.6871) \qquad (3)$$

where S - percentage shrinkage, M_0 - initial moisture content, % (w/w), M - moisture content, % (w/w).

Fig. 2 shows that the agreement between the prediction and experiments is reasonable. Furthermore, Fig. 2 shows that shrinkage can be related linearly with moisture content reduction in the range 0-10 % (w/w).

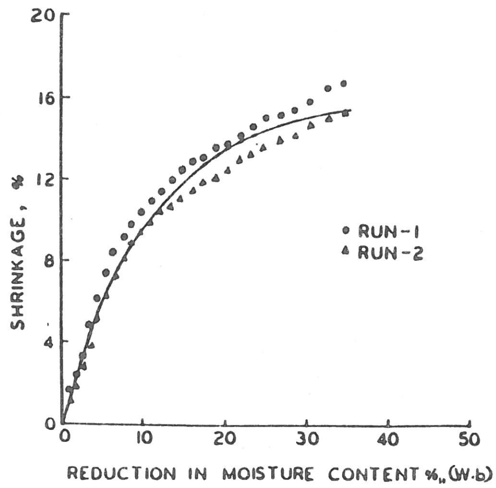

Fig. 2. Predicted and observed shrinking of malt.

Physically the nonlinearity of shrinkage of malt can be interpreted as follows. The shrinkage of a malt bed at any instant during drying is the cumulative effect of the free shrinkage of the cells due to loss of moisture and elastic shrinkage, if any, due to constraints on the free shrinkage exerted by the adjacent cells of the grains in the bed. The rate of shrinkage of cells in the malt grains decreases as the moisture content approaches a low value. This explains why the rate of shrinkage in the malt bed gradually decreases to almost zero at a very low moisture content.

CONCLUSIONS

The shrinkage of a malt bed during drying is, to a good approximation, a nonlinear function of moisture reduction. Eq. (4) shows good agreement between the prediction and experimental values and it is better than the linear relationship proposed by previous workes.

REFERENCES

1. **Bala B.K.**: Deep bed drying of malt. Ph.D. Thesis. University of Newcastle Upon Tyne, 1983.
2. **Boyce D.S.**: Heat and moisture transfer in ventilated grain. Ph.D. Thesis. University of Newcastle Upon Tyne., 1966.
3. **Nellist M.E.**: The drying of ryegrass seeds in deep layers. Ph.D. Thesis. University of Newcastle Upon Tyne, 1974.
4. **Spencer H.B.**: A revised model of wheat drying process. J. Agric. Eng. Res., 17(1), 189-194, 1972.
5. **Wileman R.H.**: Shrinkage of artificially dried seed corn. Agric. Eng., 256, 1941.